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Fortran 90

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Fortran

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FOREWORD

(This foreword is not part of this standard.)

Standard Programming Language Fortran 90. This standard specifies the form and establishes the interpretation of programs expressed in the Fortran language (throughout this document referred to simply as "Fortran". It consists of the specification of the language Fortran. No subsets are specified in this standard. With limitations noted in 1.4.1, the syntax and semantics of the standard commonly known as "FORTRAN 77" are contained entirely within this standard. Therefore, any standard-conforming FORTRAN 77 program is standard conforming under this standard. New features can be compatibly incorporated into such programs, with any exceptions indicated in the text of this standard.

Since the publication of FORTRAN 77 (April 1978), the technical committee, X3J3, has been developing this standard. The central philosophy has been to modernize Fortran so that it may continue its long history as a scientific and engineering programming language.

The committee prefers that the complete capitalization of the language name no longer take place and that the name of the language be spelled "Fortran". Except for referencing FORTRAN 77 and FORTRAN 66, we have used this spelling purposefully in this standard and prefer that all references to the language name in user documentation, industry publications, etc. now use this spelling.

OVERVIEW

Among the additions to FORTRAN 77 in this standard, seven stand out as the major ones:

(1) Array operations

(2) Improved facilities for numerical computation

(3) Parameterized intrinsic data types

(4) User-defined data types

(5) Facilities for modular data and procedure definitions

(6) Pointers

(7) The concept of language evolution

A number of other additions are also included in this standard, such as improved source form facilities, more control constructs, recursion, additional input/output facilities, and dynamically allocatable arrays.

A standard-conforming Fortran compiler is also a standard-conforming FORTRAN 77 compiler.

Array Operations. Computation involving large arrays is an important part of engineering and scientific computing. Arrays may be used as entities in Fortran. Operations for processing whole arrays and subarrays (array sections) are included in the language for two principal reasons: (1) these features provide a more concise and higher level language that will allow programmers more quickly and reliably to develop and maintain scientific/engineering applications, and (2) these features can significantly facilitate optimization of array operations on many computer architectures.

The FORTRAN 77 arithmetic, logical, and character operations and intrinsic (predefined) functions are extended to operate on array-valued operands. These include whole, partial, and masked array assignment, array-valued constants and expressions, and facilities to define user-supplied array-valued functions. New intrinsic procedures are provided to manipulate and construct arrays, to perform gather/scatter operations, and to support extended computational capabilities involving arrays. For example, an intrinsic function is provided to sum the elements of an array.

Numerical Computation. Scientific computation is one of the principal application domains of Fortran, and a guiding objective for all of the technical work is to strengthen Fortran as a vehicle for implementing scientific software. Though nonnumeric computations are increasing dramatically in scientific applications, numeric computation remains dominant. Accordingly, the additions include portable control over numeric precision specification, inquiry as to the characteristics of numeric representation, and improved control of the performance of numerical programs (for example, improved argument range reduction and scaling).

Parameterized Character Data Type. Optional facilities for multibyte character data for languages with large character sets, such as those in China and Japan, are added by using a kind parameter for the character data type. This facility allows additional character sets for special purposes as well, such as characters for mathematics, chemistry, or music.

Derived Types. "Derived type" is the term given to that set of features in this standard that allows the programmer to define arbitrary data structures and operations on them. Data structures are user-defined aggregations of intrinsic and derived data types. Intrinsic uses of structured objects include assignment, input/output, and as procedure arguments. With no additional derived-type operations defined by the user, the derived data type facility is a simple data structuring mechanism. With additional operation definitions, derived types provide an effective implementation mechanism for data abstractions.

Procedure definitions may be used to define operations on intrinsic or derived types and nonintrinsic assignments for intrinsic and derived types.

Modular Definitions. In FORTRAN 77, there is no way to define a global data area in only one place and have all the program units in an application use that definition. In addition, the ENTRY statement is awkward and restrictive for implementing a related set of procedures, possibly involving common data objects. Finally, there is no means in FORTRAN 77 by which procedure definitions, especially interface information, may be made known locally to a program unit. These and other deficiencies are remedied by a new type of program unit that may contain any combination of data object declarations, derived-type definitions, procedure definitions, and procedure interface information. This program unit, called a module, may be considered to be a generalization and replacement for the block data program unit. A module may be accessed by any program unit, thereby making the module contents available to that program unit. Thus, modules provide improved facilities for defining global data areas, procedure packages, and encapsulated data abstractions.

Pointers. Pointers allow arrays to be sized dynamically and ranged, and structures to be linked to create lists, trees, and graphs. An object of any intrinsic or derived type may be declared to have the pointer attribute. Once such an object becomes associated with a target, it may appear anywhere a nonpointer object with the same type, type parameters, and shape may appear.

Language Evolution. With the addition of new facilities, certain old features become redundant and may eventually be phased out of the language as their usage declines. For example, the numeric facilities alluded to above provide the functionality of double precision; with the new array facilities, nonconformable argument association (such as associating an array element with a dummy array) is unnecessary (and in fact is not useful as an array operation); and block data program units are redundant and inferior to modules.

As part of the evolution of the language, categories of language features (deleted and obsolescent) are provided which allow unused features of the language to be removed from future standards.

DOCUMENT ORGANIZATION

This document is organized in 14 sections, dealing with 7 conceptual areas. These 7 areas, and the sections in which they are treated, are:

High/Low Level Concepts	Sections 2,3
Data Concepts	Sections 4,5,6
Computations	Sections 7,13
Execution Control	Section 8
Input/Output	Sections 9,10
Program Units	Sections 11,12
Scoping and Association Rules	Section 14

High/Low Level Concepts. Section 2 (Fortran Terms and Concepts) contains many of the high level concepts of Fortran. This includes the concept of an executable program and the relationships among its major parts. Also included are the syntax of program units, the rules for statement ordering, and the definitions of many of the fundamental terms used throughout the document.

Section 3 (Characters, Lexical Tokens, and Source Form) describes the low level elements of Fortran, such as the character set and the allowable forms for source programs. It also contains the rules for constructing literal constants and names for Fortran entities, and lists all of the Fortran operators.

Data Concepts. The array operations (arrays as data objects) and data structures provide a rich set of data concepts in Fortran. The main concepts are those of data type, data object, and the use of data objects, which are described in Sections 4, 5, and 6, respectively.

Section 4 (Intrinsic and Derived Data Types) describes the distinction between a data type and a data object, and then focuses on data type. It defines a data type as a set of data values, corresponding forms (constants) for representing these values, and operations on these values. The concept of an intrinsic data type is introduced, and the properties of Fortran's intrinsic types (INTEGER, REAL, COMPLEX, LOGICAL, and CHARACTER) are described. Note that only type concepts are described here, and not the declaration and properties of data objects.

Section 4 also introduces the concept of derived (user-defined) data types, which are compound types whose components ultimately resolve into intrinsic types. The details of defining a derived type are given (note that this has no counterpart with intrinsic types as intrinsic types are predefined and therefore need not—indeed cannot—be redefined by the programmer). As with intrinsic types, this section deals only with type properties, and not with the declaration of data objects of derived type.

Section 5 (Data Object Declarations and Specifications) describes in detail how named data objects are declared and given the desired properties (attributes). An important attribute (the only one required for each data object) is the object's data type, so the type declaration statement is the main feature of this section. The various attributes are described in detail, as well as the two ways that attributes may be specified (type declaration statements and attribute specification statements). Implicit typing and storage association (COMMON and EQUIVALENCE) are also described in this section, as well as data object value initialization.

Section 6 (Use of Data Objects) deals mainly with the concept of a variable, and describes the various forms that variables may take. Scalar variables include character strings and substrings, structured (derived-type) objects, structure components, and array elements. Arrays are considered to be variables, as are array sections. Among the array facilities described here are array sections (subarrays), and array allocation and deallocation (user controlled dynamic arrays). The section concludes with a summary of the allowed appearances of array names.

Computations. Section 7 (Expressions and Assignment) describes how computations are expressed in Fortran. This includes the forms that expression operands (primaries) may take and the role of operators in these expressions. Operator precedence is rigorously defined in syntax rules and summarized in tabular form. This description includes the relationship of defined operators (user-defined operators) to the intrinsic operators (+, *, .AND., .OR., etc.). The rules for both expression evaluation and the interpretation (semantics) of intrinsic and defined operators are described in detail.

Section 7 also describes assignment of computational results to data objects, which has three principal forms: the conventional assignment statement, the pointer assignment statement, and the WHERE statement and construct. The WHERE statement and construct allow masked array assignment.

Section 13 (Intrinsic Procedures) describes more than one hundred intrinsic procedures that provide a rich set of computational capabilities. In addition to the FORTRAN 77 intrinsic functions, this includes many array processing functions, a comprehensive set of numerical environmental inquiry functions, and a set of procedures for the manipulation of bits in nonnegative integer data.

Execution Control. Section 8 (Execution Control) describes the control constructs (IF, CASE, and DO), branching statements (various forms of GO TO), and other control statements (IF, arithmetic IF, CONTINUE, STOP, and PAUSE). These are as in FORTRAN 77 except for the addition of the CASE construct and the extension of the DO loop to include an END DO termination option, additional control clauses, and the addition of the EXIT and CYCLE statements.

Input/Output. Section 9 (Input/Output Statements) contains definitions for records, files, file connections (OPEN, CLOSE, and preconnected files), data transfer statements (READ, WRITE, and PRINT) that include processing of partial and variable length records, file positioning, and file inquiry (INQUIRE).

Section 10 (Input/Output Editing) describes input/output formatting. This includes the FORMAT statement and FMT= specifier, edit descriptors, list-directed I/O, and namelist I/O.

Program Units. Section 11 (Program Units) describes main programs, internal procedures, modules, and block data program units. Modules, along with the USE statement, are described as a mechanism for encapsulating data and procedure definitions that are to be used by (accessible to) other program units. Modules are described as vehicles for defining global derived-type definitions, global data object declarations, procedure libraries, and combinations thereof.

Section 12 (Procedures) contains a comprehensive treatment of procedure definition and invocation, including that for user-defined functions and subroutines. The concepts of implicit and explicit procedure interfaces are explained, and situations requiring explicit procedure interfaces are identified. The rules governing actual and dummy arguments, and their association, are described.

Section 12 also describes the use of the OPERATOR option on interface blocks to allow function invocation in the form of infix and prefix operators as well as the traditional functional form. Similarly, the use of the ASSIGNMENT option on interface blocks is described as allowing an alternate syntax for certain subroutine calls. This section also contains descriptions of recursive procedures, the RETURN statement, the ENTRY statement, internal procedures and the CONTAINS statement, statement functions, overloaded procedure names, and non-Fortran procedures.

Scoping and Association Rules. Section 14 (Scope, Association, and Definition) explains the use of the term "scope" (especially important now because of the addition of internal procedures, modules, and other new features), and describes the scope properties of various entities, including names and operators. Also described are the general rules governing procedure argument association, pointer association, use association (accessing entities in modules), and storage association. Finally, Section 14 describes the events that cause variables to become defined (have predictable values) and events that cause variables to become undefined.

Subcommittee X3J3 on Fortran, with the guidance of the international Fortran Working Group ISO/IEC JTC1/SC22/WG5, developed this standard. The technical development has been carried out by subgroups, whose work is reviewed by the full committee. During the period of development of the draft Fortran standard, many persons assumed important roles of leadership:

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FIGURES

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1. INTRODUCTION

1.1 Purpose. This standard specifies the form and establishes the interpretation of programs expressed in the Fortran language. The purpose of this standard is to promote portability, reliability, maintainability, and efficient execution of Fortran programs for use on a variety of computing systems. The foreword and appendices are not part of the standard.

1.2 Processor. The combination of a computing system and the mechanism by which programs are transformed for use on that computing system is called a **processor** in this standard.

1.3 Scope. This standard specifies the bounds of the Fortran language by identifying both those items included and those items excluded.

1.3.1 Inclusions. This standard specifies:

(1) The forms that a program written in the Fortran language may take

(2) The rules for interpreting the meaning of a program and its data

(3) The form of the input data to be processed by such a program

(4) The form of the output data resulting from the use of such a program

1.3.2 Exclusions. This standard does not specify:

(1) The mechanism by which programs are transformed for use on computing systems

(2) The operations required for setup and control of the use of programs on computing systems

(3) The method of transcription of programs or their input or output data to or from a storage medium

(4) The program and processor behavior when the rules of this standard fail to establish an interpretation except for the processor detection and reporting requirements in items (2), (3), and (4) of 1.4

(5) The size or complexity of a program and its data that will exceed the capacity of any specific computing system or the capability of a particular processor

(6) The physical properties of the representation of quantities and the method of rounding, approximating, or computing numeric values on a particular processor

(7) The physical properties of input/output records, files, and units

(8) The physical properties and implementation of storage

1.4 Conformance. The requirements, prohibitions, and options specified in this standard refer primarily to permissible forms and relationships for a standard-conforming program rather than for a processor. The optional output forms produced by a processor, which are not under the control of a program, are an example of an exception. The requirements, prohibitions, and options for a standard-conforming processor usually must be inferred from those given for programs.

An executable program (2.2.2) is a **standard-conforming program** if it uses only those forms and relationships described herein and if the executable program has an interpretation according to this standard. A program unit (2.2) conforms to this standard if it can be included in an executable program in a manner that allows the executable program to be standard conforming.

A processor conforms to this standard if:

(1) It executes any standard-conforming program in a manner that fulfills the interpretations herein, subject to any limits that the processor may impose on the size and complexity of the program.

(2) It contains the capability to detect and report the use within a submitted program unit of a form designated herein as deleted or obsolescent, insofar as such use can be detected by reference to the numbered syntax rules and their associated constraints.

(3) It contains the capability to detect and report the use within a submitted program unit of an additional form or relationship that is not permitted by the numbered syntax rules or their associated constraints.

(4) It contains the capability to detect and report the use within a submitted program of kind type parameter values (4.3) not supported by the processor.

(5) It contains the capability to detect and report the use within a submitted program of source form or characters not permitted by Section 3.

(6) It contains the capability to detect and report the use within a submitted program of name usage not consistent with the scope rules for names, labels, operators, and assignment symbols in Section 14.

(7) It contains the capability to detect and report the reason for rejecting a program.

However, in a *format-specification* that is not part of a *format-stmt* (10.1.1), a processor is not required to detect or report the use of deleted or obsolescent features, or the use of additional forms or relationships.

A standard-conforming processor may allow additional forms and relationships provided that such additions do not conflict with the standard forms and relationships. However, a standard-conforming processor may allow additional intrinsic procedures even though this could cause a conflict with the name of a procedure in a standard-conforming program. If such a conflict occurs and involves the name of an external procedure, the processor is permitted to use the intrinsic procedure unless the name is given the EXTERNAL attribute in the same scoping unit (2.2.1). A standard-conforming program must not use nonstandard intrinsic procedures that have been added by the processor.

Note that a standard-conforming program must not use any forms or relationships that are prohibited by this standard, but a standard-conforming processor may allow such forms and relationships if they do not change the proper interpretation of a standard-conforming program. For example, a standard-conforming processor may allow a nonstandard data type.

Because a standard-conforming program may place demands on a processor that are not within the scope of this standard or may include standard items that are not portable, such as external procedures defined by means other than Fortran, conformance to this standard does not ensure that a standard-conforming program will execute consistently on all or any standard-conforming processors.

In some cases, this standard allows the provision of facilities that are not completely specified in the standard. These facilities are identified as **processor dependent**. The facility must be provided, with methods or semantics determined by the processor.

1.4.1 FORTRAN 77 Compatibility. This standard is an upward compatible extension to the preceding Fortran standard, ANSI X3.9-1978, informally referred to as FORTRAN 77. A standard-conforming processor for this standard is a standard-conforming processor for FORTRAN 77. Any standard-conforming FORTRAN 77 program remains standard conforming under this standard; however, see item (4) below regarding intrinsic procedures. This standard restricts the behavior for some features that were processor dependent in FORTRAN 77. Therefore, a standard-conforming FORTRAN 77 program that uses one of these processor-dependent features may have a different interpretation under this standard, yet remain a standard-conforming program. The following FORTRAN 77 features have different interpretations in this standard:

(1) FORTRAN 77 permitted a processor to supply more precision derived from a real constant than can be contained in a real datum when the constant is used to initialize a DOUBLE PRECISION data object in a DATA statement. This standard does not permit a processor this option.

(2) If a named variable that is not in a common block is initialized in a DATA statement and does not have the SAVE attribute specified, FORTRAN 77 leaves its SAVE attribute processor dependent. This standard specifies that this named variable has the SAVE attribute (5.2.9).

(3) FORTRAN 77 requires that the number of values required by the input list must be less than or equal to the number of values in the record during formatted input. This standard specifies that the input record is logically padded with blanks if there are not enough values in the record, unless the PAD= 'NO' option is specified in an appropriate OPEN statement (9.4.4.4.2)

(4) This standard has more intrinsic functions than did FORTRAN 77 and adds a few intrinsic subroutines. Therefore, a standard-conforming FORTRAN 77 program may have a different interpretation under this standard if it invokes a procedure having the same name as one of the new standard intrinsic procedures, unless that procedure is specified in an EXTERNAL statement as recommended for nonintrinsic functions in the appendix to the FORTRAN 77 standard.

1.5 Notation Used in This Standard. In this standard, "must" is to be interpreted as a requirement; conversely, "must not" is to be interpreted as a prohibition.

1.5.1 Syntax Rules. Syntax rules are used to help describe the form that Fortran lexical tokens, statements, and constructs may take. These syntax rules are expressed in a variation of Backus-Naur form (BNF) in which:

(1) Characters from the Fortran character set are to be written as shown, except where otherwise noted. (3.1)

(2) Lower-case italicized letters and words (often hyphenated and abbreviated) represent general syntactic classes for which specific syntactic entities must be substituted in actual statements.

Some common abbreviations used in syntactic terms are:

stmt	for	statement	*attr*	for	attribute
expr	for	expression	*decl*	for	declaration
spec	for	specifier	*def*	for	definition
int	for	integer	*desc*	for	descriptor
arg	for	argument	*op*	for	operator

(3) The syntactic metasymbols used are:

is	introduces a syntactic class definition
or	introduces a syntactic class alternative
[ ]	encloses an optional item
[ ] ...	encloses an optionally repeated item which may occur zero or more times
■	continues a syntax rule

(4) Each syntax rule is given a unique identifying number of the form R*snn*, where *s* is a one- or two-digit section number and *nn* is a two-digit sequence number within that section. The syntax rules are distributed as appropriate throughout the text, and are referenced by number as needed. Some rules in Sections 2 and 3 are more fully described in later sections; in such cases, the section number *s* is the number of the later section where the rule is repeated. The rules also are collected in Appendix D.

(5) The syntax rules are not a complete and accurate syntax description of Fortran, and cannot be used to generate automatically a Fortran parser; where a syntax rule is incomplete, it is accompanied by the corresponding constraints.

(6) Obsolescent features (1.6) are shown in a distinguishing type size. This is an example of the size used for obsolescent features.

An example of the use of syntax rules is:

int-literal-constant is *digit* [*digit*] ...

The following forms are examples of forms for an integer literal constant allowed by the above rule:

digit
digit digit
digit digit digit digit
digit digit digit digit digit digit digit digit

When specific entities are substituted for *digit*, actual integer literal constants might be:

```
4
67
1999
10243852
```

1.5.2 Assumed Syntax Rules. In order to minimize the number of additional syntax rules and convey appropriate constraint information, the following rules are assumed. The letters "*xyz*" stand for any legal syntactic class phrase:

xyz-list is *xyz* [, *xyz*] ...

xyz-name is *name*

scalar-xyz is *xyz*

Constraint: *scalar-xyz* must be scalar.

1.5.3 Syntax Conventions and Characteristics.

(1) Any syntactic class name ending in "*-stmt*" follows the source form statement rules: it must be delimited by end-of-line or semicolon, and may be labeled unless it forms part of another statement (such as an IF or WHERE statement). Conversely, everything considered to be a source form statement is given a "*-stmt*" ending in the syntax rules.

(2) The rules on statement ordering are described rigorously in the definition of *program-unit* (R202-R216). Expression hierarchy is described rigorously in the definition of *expr* (R723).

(3) The suffix "*-spec*" is used consistently for specifiers, such as keyword type parameters, keyword actual arguments, and input/output statement specifiers. It also is used for type declaration attribute specifications (for example, "*array-spec*" in R512), and in a few other cases.

(4) When reference is made to a type parameter, including the surrounding parentheses, the term "selector" is used. See, for example, "*length-selector*" (R507) and "*kind-selector*" (R505).

(5) The term "*subscript*" (for example, R615, R616, and R617) is used consistently in array definitions.

1.5.4 Text Conventions. In the descriptive text, the normal English word equivalent of a BNF syntactic term is usually used. Specific statements and attributes are identified in the text by the upper-case keyword, e.g., "END statement". Boldface words are used in the text where they are first defined with a specialized meaning.

1.6 Deleted and Obsolescent Features. This standard protects the users' investment in existing software by including all of the language elements of ANSI X3.9-1978 that are not processor dependent. This document identifies two categories of outmoded features. There are none in the first category, **deleted features**, which consists of features considered to have been redundant in ANSI X3.9-1978 and largely unused. Those in the second category, **obsolescent features**, are considered to have been redundant in ANSI X3.9-1978, but are still used frequently.

1.6.1 Nature of Deleted Features.

(1) Better methods existed in ANSI X3.9-1978.

(2) These features are not included in this revision of Fortran.

1.6.2 Nature of Obsolescent Features.

(1) Better methods existed in ANSI X3.9-1978.

(2) It is recommended that programmers use these better methods in new programs and convert existing code to these methods.

(3) These features are identified in the text of this document by a distinguishing type font (1.5.1).

(4) If the use of these features has become insignificant in Fortran programs, it is recommended that future Fortran standards committees consider deleting them from the next revision.

(5) It is recommended that the next Fortran standards committee consider for deletion only those language features that appear in the list of obsolescent features.

(6) It is recommended that processors supporting the Fortran language continue to support these features as long as they continue to be used widely in Fortran programs.

1.7 Modules. This standard provides facilities that encourage the design and use of modular and reusable software. Data and procedure definitions may be organized into nonexecutable program units, called modules, and made available to any other program unit. In addition to global data and procedure library facilities, modules provide a mechanism for defining data abstractions and certain language extensions. Modules are described in 11.3.

A module may be standardized as a separate collateral standard. A **standard module** must not use any obsolescent features, nor any nonstandard form or relations.

2. FORTRAN TERMS AND CONCEPTS

2.1 High Level Syntax. This section introduces the terms associated with program units and other Fortran concepts above the construct, statement, and expression levels and illustrates their relationships. The syntax rule notation is described in 1.5.1. Note that some of the syntax rules in this section are subject to constraints that are given only at the appropriate places in later sections.

R201 *executable-program* **is** *program-unit*
[*program-unit*] ...

An *executable-program* must contain exactly one *main-program program-unit*.

R202 *program-unit* **is** *main-program*
or *external-subprogram*
or *module*
or *block-data*

R1101 *main-program* **is** [*program-stmt*]
[*specification-part*]
[*execution-part*]
[*internal-subprogram-part*]
end-program-stmt

R203 *external-subprogram* **is** *function-subprogram*
or *subroutine-subprogram*

R1218 *function-subprogram* **is** *function-stmt*
[*specification-part*]
[*execution-part*]
[*internal-subprogram-part*]
end-function-stmt

R1222 *subroutine-subprogram* **is** *subroutine-stmt*
[*specification-part*]
[*execution-part*]
[*internal-subprogram-part*]
end-subroutine-stmt

R1104 *module* **is** *module-stmt*
[*specification-part*]
[*module-subprogram-part*]
end-module-stmt

R1110 *block-data* **is** *block-data-stmt*
[*specification-part*]
end-block-data-stmt

R204 *specification-part* **is** [*use-stmt*] ...
[*implicit-part*]
[*declaration-construct*] ...

R205 *implicit-part* **is** [*implicit-part-stmt*] ...
implicit-stmt

R206 *implicit-part-stmt* **is** *implicit-stmt*
or *parameter-stmt*
or *format-stmt*
or *entry-stmt*

R207 *declaration-construct* **is** *derived-type-def*
or *interface-block*
or *type-declaration-stmt*
or *specification-stmt*
or *parameter-stmt*

			or *format-stmt*
			or *entry-stmt*
			or *stmt-function-stmt*
R208	*execution-part*	is	*executable-construct* [*execution-part-construct*] ...
R209	*execution-part-construct*	is	*executable-construct*
		or	*format-stmt*
		or	*data-stmt*
		or	*entry-stmt*
R210	*internal-subprogram-part*	is	*contains-stmt* *internal-subprogram* [*internal-subprogram*] ...
R211	*internal-subprogram*	is	*function-subprogram*
		or	*subroutine-subprogram*
R212	*module-subprogram-part*	is	*contains-stmt* *module-subprogram* [*module-subprogram*] ...
R213	*module-subprogram*	is	*function-subprogram*
		or	*subroutine-subprogram*
R214	*specification-stmt*	is	*access-stmt*
		or	*allocatable-stmt*
		or	*common-stmt*
		or	*data-stmt*
		or	*dimension-stmt*
		or	*equivalence-stmt*
		or	*external-stmt*
		or	*intent-stmt*
		or	*intrinsic-stmt*
		or	*namelist-stmt*
		or	*optional-stmt*
		or	*pointer-stmt*
		or	*save-stmt*
		or	*target-stmt*
R215	*executable-construct*	is	*action-stmt*
		or	*case-construct*
		or	*do-construct*
		or	*if-construct*
		or	*where-construct*
R216	*action-stmt*	is	*allocate-stmt*
		or	*assignment-stmt*
		or	*backspace-stmt*
		or	*call-stmt*
		or	*close-stmt*
		or	*computed-goto-stmt*
		or	*continue-stmt*
		or	*cycle-stmt*
		or	*deallocate-stmt*
		or	*endfile-stmt*
		or	*end-function-stmt*
		or	*end-program-stmt*
		or	*end-subroutine-stmt*
		or	*exit-stmt*
		or	*goto-stmt*

or *if-stmt*
or *inquire-stmt*
or *nullify-stmt*
or *open-stmt*
or *pointer-assignment-stmt*
or *print-stmt*
or *read-stmt*
or *return-stmt*
or *rewind-stmt*
or *stop-stmt*
or *where-stmt*
or *write-stmt*
or *arithmetic-if-stmt*
or *assign-stmt*
or *assigned-goto-stmt*
or *pause-stmt*

Constraint: An *execution-part-construct* must not contain an *end-function-stmt*, an *end-program-stmt*, or an *end-subroutine-stmt*.

2.2 Program Unit Concepts. Program units are the fundamental components of a Fortran program. A **program unit** may be a main program, an external subprogram, a module, or a block data program unit. A subprogram may be a function subprogram or a subroutine subprogram. A module contains definitions that are to be made accessible to other program units. A block data program unit is used to specify initial values for named common block data objects. Each type of program unit is described in Section 11 or 12. An **external subprogram** is a subprogram that is not contained within a main program, a module, or another subprogram. An **internal subprogram** is a subprogram that is contained within a main program or another subprogram. A **module subprogram** is a subprogram that is contained in a module but is not an internal subprogram.

A program unit consists of nonoverlapping scoping units (Section 14).

2.2.1 Executable Program. An **executable program** consists of exactly one main program unit and any number (including zero) of other kinds of program units. The set of program units may include any combination of the different kinds of program units in any order.

2.2.2 Main Program. The main program is described in 11.1.

2.2.3 Procedure. A **procedure** encapsulates an arbitrary sequence of computations that may be invoked directly during program execution. A principal difference between the two kinds of procedures is the way in which each is invoked. A **function** is a procedure that is invoked in an expression; its invocation causes a value to be computed which is then used in evaluating the expression. A **subroutine** is a procedure that is invoked in a CALL statement or by a defined assignment statement (12.4.4, 12.3.2.1). A subroutine may be used to change the program state by changing the values of any of the data objects accessible to the subroutine; a function may do this in addition to computing the function value.

Procedures are described further in Section 12.

2.2.3.1 External Procedure. An **external procedure** is a procedure that is defined by an external subprogram or by means other than Fortran. An external procedure may be invoked by the main program or by any procedure of an executable program.

2.2.3.2 Module Procedure. A **module procedure** is a procedure that is defined by a module subprogram (R213). A module procedure may be invoked by another module subprogram in the module or by any scoping unit using the module. The module containing the subprogram is called the host of the module procedure.

2.2.3.3 Internal Procedure. An **internal procedure** is a procedure that is defined by an internal subprogram (R211). The containing main program or subprogram is called the **host** of the internal procedure. An internal procedure is local to its host in the sense that the internal procedure is accessible within the scoping units of the host and all its other internal procedures but is not accessible elsewhere.

2.2.3.4 Procedure Interface Block. The purpose of a **procedure interface block** is to describe the interfaces (12.3) to a set of procedures and to permit them to be invoked through either a single generic name, a defined operator, or a defined assignment. It determines the forms of reference through which the procedure may be invoked.

2.2.4 Module. A **module** contains (or accesses from other modules) definitions that are to be made accessible to other program units. These definitions include data object declarations, type definitions, procedure definitions, and procedure interface blocks. The purpose of a module is to make the definitions it contains accessible to all other program units in an executable program that request such accessibility. A scoping unit in another program unit may request access to the definitions contained in a module. Modules are further described in Section 11.

2.3 Execution Concepts. A program unit is a sequence of statements. Each statement is classified as either an **executable statement** or a **nonexecutable statement.** There are restrictions on the order in which statements may appear in a program unit, and certain executable statements may appear only in certain executable constructs.

2.3.1 Executable/Nonexecutable Statements. Program execution is a sequence, in time, of computational actions. An executable statement is an instruction to perform or control one or more of these actions. Thus, the executable statements of a program unit determine the computational behavior of the program unit. The executable statements are all of those that make up the syntactic class of *executable-construct*.

Nonexecutable statements do not specify actions; they are used to configure the program environment in which computational actions take place. The nonexecutable statements are all those not classified as executable. All statements in a block data program unit must be nonexecutable. A module may contain executable statements only within a subprogram in the module.

2.3.2 Statement Order. The syntax rules of Section 2.1 specify the statement order within program units and subprograms. These rules are illustrated in Figure 2.1 and Table 2.1. Figure 2.1 shows the ordering rules for statements and applies to all program units and subprograms except that an internal subprogram must not contain another internal subprogram. Table 2.1 shows which statements are allowed in the scoping unit of a program unit, a subprogram, or an interface block (12.3.2.1). In Figure 2.1, vertical lines delineate varieties of statements that may be interspersed and horizontal lines delineate varieties of statements that must not be interspersed. USE statements, if any, must appear immediately after the program unit heading. Internal or module subprograms must follow a CONTAINS statement. Between USE and CONTAINS statements in a subprogram, nonexecutable statements generally precede executable statements, though the FORMAT statement, DATA statement, and ENTRY statement may appear among the executable statements.

Figure 2.1 Requirements on Statement Ordering

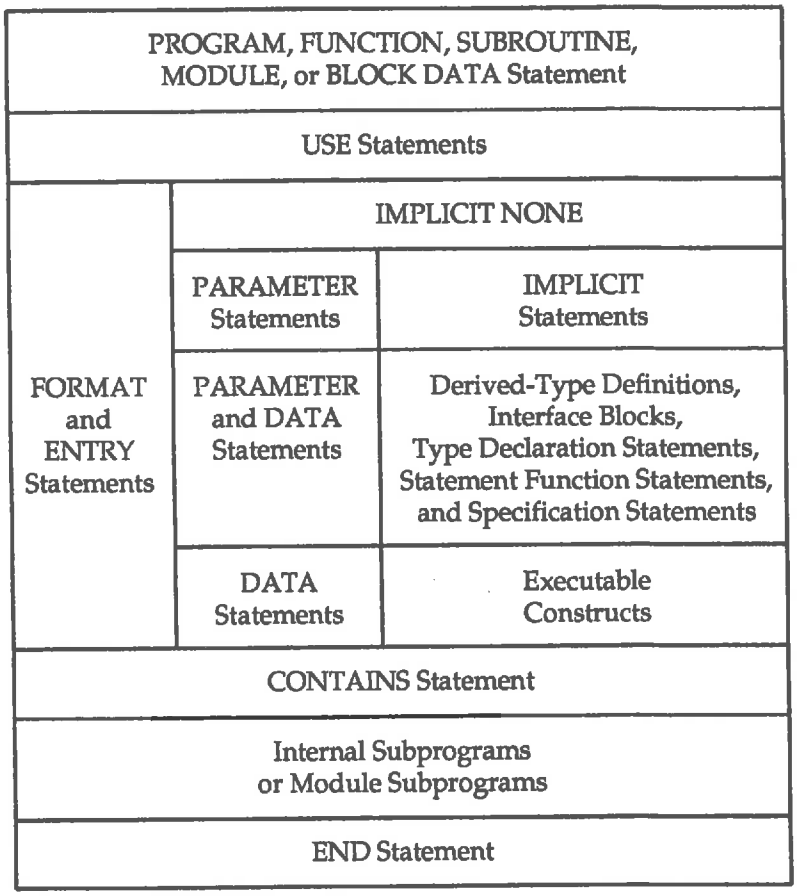

Table 2.1 Statements Allowed in Scoping Units

Kind of Scoping Unit:	Main Program	Module	Block Data	External Subprog	Module Subprog	Internal Subprog	Interface Body
USE Statement	Yes	Yes	Yes	Yes	Yes	Yes	Yes
ENTRY Statement	No	No	No	Yes	Yes	No	No
FORMAT Statement	Yes	No	No	Yes	Yes	Yes	No
Misc. Declarations (See Note)	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Derived-Type Definition	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Interface Block	Yes	Yes	No	Yes	Yes	Yes	Yes
Statement Function	Yes	No	No	Yes	Yes	Yes	No
Executable Statement	Yes	No	No	Yes	Yes	Yes	No
CONTAINS	Yes	Yes	No	Yes	Yes	No	No

Note: Misc. Declarations are PARAMETER Statements, IMPLICIT Statements, DATA Statements, Type Declaration Statements, and Specification Statements.

2.3.3 The END Statement. An *end-program-stmt*, *end-function-stmt*, *end-subroutine-stmt*, *end-module-stmt*, or *end-block-data-stmt* is an **END statement**. Each program unit and external subprogram must have exactly one END statement, which may be labeled; it must be the last statement of the program unit or external subprogram. The *end-program-stmt*, *end-function-stmt*, and *end-subroutine-stmt* statements are executable, and may be branch target statements. Executing an *end-program-stmt* causes termination of execution of the executable program. Executing an *end-function-stmt* or *end-subroutine-stmt* is equivalent to executing a *return-stmt* in a subprogram.

The *end-module-stmt* and *end-block-data-stmt* statements are nonexecutable.

2.3.4 Execution Sequence. Execution of an executable program begins with the first executable construct of the main program. The execution of a main program or subprogram involves execution of the executable constructs within its scoping unit. When a procedure is invoked, execution begins with the first executable construct appearing after the invoked entry point. With the following exceptions, the effect of execution is as if the executable constructs are executed in the order in which they appear in the main program or subprogram until a STOP, RETURN, or END statement is executed. The exceptions are:

(1) Execution of a branching statement (8.2) changes the execution sequence. These statements explicitly specify a new starting place for the execution sequence.

(2) IF constructs, CASE constructs, and DO constructs contain an internal statement structure and execution of these constructs involves implicit (i.e., automatic) internal branching. See Section 8 for the detailed semantics of each of these constructs.

(3) Alternate return and END=, ERR=, and EOR= specifiers may result in a branch.

Internal subprograms may precede the END statement of a main program or a subprogram. The execution sequence excludes all such definitions.

2.4 Data Concepts.

Nonexecutable statements are used to define the characteristics of the data environment. This includes typing variables, declaring arrays, and defining new data types.

2.4.1 Data Type. A **data type** is a named category of data that is characterized by a set of values, together with a way to denote these values and a collection of operations that interpret and manipulate the values. This central concept is described in 4.1.

There are two categories of data types: intrinsic types and derived types.

2.4.1.1 Intrinsic Type. An **intrinsic type** is a type that is defined implicitly, along with operations, and is always accessible. The intrinsic types are INTEGER, REAL, COMPLEX, CHARACTER, and LOGICAL. The properties of intrinsic types are described in 4.3. An intrinsic type may be parameterized, in which case the set of data values depends on the values of the parameters. Such a parameter is called a **type parameter** (4.3). The type parameters are KIND and LEN.

The **kind type parameter** indicates the decimal range for the integer type (4.3.1.1), the decimal precision and exponent range for the real and complex types (4.3.1.2, 4.3.1.3), and the representation methods for the character and logical types (4.3.2.1, 4.3.2.2).

2.4.1.2 Derived Type. A **derived type** is a type that is not defined implicitly but requires a type definition to declare components of intrinsic or of other derived types. A scalar object of such a derived type is called a **structure** (5.1.1.7). The only intrinsic operation for derived types is assignment with type agreement (4.4.5). For each derived type, structure constructors are available to provide values (4.4.4). In addition, data objects of derived type may be used as procedure arguments and function results, and may appear in input/output lists. If additional operations are needed for a derived type, they must be supplied as procedure definitions.

Derived types are described further in 4.4.

2.4.2 Data Value. Each intrinsic type has associated with it a set of values that a datum of that type may take. The values for each intrinsic type are described in 4.3. Because derived types are ultimately specified in terms of components of intrinsic types, the values that objects of a derived type may assume are determined by the type definition and the sets of values.

2.4.3 Data Entity. A **data entity** is an entity that has, or may have, a data value. A data entity is a constant, a variable, an expression value, or a function result. In addition, it is either a scalar or an array.

2.4.3.1 Data Object. A data object (often abbreviated to **object**) is a datum of intrinsic or derived type or an array of such data.

2.4.3.2 Subobjects. Portions of certain named data objects may be referenced and defined independently of the other portions. These include portions of arrays (array elements and array sections), portions of character strings (substrings), and portions of structures (components). These subobjects are themselves considered to be data objects and are described in Section 6.

2.4.4 Constant. A **constant** is a data object whose value must not change during execution of an executable program.

A constant with a name is called a **named constant**. Named constants and the means by which they are defined are described in Section 5. A constant without a name is called a **literal constant**.

2.4.5 Variable. A **variable** is a data object whose value can be defined and redefined during execution of an executable program. A data object explicitly declared as an array and not having the PARAMETER attribute is a variable. A scalar data object, declared explicitly or implicitly and not having the PARAMETER attribute, is also a variable. In some cases, a portion of a variable may itself be a variable and may be assigned a value independently of the other portions. The following are variables:

a named scalar variable	(a scalar object)
a named array variable	(an array object)
an array element	(a scalar subobject)
an array section	(an array subobject)
a structure component	(a scalar or an array subobject)
a substring	(a scalar subobject)

2.4.6 Scalar. A **scalar** is a datum that is not an array. Scalars may be of any intrinsic type or derived type. Note that a structure is scalar even if it has arrays as components. The **rank** of a scalar is zero.

2.4.7 Array. An **array** is a set of scalar data, all of the same type and type parameters, whose individual elements are arranged in a rectangular pattern. An **array element** is one of the individual elements in the array and is a scalar. An **array section** is a subset of the elements of an array and is itself an array.

An array with a name has one subscript for each dimension of the pattern. The pattern may have up to seven dimensions, and any **extent** (size) in any dimension. The **rank** of the array is the number of dimensions, and its **size** is the total number of elements which is equal to the product of the extents. An array may have zero size. The **shape** of an array is determined by its rank and its extent in each dimension, and may be represented as a rank-one array whose elements are the extents. All named arrays must be declared, and the rank of a named array is specified in its declaration. The rank of a named array, once declared, is constant and the extents may be constant also. However, the extents may vary during execution for a dummy argument array, an automatic array, a pointer array, and an allocatable array.

Two arrays are **conformable** if they have the same shape. A scalar is conformable with any array. Any intrinsic operation defined for scalar objects may be applied to conformable objects. Such operations are performed element-by-element to produce a resultant array conformable with the array operands. Element-by-element operation means corresponding elements of the operand arrays are involved in a "scalar-like" operation to produce the corresponding element in the result array, and all such element operations may be performed in any order or simultaneously. Such an operation is described as elemental.

A rank-one array may be constructed from scalars and other rank-one arrays and may be reshaped into any allowable array shape (4.5).

Array objects may be of any intrinsic type or derived type and are described further in 6.2.

2.4.8 Pointer. A pointer is a variable that has the POINTER attribute. It must not be referenced or defined until it is associated with a target by allocation (6.3.1) or pointer assignment (7.5.2). A pointer is **disassociated** if it is not currently associated with a target. If it is an array, the rank is declared, but the extents are determined when the pointer is associated with a target.

2.4.9 Storage. Many of the facilities of this standard make no assumptions about the physical storage characteristics of data objects. However, program units that include storage association dependent features must observe certain storage constraints (14.6.3).

2.5 Fundamental Terms. The following terms are defined here and used throughout this standard.

2.5.1 Name and Designator. A **name** is used to identify a program constituent, such as a program unit, named variable, named constant, dummy argument, or derived type. The rules governing the construction of names are given in 3.2.2. A **subobject designator** is a name followed by one or more of the following: component selectors, array section selectors, array element selectors, and substring selectors.

2.5.2 Keyword. The term **keyword** is used in two ways in this standard. A word that is part of the syntax of a statement is a **statement keyword.** These keywords are not reserved words; that is, names with the same spellings are allowed. Examples of statement keywords are: IF, READ, UNIT, KIND, and INTEGER.

An **argument keyword** is a dummy argument name. Section 13 specifies argument keywords for all of the intrinsic procedures. Argument keywords for external procedures may be specified in a procedure interface block (12.3.2.1).

2.5.3 Declaration. The term **declaration** refers to the specification of attributes for various program entities. Often this involves specifying the data type of a named data object or specifying the shape of a named array object.

2.5.4 Definition. The term **definition** is used in two ways. First, when a data object is given a valid value during program execution, it is said to become **defined.** This is often accomplished by execution of an assignment statement or input statement. Under certain circumstances, a variable ceases to have a predictable value and is said to become **undefined.** Section 14 describes the ways in which variables may become defined and undefined. The second use of the term **definition** refers to the declaration of derived types and procedures.

2.5.5 Reference. A **data object reference** is the appearance of the data object name, subobject designator, or pointer associated with a target in a context requiring its value at that point during execution.

A **procedure reference** is the appearance of the procedure name or its operator symbol or the assignment symbol in a context requiring execution of the procedure at that point.

The appearance of a data object name, data subobject designator, or procedure name in an actual argument list does not constitute a reference to that data object, data subobject, or procedure unless such a reference is needed to complete the specification of the actual argument.

A **module reference** is the appearance of a module name in a USE statement (11.3.1).

2.5.6 Association. **Association** may be name association (14.6.1), pointer association (14.6.2), or storage association (14.6.3). Name association may be argument association, host association, or use association.

Storage association causes different entities to have related values due to using the same storage. All other associations permit an entity to be identified by different names in the same scoping unit or by the same name or different names in different scoping units.

2.5.7 Intrinsic. The qualifier intrinsic signifies that the term to which it is applied is defined in this standard. Intrinsic applies to data types, procedures, and operators. All intrinsic data types, procedures, and operators may be used in any scoping unit without further definition or specification.

2.5.8 Operator. An operator specifies a particular computation involving one (unary operator) or two (binary operator) data values (operands). Fortran contains a number of intrinsic operators (e.g., the arithmetic operators +, −, ∗, /, and ∗∗ with numeric operands and the logical operators .AND., .OR., etc. with logical operands). Additional operators also may be defined within an executable program (7.1.3).

2.5.9 Sequence. A sequence is a set ordered by a one-to-one correspondence with the numbers 1, 2, through n. The number of elements in the sequence is n. A sequence may be empty, in which case it contains no elements.

The elements of a nonempty sequence are referred to as the first element, second element, etc. The nth element, where n is the number of elements in the sequence, is called the last element. An empty sequence has no first or last element.

3. CHARACTERS, LEXICAL TOKENS, AND SOURCE FORM

This section describes the Fortran character set and the various lexical tokens such as names and operators. This section also describes the rules for the forms that Fortran programs may take.

3.1 Processor Character Set. The processor character set is processor dependent. The structure of a processor character set is:

(1) **Control characters** ('newline', for example)

(2) **Graphic characters**

(a) Letters (3.1.1)

(b) Digits (3.1.2)

(c) Underscore (3.1.3)

(d) Special characters (3.1.4)

(e) Other characters (3.1.5)

The letters, digits, underscore, and special characters make up the **Fortran character set.**

R301 *character* **is** *alphanumeric-character*
or *special-character*

R302 *alphanumeric-character* **is** *letter*
or *digit*
or *underscore*

Except for the currency symbol, the graphics used for the characters must be as given in 3.1.1, 3.1.2, 3.1.3, and 3.1.4. However, the style of any graphic is not specified.

3.1.1 Letters. The twenty-six **letters** are:

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

The set of letters define the syntactic class *letter*.

If a processor also permits lower-case letters, the lower-case letters are equivalent to the corresponding upper-case letters in program units except in a character context (3.3).

3.1.2 Digits. The ten **digits** are:

0 1 2 3 4 5 6 7 8 9

The ten digits define the syntactic class *digit*. The digits are interpreted according to the number system of the constant in which they are used: binary, octal, decimal, or hexadecimal.

3.1.3 Underscore.

R303 *underscore* **is** _

The underscore may be used as a significant character in a name.

3.1.4 Special Characters. The twenty-one **special characters** are:

Character	Name of Character	Character	Name of Character
	Blank	:	Colon
=	Equals	!	Exclamation Point
+	Plus	"	Quotation Mark or Quote
–	Minus	%	Percent
*	Asterisk	&	Ampersand
/	Slash	;	Semicolon
(	Left Parenthesis	<	Less Than
)	Right Parenthesis	>	Greater Than
,	Comma	?	Question Mark
.	Decimal Point or Period	$	Currency Symbol
'	Apostrophe		

The twenty-one special characters define the syntactic class *special-character*. The special characters are used for operator symbols, bracketing, and various forms of separating and delimiting other lexical tokens. The special characters $ and ? have no specified use.

3.1.5 Other Characters. Additional characters may be representable in the processor, but may appear only in character constants, character string edit descriptors, comments, and input/output records (4.3.2.1, 10.2.1, 3.3.1.1, 3.3.2.1, 9.1.1).

The default character type must support a character set that includes the Fortran character set. Other character sets may be supported by the processor in terms of nondefault character types. The characters available in the nondefault character types are not specified, except that one character in each nondefault character type must be designated as a blank character to be used as a padding character.

3.2 Low-Level Syntax. The low-level syntax describes the fundamental lexical tokens of a program unit. **Lexical tokens** are sequences of characters with indivisible interpretations that constitute the building blocks of a program. They are keywords, names, constants other than complex literal constants, operators, labels, delimiters: comma, =, =>, +, :, ::, ;, and %.

3.2.1 Keywords. Keywords appear as upper-case words in the syntax rules in Sections 4 through 12.

3.2.2 Names. Names are used for various entities such as variables, program units, dummy arguments, named constants, and derived types.

R304 *name* is *letter* [*alphanumeric-character*] ...

Constraint: The maximum length of a *name* is 31 characters.

Examples of names:

```
A1
NAME_LENGTH                    (single underscore)
S_P_R_E_A_D__O_U_T              (two consecutive underscores)
TRAILER_                       (trailing underscore)
```

3.2.3 Constants.

R305 *constant* is *literal-constant*
or *named-constant*

R306 *literal-constant* is *int-literal-constant*
or *real-literal-constant*
or *complex-literal-constant*

or *logical-literal-constant*
or *char-literal-constant*
or *boz-literal-constant*

R307 *named-constant* is *name*

R308 *int-constant* is *constant*

Constraint: *int-constant* must be of type integer.

R309 *char-constant* is *constant*

Constraint: *char-constant* must be of type character.

3.2.4 Operators.

R310 *intrinsic-operator* is *power-op*
or *mult-op*
or *add-op*
or *concat-op*
or *rel-op*
or *not-op*
or *and-op*
or *or-op*
or *equiv-op*

R708 *power-op* is **

R709 *mult-op* is *
or /

R710 *add-op* is +
or -

R712 *concat-op* is //

R714 *rel-op* is .EQ.
or .NE.
or .LT.
or .LE.
or .GT.
or .GE.
or ==
or /=
or <
or <=
or >
or >=

R719 *not-op* is .NOT.

R720 *and-op* is .AND.

R721 *or-op* is .OR.

R722 *equiv-op* is .EQV.
or .NEQV.

R311 *defined-operator* is *defined-unary-op*
or *defined-binary-op*
or *generic-intrinsic-op*

R704 *defined-unary-op* is . *letter* [*letter*] ... .

R724 *defined-binary-op* is . *letter* [*letter*] ... .

R312 *generic-intrinsic-op* is *intrinsic-operator*

Constraint: A *defined-unary-op* and a *defined-binary-op* must not contain more than 31 letters and must not be the same as any *intrinsic-operator* or *logical-literal-constant*.

3.2.5 Statement Labels. A statement label provides a means of referring to an individual statement. Any statement not forming part of another statement may be labeled.

R313 *label* is *digit* [*digit* [*digit* [*digit* [*digit*]]]]

Constraint: At least one digit in a *label* must be nonzero.

If a statement is labeled, the statement must contain a nonblank character. The same statement label must not be given to more than one statement in a scoping unit. Leading zeros are not significant in distinguishing between statement labels. For example:

```
99999
10
 010
```

are all statement labels. The last two are equivalent.

3.2.6 Delimiters. Delimiters are used to enclose character constants or other lexical tokens. The following pairs are delimiters:

```
( ... )
/ ... /
" ... "
' ... '
. ... .
(/ ... /)
```

3.3 Source Form. A Fortran program unit is a sequence of one or more Fortran statements and comments. A Fortran **statement** is a sequence of one or more complete or partial lines. A **line** is a sequence of zero or more characters. Lines following a program unit END statement are not part of that program unit.

Any syntax rule ending in "*-stmt*" identifies a Fortran statement.

A **character context** means characters within (between the delimiters of) a character literal constant or within a character string edit descriptor (10.7).

Any character representable in the processor may occur in a character context or in a comment.

There are two **source forms**: free and fixed. Free form and fixed form must not be mixed in the same program unit. The means for specifying the source form of a program unit are processor dependent.

3.3.1 Free Source Form. In **free source form**, each source line may contain from zero to 132 characters and there are no restrictions on where a statement (or portion of a statement) may appear within a line. However, if a line contains any character that is not of default kind (4.3.2.1), the number of characters allowed on the line is processor dependent.

In free form, blank characters must not appear within lexical tokens other than in a character context. Blanks may be inserted freely between tokens to improve readability; for example, blanks may occur between the tokens that form a complex literal constant. A sequence of blank characters outside of a character context is equivalent to a single blank character.

A blank must be used to separate names, constants, or labels from adjacent keywords, names, constants, or labels. For example, in

```
REAL X
READ 10
30 DO K=1,3
```

the blanks are required after REAL, READ, 30, and DO.

One or more blanks must be used to separate certain adjacent keywords and may be optionally used as indicated below.

Blanks Optional	Blank Mandatory
BLOCK DATA	CASE DEFAULT
DOUBLE PRECISION	IMPLICIT *type-spec*
ELSE IF	IMPLICIT NONE
END BLOCK DATA	RECURSIVE FUNCTION
END DO	RECURSIVE SUBROUTINE
END FILE	RECURSIVE *type-spec*
END FUNCTION	*type-spec* FUNCTION
END IF	*type-spec* RECURSIVE
END INTERFACE	
END MODULE	
END PROGRAM	
END SELECT	
END SUBROUTINE	
END TYPE	
END WHERE	
GO TO	
IN OUT	
SELECT CASE	

3.3.1.1 Free Form Commentary. The character "!" initiates a comment except when it appears within a character context. The comment extends to the end of the source line. If the first nonblank character on a line is an "!", the line is called a comment line. Lines containing only blanks or containing no characters are also comment lines. Comments may appear anywhere in a program unit and may precede the first statement of a program unit. Comments have no effect on the interpretation of the program unit.

3.3.1.2 Free Form Statement Separation. The character ";" separates statements, or partial statements, on a single source line except when it appears in a character context or in a comment. If a ";" separator is followed by zero or more blanks and one or more ";" separators, the sequence from the first ";" to the last, inclusive, is the same as a single ";" separator.

3.3.1.3 Free Form Statement Continuation. The character "&" is used to indicate that the current statement is continued on the next line that is not a comment line. Comment lines cannot be continued; an "&" in a comment has no effect. Comments may occur within a continued statement. When used for continuation, the "&" is not part of the statement. No line may contain only a single "&" as the only nonblank character or a single "&" before an "!", if any.

3.3.1.3.1 Noncharacter Context Continuation. If an "&" not in a comment is the last nonblank character on a line or the last nonblank character before an "!", the statement is continued on the next line that is not a comment line. If the first nonblank character on the next noncomment line is an "&", the statement continues at the next character position following the "&"; otherwise, it continues with the first character position of the next noncomment line.

If a lexical token is split across the end of a line, the first nonblank character on the first following noncomment line must be an "&" immediately followed by the successive characters of the split token.

3.3.1.3.2 Character Context Continuation. If a character context is to be continued, the "&" must be the last nonblank character on the line and must not be followed by commentary. An "&" must be the first nonblank character on the next line that is not a comment line and the statement continues with the next character following the "&".

3.3.1.4 Free Form Statements. A label may precede any statement not forming part of another statement. Note that no Fortran statement begins with a digit. A free form statement must not have more than 39 continuation lines.

3.3.2 Fixed Source Form. In fixed source form, each line must contain exactly 72 characters and there are restrictions on where a statement may appear within a line. Note that if a source line contains nondefault kind characters, its maximum number of characters is processor dependent.

Except in a character context, blanks are insignificant and may be used freely throughout the program.

3.3.2.1 Fixed Form Commentary. The character "!" initiates a comment except when it appears within a character context or in character position 6. The comment extends to the end of the line. If the first nonblank character on a line is an "!" in any character position other than character position 6, the line is a comment line. Lines beginning with a "C" or "*" in character position 1 and lines containing only blanks are also comments. Comments may appear anywhere within a program unit and may precede the first statement of the program unit. Comments have no effect on the interpretation of the program unit.

3.3.2.2 Fixed Form Statement Separation. The character ";" separates statements, or partial statements, on a single source line except when it appears in a character context or in a comment. If a ";" separator is followed by zero or more blanks and one or more ";" separators, the sequence from the first ";" to the last, inclusive, is the same as a single ";" separator.

3.3.2.3 Fixed Form Statement Continuation. Except within commentary, character position 6 is used to indicate continuation. If character position 6 contains a blank or zero, this line is the initial line of a new statement which begins in character position 7. If character position 6 contains any character other than blank or zero, character positions 7–72 of this line constitute a continuation of the preceding noncomment line. Note that an "!" or ";" in character position 6 indicates a continuation of the preceding noncomment line. Comment lines cannot be continued. Comment lines may occur within a continued statement.

3.3.2.4 Fixed Form Statements. A label, if present, must occur in character positions 1 through 5 of the first line of a statement; otherwise, positions 1 through 5 must be blank. Blanks may appear anywhere within a label. Note that a statement following a ";" on the same line must not be labeled. Character positions 1 through 5 of any continuation lines must be blank. A fixed form statement must not have more than 19 continuation lines. The program unit END statement must not be continued and no other statement in the program unit may have an initial line that appears to be a program unit END statement.

3.4 Including Source Text. Additional text may be incorporated into the source text of a program unit during processing. This is accomplished with the **INCLUDE line**, which has the form

INCLUDE *char-literal-constant*

The *char-literal-constant* must not have a kind type parameter value that is a *named-constant*.

An INCLUDE line is not a Fortran statement.

An INCLUDE must appear on a single source line where a statement may appear; it must be the only nonblank text on this line other than an optional trailing comment. Thus, a statement label is not allowed.

The effect of the INCLUDE line is as if the referenced source text physically replaced the INCLUDE line prior to program processing. Included text may contain any source text, including additional INCLUDE lines; such nested INCLUDE lines are similarly replaced with the specified source text. The maximum depth of nesting of any nested INCLUDE lines is processor dependent.

When an INCLUDE line is resolved, the first included statement line must not be a continuation line and the last included line must not be continued.

The interpretation of *char-literal-constant* is processor dependent. An example of a possible valid interpretation is that *char-literal-constant* is the name of a file that contains the source text to be included.

4. INTRINSIC AND DERIVED DATA TYPES

Fortran provides an abstract means whereby data may be categorized without relying on a particular physical representation. This abstract means is the concept of **data type**. Each data type has a name. The names of the intrinsic types are predefined by the language; the names of any derived types must be defined in type definitions (4.4.1). A data type is characterized by a set of values, a means to denote the values, and a set of operations that can manipulate and interpret the values.

For example, the logical data type has a set of two values, denoted by the lexical tokens .TRUE. and .FALSE., which are manipulated by logical operations.

An example of a less restricted data type is the integer data type. This data type has a processor-dependent set of integer numeric values, each of which is denoted by an optional sign followed by a string of digits, and which may be manipulated by integer arithmetic operations and relational operations.

The means by which a value is denoted indicates both the type of the value and a particular member of the set of values characterizing that type. Intrinsic data types are parameterized. In this case, the set of values is constrained by the value of the parameter or parameters. For example, the character data type has a length parameter that constrains the set of character values to those whose length is equal to the value of the parameter.

An intrinsic type is one that is predefined by the language. The intrinsic types are integer, real, complex, character, and logical. The phrase "defined intrinsically" will be used later in this section to mean "predefined" in this sense.

In addition to the intrinsic types, application specific types may be derived. Objects of derived type have **components**. Each component is of an intrinsic type or of a derived type. A type definition (4.4.1) is required to supply the name of the type and the names and types of its components. For example, if the complex type were not intrinsic but had to be derived, a type definition would be required to supply the name "complex" and declare two components, each of type real.

Means are provided to denote values of a derived type (4.4.4) and to define operations that can be used to manipulate objects of a derived type (4.4.5). A derived type must be defined in the executable program, whereas an intrinsic type is predefined. A derived type may be used only where its definition is accessible (4.4.1). An intrinsic type is always accessible.

4.1 The Concept of Data Type.

A data type has (1) a name, (2) a set of valid values, (3) a means to denote such values (constants), and (4) a set of operations to manipulate the values.

4.1.1 Set of Values.

For each data type, there is a set of valid values. The set of valid values may be completely determined, as is the case for logical, or may be determined by a processor-dependent method, as is the case for integer and real. For complex or derived types, the set of valid values consists of the set of all the combinations of the values of the individual components. For parameterized types, the set of valid values depends on the values of the parameters.

4.1.2 Constants.

For each of the intrinsic data types, the syntax for literal constants of that type is specified in this standard. These literal constants are described in 4.3 for each intrinsic type. Within an executable program, all literal constants that have the same form have the same value.

A constant value may be given a name (5.1.2.1, 5.2.10).

A constant value of derived type may be constructed (4.4.4) using a structure constructor from an appropriate sequence of constant expressions (7.1.6.1). Such a constant value is considered to be a scalar even though the value may have components that are arrays.

4.1.3 Operations.

For each of the intrinsic data types, a set of operations and corresponding operators are defined intrinsically. These are described in Section 7. The intrinsic set may be augmented with operations and operators defined by functions with the OPERATOR interface (12.3.2.1). Operator definitions are described in Sections 7 and 12.

For derived types, the only intrinsic operation is assignment. All other operations must be defined by the executable program (4.4.5).

4.2 Relationship of Types and Values to Objects and Entities. The name of a data type serves as a type specifier and may be used to declare objects of that type. A declaration specifies the type attribute for a named object. A data object may be declared explicitly or implicitly. Once a derived type is defined, an object may be declared to be of that type. Data objects may have attributes in addition to their types. Section 5 describes the way in which a data object is declared and how its type and other attributes are specified.

An array is a collection of subobjects.

Scalar data of any intrinsic or derived type may be shaped in a rectangular pattern to compose an array of the same type. An array is an object and has a type just as a scalar object does.

A scalar object of derived type is referred to as a structure. The components of a structure are subobjects.

Variables may be objects or subobjects. The data type of a variable determines which values that variable may take. Assignment provides one means of defining or redefining the value of a variable of any type. Assignment is defined intrinsically for all types when the type, type parameters, and shape of both the variable and the value to be assigned to it are identical. Assignment between objects of certain differing intrinsic types, type parameters, and shapes is described in Section 7. For example, assignment of an integer value to a real variable is defined intrinsically. For an assignment that is not defined intrinsically, conversions may be defined by a subroutine (7.5.1.3) with the ASSIGNMENT interface (12.3.2.1).

The data type of a variable determines the operations that may be used to manipulate the variable.

A **data entity** is an entity that has, or may have, a data value. It may be a constant, a variable, an expression value, or a function result. Each data entity has a data type. If the entity is a variable, named constant, or function result, the type may be specified explicitly; if the entity is an expression value, the type is determined by the rules in Section 7.

4.3 Intrinsic Data Types. The intrinsic data types are:

numeric types:	Integer, Real, and Complex
nonnumeric types:	Character and Logical

4.3.1 Numeric Types. The **numeric types** are provided for numerical computation. The normal operations of arithmetic, addition (+), subtraction (–), multiplication (*), division (/), exponentiation (**), negation (unary –), and identity (unary +), are defined intrinsically for this set of types.

Each numeric type includes a zero value, which is considered to be neither negative nor positive. The value of a signed zero is the same as the value of an unsigned zero. In this standard, the unqualified term "literal constant" means "unsigned literal constant" when applied to numeric types.

4.3.1.1 Integer Type. The set of values for the **integer type** is a subset of the mathematical integers. A processor must provide one or more **representation methods** that define sets of values for data of type integer. Each such method is characterized by a value for a type parameter called the **kind** type parameter. The kind type parameter of a representation method is returned by the intrinsic inquiry function KIND (13.13.51). The smallest kind value that provides a given range is returned by the intrinsic function SELECTED_INT_KIND (13.13.92). The decimal exponent range of a representation method is returned by the intrinsic function RANGE (13.13.85).

If two representation methods have kind type parameters k_1 and k_2 with $k_1 < k_2$, the decimal exponent range of the first is less than or equal to the decimal exponent range of the second.

The type specifier (R502) for the integer type is the keyword INTEGER.

If the kind type parameter is not specified, the default kind value is KIND (0) and the data entity is of type **default integer**.

Any integer value may be represented as a *signed-int-literal-constant*.

R401 *signed-digit-string* is [*sign*] *digit-string*

R402 *digit-string* is *digit* [*digit*] ...

R403 *signed-int-literal-constant* is [*sign*] *int-literal-constant*

R404 *int-literal-constant* is *digit-string* [_ *kind-param*]

R405 *kind-param* is *digit-string*
or *scalar-int-constant-name*

R406 *sign* is +
or –

Constraint: The value of *kind-param* must be nonnegative.

Constraint: The value of *kind-param* must specify a representation method that exists on the processor.

The optional kind type parameter following *digit-string* specifies the kind type parameter of the integer constant; if it is not present, the constant is of type default integer.

Examples of unsigned and signed integer literal constants are:

```
473
+56
-101
21_2
21_SHORT
1976354279568241_8
```

where SHORT is a scalar nonnegative integer named constant whose value must be a valid kind type parameter value for the integer type.

An integer constant is interpreted as a decimal value.

In a DATA statement (5.2.9), an unsigned binary, octal, or hexadecimal literal constant must correspond to an integer scalar entity.

R407 *boz-literal-constant* is *binary-constant*
or *octal-constant*
or *hex-constant*

Constraint: A *boz-literal-constant* may appear only in a DATA statement.

R408 *binary-constant* is B ' *digit* [*digit*] ... '
or B " *digit* [*digit*] ... "

Constraint: *digit* must have one of the values 0 or 1.

R409 *octal-constant* is O ' *digit* [*digit*] ... '
or O " *digit* [*digit*] ... "

Constraint: *digit* must have one of the values 0 through 7.

R410 *hex-constant* is Z ' *hex-digit* [*hex-digit*] ... '
or Z " *hex-digit* [*hex-digit*] ... "

R411 *hex-digit* is digit
or A
or B
or C
or D
or E

or F

In these constants, the binary, octal, and hexadecimal digits are interpreted according to their respective number systems.

4.3.1.2 Real Type. The real type has values that approximate the mathematical real numbers. A processor must provide two or more **approximation methods** that define sets of values for data of type real. Each such method has a **representation method** and is characterized by a value for a type parameter called the **kind** type parameter. The kind type parameter of an approximation method is returned by the intrinsic inquiry function KIND (13.13.51). The smallest kind value that provides a given precision and a given exponent range is returned by the intrinsic function SELECTED_REAL_KIND (13.13.93). The decimal precision and decimal exponent range of an approximation method are returned by the intrinsic functions PRECISION (13.13.79) and RANGE (13.13.85).

If two approximation methods have kind type parameters k_1 and k_2 with $k_1 < k_2$, the decimal precision of the first is less than or equal to the decimal precision of the second.

The type specifier for the real type is the keyword REAL and the type specifier for the double precision real type is the keyword DOUBLE PRECISION.

If the type keyword REAL is specified and the kind type parameter is not specified, the default kind value is KIND (0.0) and the data entity is of type **default real**. If the type keyword DOUBLE PRECISION is specified, a kind type parameter must not be specified and the data entity is of type **double precision real**. The kind type parameter of such an entity has the value KIND (0.0D0). The decimal precision of the double precision approximation method must be greater than that of the default real method.

R412 *signed-real-literal-constant* **is** [*sign*] *real-literal-constant*

R413 *real-literal-constant* **is** *significand* [*exponent-letter exponent*] [_ *kind-param*]
or *digit-string exponent-letter exponent* [_ *kind-param*]

R414 *significand* **is** *digit-string* . [*digit-string*]
or . *digit-string*

R415 *exponent-letter* **is** E
or D

R416 *exponent* **is** *signed-digit-string*

Constraint: If both *kind-param* and *exponent-letter* are present, *exponent-letter* must be E.

Constraint: The value of *kind-param* must specify an approximation method that exists on the processor.

A real literal constant without a kind type parameter is a default real constant if it is without an exponent part or has exponent letter E, and is a double precision real constant if it has exponent letter D. A real literal constant written with a kind type parameter is a real constant with the specified kind type parameter.

The exponent represents the power of ten scaling to be applied to the significand or digit string. The meaning of these constants is as in decimal scientific notation.

The significand may be written with more digits than a processor will use to approximate the value of the constant.

Examples of signed real literal constants are:

```
-12.78
+1.6E3
2.1
-16.E4_8
```

```
0.45E-4
10.93E7_QUAD
.123
3E4
```

In 10.93E7_QUAD, the named integer constant QUAD must have been defined and its value must be a kind type parameter value for the real type.

4.3.1.3 Complex Type. The **complex type** has values that approximate the mathematical complex numbers. The values of a complex type are ordered pairs of real values. The first real value is called the **real part**, and the second real value is called the **imaginary part**.

Each approximation method used to represent data entities of type real is available for both the real and imaginary parts of a data entity of type complex. A **kind** type parameter may be specified for a complex entity and selects for both parts the real approximation method characterized by this kind type parameter value.

If a kind type parameter is not specified, the type of both parts is default real and the complex data entity is **default complex**.

The type specifier for the complex type is the keyword COMPLEX. There is no keyword for double precision complex.

R417 *complex-literal-constant* is (*real-part* , *imag-part*)

R418 *real-part* is *signed-int-literal-constant*
or *signed-real-literal-constant*

R419 *imag-part* is *signed-int-literal-constant*
or *signed-real-literal-constant*

If the real part and imaginary part of a complex literal constant are both real but do not have the same kind type parameter values, the part with the lesser parameter value is converted to the approximation method of the other part. The kind type parameter value of the complex literal constant is the parameter value of the part with the greater parameter value.

If both the real and imaginary parts are signed integer literal constants, they are converted to the default real approximation method and the constant is of type default complex. If only one of the parts is a signed integer literal constant, the signed integer literal constant is converted to the approximation method selected for the signed real literal constant and the kind type parameter value of the complex literal constant is that of the signed real literal constant.

Examples of complex literal constants are:

```
(1.0, -1.0)
(3, 3.1E6)
(4.0_4, 3.6E7_8)
```

4.3.2 Nonnumeric Types. The **nonnumeric types** are provided for nonnumeric processing. The intrinsic operations defined for each of these types are given below.

4.3.2.1 Character Type. The **character type** has a set of values composed of character strings. A **character string** is a sequence of characters, numbered from left to right 1, 2, 3, ... up to the number of characters in the string. The number of characters in the string is called the **length** of the string. The length is a type parameter; its value is greater than or equal to zero. Strings of different lengths are all of type character.

A processor must provide one or more **representation methods** that define sets of values for data of type character. Each such method is characterized by a value for a type parameter called the **kind** type parameter. The kind type parameter of a representation method is returned by the intrinsic inquiry function KIND (13.13.51). Any character of a particular representation method representable in the processor may occur in a character string of that representation method.

If the kind type parameter is not specified, the default kind value is KIND ('A') and the data entity is of type **default character**.

The type specifier for the character type is the keyword CHARACTER.

A **character literal constant** is written as a sequence of characters, delimited by either apostrophes or quotation marks.

R420 *char-literal-constant* **is** [*kind-param* _] ' [*rep-char*] ... '
or [*kind-param* _] " [*rep-char*] ... "

Constraint: The value of *kind-param* must specify a representation method that exists on the processor.

The optional kind type parameter preceding the leading delimiter specifies the kind type parameter of the character constant; if it is not present, the constant is of type default character.

For the type character with kind *kind-param*, if present, and for type default character otherwise, a **representable character**, *rep-char*, is:

(1) Any character in the processor-dependent character set in fixed form source. A processor may restrict the occurrence of some or all of the control characters.

(2) Any graphic character in the processor-dependent set in free source form.

The delimiting apostrophes or quotation marks are not part of the value of the character literal constant.

An apostrophe character within a character constant delimited by apostrophes is represented by two consecutive apostrophes (without intervening blanks); in this case, the two apostrophes are counted as one character. Similarly, a quotation mark character within a character constant delimited by quotation marks is represented by two consecutive quotation marks and the two quotation marks are counted as one character.

A zero-length character literal constant is represented by two consecutive apostrophes (without intervening blanks) or two consecutive quotation marks (without intervening blanks) outside of a character context.

The intrinsic operation **concatenation** (//) is defined between two data entities of type character (7.2.2) with the same kind type parameter.

Examples of character literal constants are:

```
"DON'T"
'DON''T'
```

both of which have the value DON'T and

```
''
```

which has the zero-length character string as its value.

4.3.2.1.1 Collating Sequence. Each implementation defines a collating sequence for the character set of each kind of character. A **collating sequence** is a one-to-one mapping of the characters into the nonnegative integers such that each character corresponds to a different nonnegative integer. The intrinsic functions CHAR and ICHAR (see Section 13) provide conversions between the characters and the integers according to this mapping. Thus,

ICHAR (*'character'*)

returns the integer value of the specified character according to the collating sequence of the processor.

For the default character type, the only constraints on the collating sequence are:

(1) ICHAR ('A') < ICHAR ('B') < ··· < ICHAR ('Z') for the twenty-six letters.

(2) ICHAR ('0') < ICHAR ('1') < ··· < ICHAR ('9') for the ten digits.

(3) ICHAR (' ') < ICHAR ('0') < ICHAR ('9') < ICHAR ('A') or
ICHAR (' ') < ICHAR ('A') < ICHAR ('Z') < ICHAR ('0').

(4) ICHAR ('a') < ICHAR ('b') < ··· < ICHAR ('z'), if the processor supports lower-case letters.

(5) ICHAR (' ') < ICHAR ('0') < ICHAR ('9') < ICHAR ('a') or
ICHAR (' ') < ICHAR ('a') < ICHAR ('z') < ICHAR ('0'), if the processor supports lower-case letters.

Except for blank, there are no constraints on the location of the special characters and underscore in the collating sequence, nor is there any specified collating sequence relationship between the upper-case and lower-case letters.

ANSI X3.4-1986 (ASCII) assigns numerical codes to a set of characters that includes the letters, digits, underscore, and special characters; the ordered sequence of such codes is called in this standard the **ASCII collating sequence**. The intrinsic functions ACHAR and IACHAR provide conversions between these characters and the integers of the ASCII collating sequence. The intrinsic functions LGT, LGE, LLE, and LLT provide comparisons between strings based on the ASCII collating sequence. Note that X3.4-1986 is the US national version of ISO 646:1977. International portability is guaranteed if the set of characters used is limited to the letters, digits, underscore, and special characters.

4.3.2.2 Logical Type. The **logical type** has two values which represent true and false.

A processor must provide one or more **representation methods** for data of type logical. Each such method is characterized by a value for a type parameter called the **kind** type parameter. The kind type parameter of a representation method is returned by the intrinsic inquiry function KIND (13.13.51).

If the kind type parameter is not specified, the default kind value is KIND (.FALSE.) and the data entity is of type **default logical**.

R421 *logical-literal-constant* is .TRUE. [_ *kind-param*]
or .FALSE. [_ *kind-param*]

Constraint: The value of *kind-param* must specify a representation method that exists on the processor.

The optional kind type parameter following the trailing delimiter specifies the kind type parameter of the logical constant; if it is not present, the constant is of type default logical.

The intrinsic operations defined for data entities of logical type are: negation (.NOT.), conjunction (.AND.), inclusive disjunction (.OR.), logical equivalence (.EQV.), and logical nonequivalence (.NEQV.) as described in 7.2.4. There is also a set of intrinsically defined relational operators that compare the values of data entities of other types and yield a default logical value. These operations are described in 7.2.3.

The type specifier for the logical type is the keyword LOGICAL.

4.4 Derived Types.

Additional data types may be derived from the intrinsic data types. A type definition is required to define the name of the type and the names and types of its components. Ultimately, a derived type is resolved into components that are either of intrinsic type or are pointers.

By default, derived types defined in the specification part of a module are accessible (5.1.2.2, 5.2.3) in any scoping unit that accesses the module. This default may be changed to restrict the accessibility of such types to the host module itself. A particular type definition may be declared to be public or private regardless of the default accessibility declared for the module. In addition, a type may be accessible while its components are private.

By default, no storage sequence is implied by the order of the component definitions. However, if the definition of a derived type contains a SEQUENCE statement, the type is a **sequence type**. The order of the component definitions in a sequence type specifies a storage sequence for objects of that type.

The type specifier for derived types is the keyword TYPE followed by the name of the type in parentheses (R502).

4.4.1 Derived-Type Definition.

R422 *derived-type-def* is *derived-type-stmt*
[*private-sequence-stmt*] ...
component-def-stmt
[*component-def-stmt*] ...
end-type-stmt

R423 *private-sequence-stmt* is PRIVATE
or SEQUENCE

R424 *derived-type-stmt* is TYPE [, *access-spec* ::] *type-name*

Constraint: The same *private-sequence-stmt* must not appear more than once in a given *derived-type-def*.

Constraint: If SEQUENCE is present, all derived types specified in component definitions must be sequence types.

Constraint: An *access-spec* (5.1.2.2) or a PRIVATE statement within the definition is permitted only if the type definition is within the specification part of a module.

Constraint: If a component of a derived type is of a type declared to be private, either all components of the derived type must be private or the derived type must be private.

Constraint: A derived type *type-name* must not be the same as the name of any intrinsic type nor the same as any other accessible derived *type-name*.

R425 *end-type-stmt* is END TYPE [*type-name*]

Constraint: If END TYPE is followed by a *type-name*, the *type-name* must be the same as that in the corresponding *derived-type-stmt*.

R426 *component-def-stmt* is *type-spec* [[, *component-attr-spec-list*] ::]
component-decl-list

R427 *component-attr-spec* is POINTER
or DIMENSION (*component-array-spec*)

Constraint: No *component-attr-spec* may appear more than once in a given *component-def-stmt*.

Constraint: If the POINTER attribute is not specified for a component, a *type-spec* in the *component-def-stmt* must specify an intrinsic type or a previously defined derived type.

Constraint: If the POINTER attribute is specified for a component, a *type-spec* in the *component-def-stmt* must specify an intrinsic type or any accessible derived type including the type being defined.

R428 *component-array-spec* is *explicit-shape-spec-list*
or *deferred-shape-spec-list*

R429 *component-decl* is *component-name* [(*component-array-spec*)]
[* *char-length*]

Constraint: If the POINTER attribute is not specified, each *component-array-spec* must be an *explicit-shape-spec-list*.

Constraint: If the POINTER attribute is specified, each *component-array-spec* must be a *deferred-shape-spec-list*.

Constraint: The * *char-length* option is permitted only if the type specified is character.

Constraint: A *char-length* in a *component-decl* must be an integer constant expression.

Constraint: Each bound in the *explicit-shape-spec* (R428) must be an integer constant expression.

If the **SEQUENCE** statement is present, the type is a sequence type. If all of the ultimate components are of type default integer, default real, double precision real, default complex, or default logical and are not pointers, the type is a **numeric sequence type**. If all of the ultimate components are of type default character and are not pointers, the type is a **character sequence type.**

Note that the double colon separator in a *component-def-stmt* is required only if the DIMENSION attribute, the POINTER attribute, or both are specified; otherwise, it is optional.

A component is an array if its *component-decl* contains a *component-array-spec* (5.1.2.4) or its *component-def-stmt* contains the DIMENSION attribute. If the *component-decl* contains a *component-array-spec*, it specifies the array bounds; otherwise, the *component-array-spec* in the DIMENSION attribute specifies the array bounds.

The accessibility of a derived type may be declared explicitly by an *access-spec* in its *derived-type-stmt* or in an *access-stmt*. The accessibility is the default (5.2.3) if it is not declared explicitly. If a type definition is PRIVATE, then the type name, the structure value constructor (4.4.4) for the type, any entity that is of the type, and any procedure that has a dummy argument or function result that is of the type are accessible only within the module containing the definition.

If a type definition contains a PRIVATE statement, the component names for the type are accessible only within the module containing the definition, even if the type itself is public (5.1.2.2). The component names and hence the internal structure of the type are inaccessible in any scoping unit accessing the module via a USE statement. Similarly, the structure constructor for such a type may be employed only within the defining module.

An example of a derived-type definition is:

```
TYPE PERSON
   INTEGER AGE
   CHARACTER (LEN = 50) NAME
END TYPE PERSON
```

An example of declaring a variable CHAIRMAN of type PERSON is:

```
TYPE (PERSON) :: CHAIRMAN
```

A type definition may have a component that is an array. For example:

```
TYPE LINE
   REAL, DIMENSION (2, 2) :: COORD     ! X1, Y1, X2, Y2
   REAL                   :: WIDTH     ! Line width in centimeters
   INTEGER                :: PATTERN   ! 1 for solid, 2 for dash, 3 for dot
END TYPE LINE
```

An example of declaring a variable LINE_SEGMENT to be of the type LINE is:

```
TYPE (LINE)          :: LINE_SEGMENT
```

The scalar variable LINE_SEGMENT has a component that is an array. In this case, the array is a subobject of a scalar. Note that the double colon in the definition for COORD is required; the double colon in the definition for WIDTH and PATTERN is optional.

An example of a type with private components is:

```
TYPE POINT
   PRIVATE
   REAL :: X, Y
END TYPE POINT
```

Such a type definition is accessible in any scoping unit accessing the module via a USE statement; however, the components, X and Y, are accessible only within the module containing the definition.

A derived-type definition may have a component that is of a derived type. For example:

```
TYPE TRIANGLE
   TYPE (POINT) :: A, B, C
END TYPE TRIANGLE
```

An example of declaring a variable T to be of type TRIANGLE is:

```
TYPE (TRIANGLE) :: T
```

An example of a private type is:

```
TYPE, PRIVATE :: AUXILIARY
   LOGICAL :: DIAGNOSTIC
   CHARACTER (LEN = 20) :: MESSAGE
END TYPE AUXILIARY
```

Such a type would be accessible only within the module in which it is defined.

An example of a numeric sequence type is:

```
TYPE NUMERIC_SEQ
   SEQUENCE
   INTEGER :: INT_VAL
   REAL    :: REAL_VAL
   LOGICAL :: LOG_VAL
END TYPE NUMERIC_SEQ
```

A derived type may have a component that is a pointer. For example:

```
TYPE REFERENCE
   INTEGER                              :: VOLUME, YEAR, PAGE
   CHARACTER (LEN = 50)                 :: TITLE
   CHARACTER, DIMENSION (:), POINTER :: ABSTRACT
END TYPE REFERENCE
```

Any object of type REFERENCE will have the four components VOLUME, YEAR, PAGE, and TITLE, plus a pointer to an array of characters holding ABSTRACT. The size of this target array will be determined by the length of the abstract. The space for the target may be allocated (6.3.1) or the pointer component may be associated with a target in a pointer assignment statement (7.5.2).

A pointer component of a derived type may have as its target an object of the type of which it is a component. For example:

```
TYPE NODE
   INTEGER                 :: VALUE
   TYPE (NODE), POINTER    :: NEXT_NODE
END TYPE
```

A type such as this may be used to construct linked lists of objects of type NODE.

4.4.2 Determination of Derived Types. A particular type name may be defined at most once in a scoping unit. Derived-type definitions with the same type name may appear in different scoping units, in which case they may be independent and describe different derived types or they may describe the same type.

Two data entities have the same type if they are declared with reference to the same derived-type definition. The definition may be accessed from a module or from a host scoping unit. Data entities in different scoping units also have the same type if they are declared with reference to different derived-type definitions that have the same name, have the SEQUENCE property, and have structure components that do not have PRIVATE accessibility and agree in order, name, and attributes. Otherwise, they are of different derived types. A data entity declared using a type with the SEQUENCE property is not of the same type as an entity of a type declared to be PRIVATE or which has components that are PRIVATE.

An example of declaring two entities with reference to the same derived-type definition is:

```
TYPE POINT
   REAL  X,  Y
END TYPE POINT
TYPE (POINT) :: X1
CALL SUB (X1)
   . . .
CONTAINS
   SUBROUTINE SUB (A)
      TYPE (POINT) :: A
         . . .
   END SUBROUTINE SUB
```

The definition of derived type POINT is known in subroutine SUB because the scoping unit of SUB is contained within the scoping unit of the containing program unit (host association). Because the declarations of X1 and A both reference the same derived-type definition, X1 and A have the same type. X1 and A also would have the same type if the derived-type definition was in a module and both SUB and its containing program unit accessed the module.

An example of data entities in different scoping units having the same type is:

```
PROGRAM PGM
   TYPE EMPLOYEE
      SEQUENCE
      INTEGER         ID_NUMBER
      CHARACTER (50) NAME
   END TYPE EMPLOYEE
   TYPE (EMPLOYEE) PROGRAMMER
   CALL SUB (PROGRAMMER)
      . . .
END PROGRAM PGM

SUBROUTINE SUB (POSITION)
   TYPE EMPLOYEE
      SEQUENCE
      INTEGER         ID_NUMBER
      CHARACTER (50) NAME
   END TYPE
   TYPE (EMPLOYEE) POSITION
   . . .
END SUBROUTINE SUB
```

The actual argument PROGRAMMER and the dummy argument POSITION have the same type because they are declared with reference to a derived-type definition with the same name, the SEQUENCE property, and components that agree in order, name, shape, type, and type parameters.

Suppose the component name ID_NUMBER was ID_NUM in the subroutine. Because all the component names are not identical to the component names in derived type EMPLOYEE in the containing program unit, the actual argument PROGRAMMER would not be of the same type as the dummy argument POSITION. Thus, the program would not be standard conforming.

4.4.3 Derived-Type Values. The set of values of a specific derived type consists of all possible sequences of component values consistent with the definition of that derived type.

4.4.4 Construction of Derived-Type Values. A derived-type definition implicitly defines a corresponding **structure constructor** that allows a scalar value of derived type to be constructed from a sequence of values, one value for each component of the derived type.

R430 *structure-constructor* is *type-name* (*expr-list*)

The sequence of expressions in a structure constructor specifies component values that must agree in number, order, and rank with the components of the derived type. If necessary, each value is converted according to the rules of intrinsic assignment (7.5.1.4) to a value that agrees in type and type parameters with the corresponding component of the derived type. The shape of the expression must agree with the shape of the component. A structure constructor whose component values are all constant expressions is a derived-type constant expression. A structure constructor must not appear before the referenced type is defined.

This example illustrates a derived-type constant expression using a derived type defined in 4.4.1:

```
PERSON (21, 'JOHN SMITH')
```

A derived-type definition may have a component that is an array. Also, an object may be an array of derived type. Such arrays may be constructed using an array constructor (4.5).

Where a component in the derived type is a pointer, the corresponding constructor expressions must evaluate to an object that would be an allowable target for such a pointer in a pointer assignment statement. For example, if the variable TEXT were declared (5.1) to be

```
CHARACTER, DIMENSION (1:400), TARGET :: TEXT
```

and BIBLIO were declared using the derived-type definition REFERENCE in 4.4.1

```
TYPE (REFERENCE) :: BIBLIO
```

the statement

```
BIBLIO = REFERENCE (1, 1987, 1, "This is the title of the referenced &
                                &paper", TEXT)
```

is valid and it identifies the ABSTRACT component of the object BIBLIO with the target object TEXT.

Note that a constant expression must not be constructed for a derived type containing a pointer component because a constant value is not an allowable target in a pointer assignment statement.

4.4.5 Derived-Type Operations and Assignment. Any operations on derived-type entities and nonintrinsic assignment for derived-type entities must be defined explicitly by functions or subroutines with explicit interfaces (12.3.2.1). Arguments and function values may be of any derived or intrinsic type.

4.5 Construction of Array Values. An **array constructor** is defined as a sequence of specified scalar values and is interpreted as a rank-one array whose element values are those specified in the sequence.

R431 *array-constructor* is (/ *ac-value-list* /)

R432 *ac-value* is *expr*
or *ac-implied-do*

R433 *ac-implied-do* is (*ac-value-list* , *ac-implied-do-control*)

R434 *ac-implied-do-control* is *ac-do-variable* = *scalar-int-expr* , *scalar-int-expr* [, *scalar-int-expr*]

R435 *ac-do-variable* is *scalar-int-variable*

Constraint: *ac-do-variable* must be a named variable.

Constraint: Each *ac-value* in the sequence must have the same type and type parameters.

If an *ac-value* is a scalar expression, its value specifies an element of the array constructor. If an *ac-value* is an array expression, the values of the elements of the expression, in array element order (6.2.2.2), specify the corresponding sequence of elements of the array constructor. If an *ac-value* is an *ac-implied-do*, it is expanded to form a sequence of expressions, under the control of the *ac-do-variable*, as in the DO construct (8.1.4.4).

For an *ac-implied-do*, the loop initialization and execution is the same as for a DO construct. The *ac-do-variable* of an *ac-implied-do* that is contained within another *ac-implied-do* must not appear as the *ac-do-variable* of the containing *ac-implied-do*.

An empty sequence forms a zero-sized rank-one array.

The type and type parameters of an array constructor are those of the *ac-values*.

If every expression in an array constructor is a constant expression, the array constructor is a constant expression. An example is:

```
REAL X (3)
X = (/ 3.2, 4.01, 6.5 /)
```

A one-dimensional array may be reshaped into any allowable array shape using the RESHAPE intrinsic function (13.13.88). An example is:

```
Y = RESHAPE (SOURCE = (/ 2.0, (/ 4.5, 4.5 /), X /), SHAPE = (/ 3, 2 /))
```

This results in Y having the 3×2 array of values:

```
2.0  3.2
4.5  4.01
4.5  6.5
```

Examples of array constructors containing an implied do are:

```
(/ (I, I = 1, 1075) /)
```

and

```
(/ 3.6, (3.6 / I, I = 1, N) /)
```

Using the type definitions for PERSON and LINE of 4.4.1, an example of the construction of a derived-type array value is:

```
(/ PERSON (20, 'SMITH'), PERSON (20, 'JONES') /)
```

and an example of the construction of a derived-type scalar value with an array component is:

```
LINE (RESHAPE ((/ 0.0, 1.0, 0.0, 2.0 /)), (/ 2, 2 /), 0.1, 1)
```

In the latter example, the RESHAPE intrinsic function is used to construct a value that represents a solid line from (0,0) to (1,2) of width 0.1 centimeters.

5. DATA OBJECT DECLARATIONS AND SPECIFICATIONS

Every data object has a number of properties (including a type, rank, and shape) that determine the characteristics of the data and the uses of the objects. Collectively, these properties are termed the **attributes** of the data object. A named data object must not be specified explicitly to have a particular attribute more than once in a scoping unit. The type of a named data object is either determined implicitly by the first letter of its name (5.3) or is specified explicitly in a **type declaration statement**. Additional attributes also may be specified by separate specification statements; all of them may be included in a type declaration statement.

For example:

```
INTEGER  INCOME, EXPENDITURE
```

declares the two data objects named INCOME and EXPENDITURE to have the type integer.

```
REAL, DIMENSION (-5:+5) :: X, Y, Z
```

declares three data objects with names X, Y, and Z. These all have default real type and are explicit-shape rank-one arrays with a lower bound of –5, an upper bound of +5, and therefore a size of 11.

5.1 Type Declaration Statements.

R501 *type-declaration-stmt* is *type-spec* [[, *attr-spec*] ... ::] *entity-decl-list*

R502 *type-spec*
- is INTEGER [*kind-selector*]
- or REAL [*kind-selector*]
- or DOUBLE PRECISION
- or COMPLEX [*kind-selector*]
- or CHARACTER [*char-selector*]
- or LOGICAL [*kind-selector*]
- or TYPE (*type-name*)

R503 *attr-spec*
- is PARAMETER
- or *access-spec*
- or ALLOCATABLE
- or DIMENSION (*array-spec*)
- or EXTERNAL
- or INTENT (*intent-spec*)
- or INTRINSIC
- or OPTIONAL
- or POINTER
- or SAVE
- or TARGET

R504 *entity-decl*
- is *object-name* [(*array-spec*)] ■ [∗ *char-length*] [= *initialization-expr*]
- or *function-name* [(*array-spec*)] [∗ *char-length*]

R505 *kind-selector* is ([KIND =] *scalar-int-initialization-expr*)

Constraint: The same *attr-spec* must not appear more than once in a given *type-declaration-stmt*.

Constraint: The *function-name* must be the name of an external function, an intrinsic function, a function dummy procedure, or a statement function.

Constraint: The = *initialization-expr* must appear if the statement contains a PARAMETER attribute (5.1.2.1).

Constraint: If = *initialization-expr* appears, a double colon separator must appear before the *entity-decl-list*.

Constraint: The = *initialization-expr* must not appear if *object-name* is a dummy argument, a function result, an object in a named common block unless the type declaration is in a block data program unit, an object in blank common, an allocatable object, a pointer,

an external name, an intrinsic name, or an automatic object.

Constraint: The * *char-length* option is permitted only if the type specified is character.

Constraint: The ALLOCATABLE attribute may be used only when declaring an array that is not a dummy argument or a function result.

Constraint: An array declared with a POINTER or an ALLOCATABLE attribute must be specified with an *array-spec* that is a *deferred-shape-spec-list* (5.1.2.4.3).

Constraint: The *array-spec* for a *function-name* that does not have the pointer attribute must be an *explicit-shape-spec-list*.

Constraint: The *array-spec* for a *function-name* that does have the pointer attribute must be a *deferred-shape-spec-list*.

Constraint: An object must not have both the TARGET attribute and the PARAMETER attribute.

Constraint: If the POINTER attribute is specified, the INTENT, EXTERNAL, and INTRINSIC attributes must not be specified.

Constraint: If the TARGET attribute is specified, The EXTERNAL and INTRINSIC attributes must not be specified.

Constraint: The PARAMETER attribute must not be specified for dummy arguments, pointers, functions, or objects in a common block.

Constraint: The INTENT and OPTIONAL attributes may be specified only for dummy arguments.

Constraint: An entity must not have the PUBLIC attribute if its type has the PRIVATE attribute.

Constraint: The SAVE attribute must not be specified for an object that is in a common block, a dummy argument, a procedure, a function result, or an automatic data object.

Constraint: An entity must not have the EXTERNAL attribute if it has the INTRINSIC attribute.

Constraint: An entity in a *type-declaration-stmt* must not have the EXTERNAL or INTRINSIC attribute specified unless it is a function.

Constraint: An array must not have both the ALLOCATABLE attribute and the POINTER attribute.

Constraint: An entity must not be given explicitly any attribute more than once in a scoping unit.

Constraint: The value specified in a *kind-selector* must be nonnegative.

Note that the double colon separator in a *type-declaration-stmt* is required only if an *attr-spec* or = *initialization-expr* is specified; otherwise, the separator is optional.

A name that identifies a specific intrinsic function in a scoping unit has a type as specified in 13.12. An explicit type declaration statement is not required; however, it is permitted. If a generic intrinsic function name appears in a type declaration statement, such an appearance is not sufficient by itself to remove the generic properties from that function.

The *specification-expr* (7.1.6.2) of a *type-param-value* (5.1.1.5) or an *array-spec* (5.1.2.4) may be a nonconstant expression provided the specification expression is in an interface body (12.3.2.1) or in the specification part of a subprogram. If the data object being declared depends on the value of such a nonconstant expression and is not a dummy argument, such an object is called an **automatic data object**. An automatic object must not appear in a SAVE or DATA statement nor be declared with a SAVE attribute nor be initially defined by an = *initialization-expr*.

If a *length-selector* is a nonconstant expression, the length is declared at the entry of the procedure and is not affected by any redefinition or undefinition of the variables in the specification expression during execution of the procedure.

If an *entity-decl* contains an = *initialization-expr* and the *object-name* does not have the PARAMETER attribute, *object-name* is a variable whose value is initially defined. The *object-name* becomes

defined with the value determined from *initialization-expr* in accordance with the rules of intrinsic assignment (7.5.1.4). A variable, or part of a variable, must not be initialized more than once in an executable program.

The presence of = *initialization-expr* implies that *object-name* is saved, except for an *object-name* in a named common block. The implied SAVE attribute may be reaffirmed by explicit use of the SAVE attribute in the type declaration statement, or by inclusion of the object name in a SAVE statement (5.2.4).

An **assumed type parameter** is a type parameter of a dummy argument that is specified with an asterisk *type-param-value* (R509).

Examples of type declaration statements are:

```
REAL A (10)
LOGICAL, DIMENSION (5, 5) :: MASK1, MASK2
COMPLEX :: CUBE_ROOT = (-0.5, 0.866)

INTEGER, PARAMETER :: SHORT = SELECTED_INT_KIND (4)
REAL (KIND (0.0D0)) A
REAL (KIND = 2) B
COMPLEX (KIND = KIND (0.0D0)) :: C
INTEGER (SHORT) K      !  Range at least -9999 to 9999.
TYPE (PERSON) :: CHAIRMAN
```

5.1.1 Type Specifiers. A **type specifier** specifies the type of all entities declared in an entity declaration list. This type may override or confirm the implicit type indicated by the first letter of the entity name as declared by the implicit typing rules in effect (5.3).

5.1.1.1 INTEGER. The INTEGER type specifier specifies that all entities whose names are declared in this statement are of intrinsic type integer (4.3.1.1). The kind selector, if present, specifies the integer representation method. If the kind selector is absent, the kind type parameter is KIND (0) and the entities declared are of type default integer. An object declared with a type specifier INTEGER (KIND (0)) is of the same type as one declared with the type specifier INTEGER.

5.1.1.2 REAL. The REAL type specifier specifies that all entities whose names are declared in this statement are of intrinsic type real (4.3.1.2). The kind selector, if present, specifies the real approximation method. If the kind selector is absent, the kind type parameter is KIND (0.0) and the entities declared are of type default real. An object declared with a type specifier REAL (KIND (0.0)) is of the same type as one declared with the type specifier REAL.

5.1.1.3 DOUBLE PRECISION. The DOUBLE PRECISION type specifier specifies that entities whose names are declared in this statement are of intrinsic type double precision real (4.3.1.2). The kind parameter value is KIND (0.0D0). An object declared with a type specifier REAL (KIND (0.0D0)) is of the same type as one declared with the type specifier DOUBLE PRECISION.

5.1.1.4 COMPLEX. The COMPLEX type specifier specifies that all entities whose names are declared in this statement are of intrinsic type complex (4.3.1.3). The kind selector, if present, specifies the real approximation method of the two real values making up the real and imaginary parts of the complex value. If the kind selector is absent, the kind type parameter is KIND (0.0) and the entities declared are of type default complex. An object declared with a type specifier COMPLEX (KIND (0.0)) is of the same type as one declared with the type specifier COMPLEX.

5.1.1.5 CHARACTER. The CHARACTER type specifier specifies that all objects whose names are declared in this statement are of intrinsic type character (4.3.2.1).

The length selector specifies the length of the character objects. The **char-length* may be part of an *entity-decl*, in which case the length is specified for this single entity and overrides the length specified in the length selector. If neither a length selector nor a **char-length* is specified, the length of

the data entity is 1.

R506 *char-selector* is *length-selector*
or ([LEN=] *type-param-value* , ■
■ [KIND=] *scalar-int-initialization-expr*)
or (KIND= *scalar-int-initialization-expr* ■
■ [, LEN= *type-param-value*])

R507 *length-selector* is ([LEN =] *type-param-value*)
or ∗ *char-length* [,]

R508 *char-length* is (*type-param-value*)
or *scalar-int-literal-constant*

Constraint: The optional comma in a *length-selector* is permitted only if no double colon separator appears in the *type-declaration-stmt*.

R509 *type-param-value* is *specification-expr*
or ∗

If the length type parameter value evaluates to a negative value, the length of character entities declared is zero. A length type parameter value of ∗ may be used only in the following ways:

(1) A length type parameter value of ∗ may be used to declare a dummy argument of a procedure, in which case the dummy argument assumes the length of the associated actual argument when the procedure is invoked.

(2) A length type parameter value of ∗ may be used to declare a named constant, in which case the length is that of the constant value.

(3) In an external function, the name of the function itself may be specified with a length type parameter value of ∗; in this case, any scoping unit invoking the function must declare this function name with a length type parameter value other than ∗ or access such a definition by host or use association. When the function is invoked, the length of the result variable in the function is assumed from the value of this type parameter.

The length specified for a character-valued statement function or statement function dummy argument of type character must be an integer constant expression.

The kind selector, if present, specifies the character representation method. If the kind selector is absent, the kind type parameter is KIND ('A') and the entities declared are of type default character.

Examples of character type declaration statements are:

```
CHARACTER (LEN = 10, KIND = 2)  A
CHARACTER *10  B, C *20
```

5.1.1.6 LOGICAL. The LOGICAL type specifier specifies that all entities whose names are declared in this statement are of intrinsic type logical (4.3.2.2).

The kind selector, if present, specifies the representation method. If the kind selector is absent, the kind type parameter is KIND (.FALSE.) and the entities declared are of type default logical.

5.1.1.7 Derived Type. A TYPE type specifier specifies that all entities whose names are declared in this statement are of the derived type specified by the *type-name*. The components of each such entity also are declared to be of the types specified by the corresponding *component-def* statements of the *derived-type-def* (4.4.1). When a data entity is specified to be of a derived type, the derived type must have been defined previously by a *derived-type-def*.

A scalar entity of derived type is a structure. If a derived type has the SEQUENCE property, a scalar entity of the type is a **sequence structure**. A scalar entity of numeric sequence type (4.4.1) is a **numeric sequence structure**. A scalar entity of character sequence type (4.4.1) is a **character sequence structure**.

A declaration for a nonsequence type dummy argument must specify a derived type that is defined in the procedure or a module because the same definition must be used to declare both the actual and dummy arguments to ensure that both are of the same derived type. This restriction does not apply to arguments of sequence type (4.4.2).

5.1.2 Attributes. The additional attributes that may appear in the attribute specification of a type declaration statement further specify the nature of the objects being declared or specify restrictions on their use in the program.

5.1.2.1 PARAMETER Attribute. The **PARAMETER attribute** specifies that objects whose names are declared in this statement are named constants. The *object-name* becomes defined with the value determined from the *initialization-expr* that appears on the right of the equals, in accordance with the rules of intrinsic assignment (7.5.1.4). The appearance of a PARAMETER attribute in a specification requires that the = *initialization-expr* option appear for all objects in the *entity-decl-list*.

Any named constant that appears in the initialization expression must have been defined previously in the same type declaration statement, defined in a prior PARAMETER statement or type declaration statement using the PARAMETER attribute, or made accessible by use association or host association. A named constant must not be referenced in any other context unless it has been defined in a prior PARAMETER statement or type declaration statement using the PARAMETER attribute, or made accessible by use association or host association.

A named constant must not appear within a format specification (10.1.1).

Examples of declarations with a PARAMETER attribute are:

```
REAL, PARAMETER :: ONE = 1.0, Y = 4.1 / 3.0
INTEGER, DIMENSION (3), PARAMETER :: ORDER = (/ 1, 2, 3 /)
```

5.1.2.2 Accessibility Attribute. The **accessibility attribute** specifies the accessibility of the entities in the *entity-decl-list* to other program units by a USE statement. This includes derived-type definitions in the module.

R510 *access-spec* is PUBLIC
or PRIVATE

Constraint: An *access-spec* attribute may appear only in the *specification-part* of a module.

Entities that are declared with a PRIVATE attribute are not accessible outside the module. Entities that are declared with a PUBLIC attribute may be made accessible in other program units by the USE statement. The default for entities without an explicitly specified *access-spec* is PUBLIC, but this may be changed by a PRIVATE statement (5.2.3).

An example of an accessibility specification is:

```
REAL, PRIVATE :: X, Y, Z
```

5.1.2.3 INTENT Attribute. An **INTENT attribute** specifies the intended use of the dummy argument.

R511 *intent-spec* is IN
or OUT
or INOUT

Constraint: The INTENT attribute may appear only in the *specification-part* of a subprogram or interface body (12.3.2.1).

Constraint: The INTENT attribute must not be specified for a dummy argument that is a dummy procedure or a dummy pointer.

The INTENT (IN) attribute specifies that the dummy argument must not be redefined or become undefined during the execution of the procedure.

The INTENT (OUT) attribute specifies that the dummy argument must be defined before a reference to the dummy argument is made within the procedure and any actual argument that becomes associated with such a dummy argument must be definable. On invocation of the procedure, such a dummy argument becomes undefined.

The INTENT (INOUT) attribute specifies that the dummy argument is intended for use both to receive data from and to return data to the invoking scoping unit. Any actual argument that becomes associated with such a dummy argument must be definable.

If no INTENT attribute is specified for a dummy argument, its use is subject to the limitations of the associated actual argument (12.5.2.1, 12.5.2.2, 12.5.2.3).

An example of an INTENT specification is:

```
SUBROUTINE MOVE (FROM, TO)
   USE PERSON_MODULE
   TYPE (PERSON), INTENT (IN) :: FROM
   TYPE (PERSON), INTENT (OUT) :: TO
```

5.1.2.4 DIMENSION Attribute. The **DIMENSION attribute** specifies that entities whose names are declared in this statement are arrays. The rank or the rank and shape are specified by the *array-spec*, if there is one, in the *entity-decl*, or by the *array-spec* in the DIMENSION attribute otherwise. An *array-spec* in an *entity-decl* specifies either the rank or the rank and shape for a single array and overrides the *array-spec* in the DIMENSION attribute. If the DIMENSION attribute is omitted, an *array-spec* must be specified in the *entity-decl* to declare an array in this statement.

R512 *array-spec* is *explicit-shape-spec-list*
or *assumed-shape-spec-list*
or *deferred-shape-spec-list*
or *assumed-size-spec*

Constraint: The maximum rank is seven.

Examples of DIMENSION attribute specifications are:

```
SUBROUTINE EX (N, A, B, S)
   REAL, DIMENSION (N, 10) :: W          ! Explicit-shape array
   REAL A (:), B (0:)                    ! Assumed-shape arrays
   REAL, POINTER :: D (:, :)             ! Array pointer
   REAL, DIMENSION (:), POINTER :: P     ! Array pointer
   REAL, ALLOCATABLE, DIMENSION (:) :: E ! Allocatable array
   REAL :: S (N, *)                      ! Assumed-size array
```

5.1.2.4.1 Explicit-Shape Array. An **explicit-shape array** is a named array that is declared with an *explicit-shape-spec-list*. This specifies explicit values for the bounds in each dimension of the array.

R513 *explicit-shape-spec* is [*lower-bound* :] *upper-bound*

R514 *lower-bound* is *scalar-int-expr*

R515 *upper-bound* is *scalar-int-expr*

Constraint: An explicit-shape array whose bounds depend on the values of nonconstant expressions must be a dummy argument, a function result, or an automatic array of a procedure.

Constraint: The bounds in an explicit-shape array declaration must be specification expressions (7.1.6.2).

An **automatic array** is an explicit-shape array declared in a procedure subprogram that is not a dummy argument and has bounds that are nonconstant specification expressions.

If an explicit-shape array has bounds that are nonconstant specification expressions, the bounds, and hence shape, are determined at entry to the procedure by evaluating the bounds expressions.

The bounds of such an array are unaffected by any redefinition or undefinition of the specification expression variables during execution of the procedure.

The values of each *lower-bound* and *upper-bound* determine the bounds of the array along a particular dimension and hence the extent of the array in that dimension. The value of a lower bound or an upper bound may be positive, negative, or zero. The subscript range of the array in that dimension is the set of integer values between and including the lower and upper bounds, provided the upper bound is not less than the lower bound. If the upper bound is less than the lower bound, the range is empty, the extent in that dimension is zero, and the array is of zero size. If the *lower-bound* is omitted, the default value is 1. The number of sets of bounds specified is the rank.

5.1.2.4.2 Assumed-Shape Array. An **assumed-shape array** is a nonpointer dummy argument array that takes its shape from the associated actual argument array.

R516 *assumed-shape-spec* is [*lower-bound*] :

The rank is equal to the number of colons in the *assumed-shape-spec-list*.

The extent of a dimension of an assumed-shape array is the extent of the corresponding dimension of the associated actual argument array. If the lower bound value is d and the extent of the corresponding dimension of the associated actual argument array is s, then the value of the upper bound is $s+d-1$. The lower bound is *lower-bound*, if present, and 1 otherwise.

5.1.2.4.3 Deferred-Shape Array. A **deferred-shape array** is an array pointer or an allocatable array.

An **allocatable array** is a named array that has the ALLOCATABLE attribute and a specified rank. Its type, type parameters, name, and rank are specified in a type declaration statement containing an ALLOCATABLE attribute, but its bounds, and hence shape, are determined when space is allocated for the array by execution of an ALLOCATE statement (6.3.1).

The ALLOCATABLE attribute may be specified for an array in a type declaration statement or in an ALLOCATABLE statement (5.2.6). An array with the ALLOCATABLE attribute must be declared with a *deferred-shape-spec-list* in a type declaration statement, an ALLOCATABLE statement, or a DIMENSION statement (5.2.5). The type and type parameters may be specified in a type declaration statement.

An **array pointer** is a named array with the POINTER attribute and a specified rank. Its type, type parameters, and rank are specified in a type declaration statement or a component definition statement, but its bounds, and hence shape, are determined when it is associated with a target by pointer assignment (7.5.2) or by execution of an ALLOCATE statement (6.3.1). An array with the pointer attribute must be declared with a *deferred-shape-spec-list*.

R517 *deferred-shape-spec* is :

The rank is equal to the number of colons in the *deferred-shape-spec-list*.

The size, bounds, and shape of an unallocated allocatable array are undefined. No part of such an array may be defined, nor may any part of it be referenced except as an argument to an intrinsic inquiry function that is inquiring about the allocation status or a property of the type or type parameters. The lower and upper bounds of each dimension are those specified in the ALLOCATE statement when the array is allocated.

The size, bounds, and shape of the target of a disassociated array pointer are undefined. No part of such an array may be defined, nor may any part of it be referenced except as an argument to an intrinsic inquiry function that is inquiring about argument presence, a property of the type or type parameters, or association status. The bounds of each dimension of an array pointer may be specified in two ways:

(1) They are specified in an ALLOCATE statement (6.3.1) when the target is allocated, or

(2) They are specified in a pointer assignment statement. The lower bound of each dimension is the result of the LBOUND function (13.13.52) applied to the corresponding dimension of the target. The upper bound of each dimension is the result of the

UBOUND function (13.13.111) applied to the corresponding dimension of the target.

The bounds of the array target or allocatable array are unaffected by any subsequent redefinition or undefinition of variables involved in the bounds.

A pointer dummy argument may be associated only with a pointer actual argument. An actual argument that is a pointer may be associated with a nonpointer dummy argument.

A function result may be declared to have the pointer attribute.

5.1.2.4.4 Assumed-Size Array. An **assumed-size array** is a dummy argument array whose size is assumed from that of an associated actual argument. The rank and extents may differ for the actual and dummy arrays; only the size of the actual array is assumed by the dummy array.

R518 *assumed-size-spec* **is** [*explicit-shape-spec-list* ,] [*lower-bound* :] *

Constraint: The function name of an array-valued function must not be declared as an assumed-size array.

The size of an assumed-size array is determined as follows:

(1) If the actual argument associated with the assumed-size dummy array is an array of any type other than default character, the size is that of the actual array.

(2) If the actual argument associated with the assumed-size dummy array is an array element of any type other than default character with a subscript order value of r (6.2.2.2) in an array of size x, the size of the dummy array is $x-r+1$.

(3) If the actual argument is a default character array, default character array element, or a default character array element substring (6.1.1), and if it begins at character storage unit t of an array with c character storage units, the size of the dummy array is MAX (INT ((*c* – *t* + 1) / *e*), 0), where e is the length of an element in the dummy character array.

The rank equals one plus the number of *explicit-shape-specs*.

If an assumed-size array has rank $n>1$, the product of the extents of the first $n-1$ dimensions must be less than or equal to the size of the associated actual array.

An assumed-size array has no upper bound in its last dimension and therefore has no extent in its last dimension and no shape. An assumed-size array name must not be written as a whole array reference except as an actual argument in a procedure reference for which the shape is not required or in a reference to the intrinsic function LBOUND.

The bounds of the first $n-1$ dimensions are those specified by the *explicit-shape-spec-list*, if present, in the *assumed-size-spec*. The lower bound of the last dimension is *lower-bound*, if present, and 1 otherwise. An assumed-size array may be subscripted or sectioned (6.2.2.3). The upper bound must not be omitted from a subscript triplet in the last dimension.

If an assumed-size array has bounds that are nonconstant specification expressions, the bounds are declared at entry to the procedure. The bounds of such an array are unaffected by any redefinition or undefinition of the specification expression variables during execution of the procedure.

5.1.2.5 SAVE Attribute. The **SAVE attribute** specifies that the objects declared in a declaration containing this attribute retain their association status, allocation status, definition status, and value after execution of a RETURN or END statement in the scoping unit containing the declaration. Such an object is called a **saved object**.

Objects in the scoping unit of a module may be declared with a SAVE attribute. Such objects retain their association status, allocation status, definition status, and value when any procedure that accesses the module in a USE statement executes a RETURN or END statement.

The SAVE attribute must not be specified for an object that is in a common block, a dummy argument, a procedure, a function result, or an automatic data object.

The SAVE attribute may appear in declarations in a main program and has no effect.

5.1.2.6 OPTIONAL Attribute. The OPTIONAL attribute may be specified only in the scoping unit of a subprogram or an interface block, and may be specified only for dummy arguments. The OPTIONAL attribute specifies that the dummy argument need not be associated with an actual argument in a reference to the procedure (12.5.2.8). The PRESENT intrinsic function (13.13.80) may be used to determine whether an actual argument has been associated with a dummy argument having the OPTIONAL attribute.

5.1.2.7 POINTER Attribute. The POINTER attribute specifies that the object must not be referenced or defined unless, as a result of executing a pointer assignment (7.5.2) or an ALLOCATE statement (6.3.1), it becomes pointer associated with a target object that may be referenced or defined. If the pointer is an array, it must be declared with a *deferred-shape-spec-list*. An object with the POINTER attribute is not storage associated. Examples of POINTER attribute specifications are:

```
TYPE (NODE), POINTER :: CURRENT, TAIL
REAL, DIMENSION (:, :), POINTER :: IN, OUT, SWAP
```

5.1.2.8 TARGET Attribute. The TARGET attribute specifies that the object may have a pointer associated with it (7.5.2). Examples of TARGET attribute specifications are:

```
TYPE (NODE), TARGET :: HEAD
REAL, DIMENSION (1000, 1000), TARGET :: A, B
```

5.1.2.9 ALLOCATABLE Attribute. The ALLOCATABLE attribute specifies that objects declared in the statement are allocatable arrays. Such arrays must be deferred-shape arrays whose shape is determined when space is allocated for each array by the execution of an ALLOCATE statement (6.3.1).

5.1.2.10 EXTERNAL Attribute. The EXTERNAL attribute specifies that an object name in a declaration containing this attribute is an external function or a dummy function and permits the name to be used as an actual argument. This attribute also may be declared via the EXTERNAL statement (12.3.2.2).

5.1.2.11 INTRINSIC Attribute. The INTRINSIC attribute specifies that an object name in a declaration containing this attribute must be the specific or generic name of an intrinsic function and permits the name to be used as an actual argument if it is a specific name of an intrinsic function (13.12). This attribute also may be declared via the INTRINSIC statement (12.3.2.3).

5.2 Attribute Specification Statements.

All attributes (other than type) may be specified for entities, independently of type, by single attribute specification statements. The combination of attributes that may be specified for a particular entity is subject to the same restrictions regardless of the method of specification.

5.2.1 INTENT Statement.

R519 *intent-stmt* is INTENT (*intent-spec*) [::] *dummy-arg-name-list*

Constraint: An *intent-stmt* may appear only in the *specification-part* of a subprogram or an interface body (12.3.2.1).

Constraint: *dummy-arg-name* must not be the name of a dummy procedure or a dummy pointer.

This statement specifies the intended use of the specified dummy arguments (5.1.2.3). Each specified dummy argument has the INTENT attribute.

An example of an INTENT statement is:

```
SUBROUTINE EX (A, B)
   INTENT (INOUT) :: A, B
```

5.2.2 OPTIONAL Statement.

R520 *optional-stmt* is OPTIONAL [::] *dummy-arg-name-list*

Constraint: An *optional-stmt* may occur only in the scoping unit of a subprogram or an interface block.

This statement specifies that any of the specified dummy arguments need not be associated with an actual argument on an invocation of the procedure (12.5.2.8). Each specified dummy argument has the OPTIONAL attribute.

An example of an OPTIONAL statement is:

```
SUBROUTINE EX (A, B)
   OPTIONAL :: A
```

5.2.3 Accessibility Statements.

R521 *access-stmt* is *access-spec* [[::] *access-id-list*]

R522 *access-id* is *use-name*
or *generic-spec*

Constraint: An *access-stmt* may appear only in the scoping unit of a module. Only one accessibility statement with an omitted *access-id-list* is permitted in the scoping unit of a module.

Constraint: Each *access-id* must be the name of a named variable, nonintrinsic procedure, derived type, named constant, or namelist group.

Constraint: A *access-id* in a PUBLIC statement must not be the name of a module procedure that has a dummy argument or function result of a type that has PRIVATE accessibility, and such a procedure must not be given PUBLIC accessibility by default.

This statement declares the accessibility, **PUBLIC** or **PRIVATE**, of the entities (5.1.2.2).

If an ACCESS statement without an *access-id-list* appears in the scoping unit of a module, the statement sets the default accessibility that applies to all potentially accessible entities in the scoping unit of the module. The statement

```
PUBLIC
```

sets the default to public accessibility. The statement

```
PRIVATE
```

sets the default to private accessibility. If no such statement appears in a module, the default is public accessibility.

Examples of accessibility statements are:

```
MODULE EX
   PRIVATE
   PUBLIC :: A, B, C
```

5.2.4 SAVE Statement.

R523 *save-stmt* is SAVE [[::] *saved-entity-list*]

R524 *saved-entity* is *object-name*
or / *common-block-name* /

Constraint: An *object-name* must not be a dummy argument name, a procedure name, a function result name, an automatic data object name, a namelist group name, or the name of an entity in a common block.

Constraint: If a SAVE statement with an omitted saved entity list occurs in a scoping unit, no other explicit occurrence of the SAVE attribute or SAVE statement is permitted in the

same scoping unit.

All objects named explicitly or included within a common block named explicitly have the SAVE attribute (5.1.2.5). If a particular common block name is specified in a SAVE statement in any scoping unit of an executable program other than the main program, it must be specified in a SAVE statement in every scoping unit in which that common block appears except in the scoping unit of the main program. For a common block declared in a SAVE statement, the current values of the objects in a common block storage sequence (5.5.2.1) at the time a RETURN or END statement is executed are made available to the next scoping unit in the execution sequence of the executable program that specifies the common block name or accesses the common block. If a named common block is specified in the scoping unit of the main program, the current values of the common block storage sequence are made available to each scoping unit that specifies the named common block. The definition status of each object in the named common block storage sequence depends on the association that has been established for the common block storage sequence.

A SAVE statement with an empty saved entity list is treated as though it contained the names of all allowed items in the same scoping unit.

A SAVE statement may appear in the specification part of a main program and has no effect.

An example of a SAVE statement is:

```
SAVE A, B, C, / BLOCKA /, D
```

5.2.5 DIMENSION Statement.

R525 *dimension-stmt* is DIMENSION [::] *array-name* (*array-spec*)
■ [, *array-name* (*array-spec*)] ...

This statement specifies a list of object names to have the DIMENSION attribute (5.1.2.4) and specifies the array properties that apply for each object named.

An example of a DIMENSION statement is:

```
DIMENSION A (10), B (10, 70), C (-3:12, *)
```

5.2.6 ALLOCATABLE Statement.

R526 *allocatable-stmt* is ALLOCATABLE [::] *array-name*
■ [(*deferred-shape-spec-list*)]
■ [, *array-name* [(*deferred-shape-spec-list*)]] ...

Constraint: The *array-name* must not be a dummy argument or function result.

Constraint: If the DIMENSION attribute for an *array-name* is specified elsewhere in the scoping unit, the *array-spec* must be a *deferred-shape-spec-list*.

This statement specifies a list of array names that have the ALLOCATABLE attribute (5.1.2.9). The shape of an allocatable array is determined when space is allocated for the array by the execution of an ALLOCATE statement (6.3.1).

An example of an ALLOCATABLE statement is:

```
REAL A, B (:)
ALLOCATABLE :: A (:, :), B
```

5.2.7 POINTER Statement.

R527 *pointer-stmt* is POINTER [::] *object-name*
■ [(*deferred-shape-spec-list*)]
■ [, *object-name* [(*deferred-shape-spec-list*)]] ...

Constraint: The INTENT attribute must not be specified for an *object-name*.

Constraint: If the DIMENSION attribute for an *object-name* is specified elsewhere in the scoping unit, the *array-spec* must be a *deferred-shape-spec-list*.

Constraint: The PARAMETER attribute must not be specified for *object-name*.

This statement specifies a list of object names that have the POINTER attribute (5.1.2.7). An object that has the POINTER attribute must not be referenced or defined unless, as a result of executing a pointer assignment (7.5.2) or an ALLOCATE statement (6.3.1), it becomes pointer associated with a target object that may be referenced or defined.

An example of a POINTER statement is:

```
TYPE (NODE) :: CURRENT
POINTER :: CURRENT, A (:, :)
```

5.2.8 TARGET Statement.

R528 *target-stmt* is TARGET [::] *object-name* [(*array-spec*)]
[, *object-name* [(*array-spec*)]] ...

Constraint: The PARAMETER attribute must not be specified for an *object-name*.

This statement specifies a list of object names that have the TARGET attribute and thus may have pointers associated with them.

An example of a TARGET statement is:

```
TARGET :: A (1000, 1000), B
```

5.2.9 DATA Statement. A DATA statement is used to provide initial values for variables.

R529 *data-stmt* is DATA *data-stmt-set* [[,] *data-stmt-set*] ...

A variable, or part of a variable, must not be initialized more than once in an executable program.

A variable that appears in a DATA statement and is typed implicitly may appear in a subsequent type declaration only if that declaration confirms the implicit typing. An array name, array section, or array element that appears in a DATA statement must have had its array properties established by a previous declaration statement.

Except for variables in named common blocks, a named variable has the SAVE attribute if any part of it is initialized in a DATA statement, and this may be confirmed by a SAVE statement or a type declaration statement containing the SAVE attribute.

R530 *data-stmt-set* is *data-stmt-object-list* / *data-stmt-value-list* /

R531 *data-stmt-object* is *variable*
or *data-implied-do*

R532 *data-stmt-value* is [*data-stmt-repeat* *] *data-stmt-constant*

R533 *data-stmt-constant* is *scalar-constant*
or *signed-int-literal-constant*
or *signed-real-literal-constant*
or *structure-constructor*
or *boz-literal-constant*

R534 *data-stmt-repeat* is *scalar-int-constant*

R535 *data-implied-do* is (*data-i-do-object-list* , *data-i-do-variable* =
scalar-int-expr , *scalar-int-expr* [, *scalar-int-expr*])

R536 *data-i-do-object* is *array-element*
or *data-implied-do*

Constraint: *array-element* must not be a subobject with a constant parent.

R537 *data-i-do-variable* is *scalar-int-variable*

Constraint: *data-i-do-variable* must be a named variable.

Constraint: The DATA statement repeat factor must be positive or zero. If the DATA statement repeat factor is a named constant, it must have been declared previously in the scoping unit or made accessible by use association or host association.

Constraint: If a *data-stmt-constant* is a *structure-constructor*, each component must be a constant expression.

Constraint: A variable whose name or designator is included in a *data-stmt-object-list* or a *data-i-do-object-list* must not be: a dummy argument, made accessible by use association or host association, in a named common block unless the DATA statement is in a block data program unit, in a blank common block, a function name, a function result name, an automatic object, a pointer, or an allocatable array.

Constraint: A subscript in an array element *data-i-do-object* must be an expression whose primaries are either constants or DO variables of the containing *data-implied-do*s.

Constraint: A *scalar-int-expr* of a *data-implied-do* must involve as primaries only constants or DO variables of the containing *data-implied-do*s.

The *data-stmt-object-list* is expanded to form a sequence of scalar variables. An array whose unqualified name appears in a *data-stmt-object-list* is equivalent to a complete sequence of its array elements in array element order (6.2.2.2). An array section is equivalent to the sequence of its array elements in array element order. A *data-implied-do* is expanded to form a sequence of array elements, under the control of the implied-DO variable, as in the DO construct (8.1.4.4).

Note that zero-sized arrays, zero-sized array sections, and implied-DO lists with iteration counts of zero contribute no variables to the expanded sequence of scalar variables, but that a zero-length character variable does contribute a variable to the list.

The *data-stmt-value-list* is expanded to form a sequence of scalar constant values. Each such value must be a constant that is either previously defined or made accessible by a use association or host association. A data statement repeat factor indicates the number of times the following constant is to be included in the sequence; omission of a data statement repeat factor has the effect of a repeat factor of 1. Note that values with a repeat factor of zero contribute no values to the expanded sequence of scalar constant values.

The expanded sequences of scalar variables and constant values are in one-to-one correspondence. Each constant specifies the initial value for the corresponding variable. The lengths of the two expanded sequences must be the same.

If an object is of type character or logical, the corresponding constant must be of the same type. When the object is of type real or complex, the corresponding constant must be of type integer, real, or complex. When the object is of type integer, the corresponding constant either must be of type integer, real, or complex, or must be a binary, octal, or hexadecimal literal constant. If an object is of derived type, the corresponding constant must be of the same type.

The value of the constant must be compatible with its corresponding variable according to the rules of intrinsic assignment (7.5.1.4), and the variable becomes initially defined with the value of the constant in accordance with the rules of intrinsic assignment.

Within an interface block (12.3.2.1), data initialization by a type declaration statement has no effect.

Examples of DATA statements are:

```
CHARACTER (LEN = 10)  NAME
INTEGER, DIMENSION (0:9) :: MILES
REAL, DIMENSION (100, 100) :: SKEW
TYPE (PERSON) MYNAME, YOURNAME
DATA  NAME / 'JOHN DOE' /, MILES / 10 * 0 /
DATA  ((SKEW (K, J), J = 1, K), K = 1, 100) / 5050 * 0.0 /
DATA  ((SKEW (K, J), J = K + 1, 100), K = 1, 99) / 4950 * 1.0 /
DATA MYNAME / PERSON (21, 'JOHN SMITH') /
DATA YOURNAME % AGE, YOURNAME % NAME / 35, 'FRED BROWN' /
```

The character variable NAME is initialized with the value JOHN DOE with padding on the right because the length of the constant is less than the length of the variable. All ten elements of the integer array MILES are initialized to zero. The two-dimensional array SKEW is initialized so that the lower triangle of SKEW is zero and the strict upper triangle is one. The structures MYNAME and YOURNAME are declared using the derived type PERSON from 4.4.1. MYNAME is initialized by a structure constructor. YOURNAME is initialized by supplying a separate value for each component.

5.2.10 PARAMETER Statement. The **PARAMETER statement** provides a means of defining a named constant. Named constants defined by a PARAMETER statement have exactly the same properties and restrictions as those declared in a type statement specifying a PARAMETER attribute (5.1.2.1).

R538 *parameter-stmt* **is** PARAMETER (*named-constant-def-list*)

R539 *named-constant-def* **is** *named-constant* = *initialization-expr*

The named constant must have its type, shape, and any type parameters specified either by a previous occurrence in a type declaration statement in the same scoping unit, or by the implicit typing rules currently in effect for the scoping unit. If the named constant is typed by the implicit typing rules, its appearance in any subsequent type declaration statement must confirm this implied type and the values of any implied type parameters.

Each named constant becomes defined with the value determined from the initialization expression that appears on the right of the equals, in accordance with the rules of intrinsic assignment (7.5.1.4).

A named constant that appears in the initialization expression must have been defined previously in the same PARAMETER statement, defined in a prior PARAMETER statement or type declaration statement using the PARAMETER attribute, or made accessible by use association or host association.

A named constant must not appear as part of a format specification (10.1.1).

Each named constant has the PARAMETER attribute.

An example of a PARAMETER statement is:

```
PARAMETER (MODULUS = MOD (28, 3), NUMBER_OF_SENATORS = 100)
```

5.3 IMPLICIT Statement. In a scoping unit, an **IMPLICIT statement** specifies a type, and possibly type parameters, for all implicitly typed data entities whose names begin with one of the letters specified in the statement. Alternatively, it may indicate that no implicit typing rules are to apply in a particular scoping unit.

R540 *implicit-stmt* **is** IMPLICIT *implicit-spec-list*
or IMPLICIT NONE

R541 *implicit-spec* **is** *type-spec* (*letter-spec-list*)

R542 *letter-spec* **is** *letter* [– *letter*]

Constraint: If IMPLICIT NONE is specified in a scoping unit, it must precede any PARAMETER statements that appear in the scoping unit and there must be no other IMPLICIT statements in the scoping unit.

Constraint: If the minus and second letter appear, the second letter must follow the first letter alphabetically.

A *letter-spec* consisting of two letters separated by a minus is equivalent to writing a list containing all of the letters in alphabetical order in the alphabetic sequence from the first letter through the second letter. For example, A–C is equivalent to A, B, C. The same letter must not appear as a single letter, or be included in a range of letters, more than once in all of the IMPLICIT statements in a scoping unit.

In each scoping unit, there is a mapping, which may be null, between each of the letters A, B, ..., Z and a type (and type parameters). An IMPLICIT statement specifies the mapping for the letters in its *letter-spec-list*. IMPLICIT NONE specifies the null mapping for all the letters. If a mapping is not specified for a letter, the default is the mapping in the host scoping unit. A program unit is treated as if it had a host with the declaration

```
IMPLICIT INTEGER (I-N), REAL (A-H, O-Z)
```

Any data entity that is not explicitly declared by a type declaration statement, is not an intrinsic function, and is not made accessible by use association or host association is declared implicitly to be of the type (and type parameters) mapped from the first letter of its name, provided the mapping is not null. The data entity is treated as if it were declared in an explicit type declaration in the outermost scoping unit in which it appears. An explicit type specification in a FUNCTION statement overrides an IMPLICIT statement for the name of that function subprogram.

The following are examples of the use of IMPLICIT statements:

```
MODULE EXAMPLE_MODULE
   IMPLICIT NONE
   ...
   INTERFACE
      FUNCTION FUN (I)    ! All data entities must
         INTEGER FUN, I   ! be declared explicitly
      END FUNCTION FUN
   END INTERFACE
CONTAINS
   FUNCTION JFUN (J)      ! All data entities must
      INTEGER JFUN, J     ! be declared explicitly.
      ...
   END FUNCTION JFUN
END MODULE EXAMPLE_MODULE

SUBROUTINE SUB
   IMPLICIT COMPLEX (C)
   C = (3.0, 2.0)      ! C is implicitly declared COMPLEX
   ...
CONTAINS
   SUBROUTINE SUB1
      IMPLICIT INTEGER (A, C)
      C = (0.0, 0.0)  ! C is host associated and of
                      ! type complex
      Z = 1.0         ! Z is implicitly declared REAL
      A = 2           ! A is implicitly declared INTEGER
      CC = 1          ! CC is implicitly declared INTEGER
      ...
   END SUBROUTINE SUB1

   SUBROUTINE SUB2
      Z = 2.0         ! Z is implicitly declared REAL and
                      ! is different from the variable of
                      ! the same name in SUB1
      ...
   END SUBROUTINE SUB2
```

```
   SUBROUTINE SUB3
      USE EXAMPLE_MODULE   ! Accesses integer function FUN
                           ! by use association
      Q = FUN (K)          ! Q is implicitly declared REAL and
      ...                  ! K is implicitly declared INTEGER
   END SUBROUTINE SUB3
END SUBROUTINE SUB
```

An IMPLICIT statement may specify a *type-spec* of derived type. For example, given an IMPLICIT statement and a type defined as follows:

```
IMPLICIT TYPE (POSN) (A-B, W-Z), INTEGER (C-V)
TYPE POSN
   REAL X, Y
   INTEGER Z
END TYPE POSN
```

variables beginning with the letters A, B, W, X, Y, and Z are implicitly typed with the type POSN and the remaining variables are implicitly typed with type INTEGER.

5.4 NAMELIST Statement. A NAMELIST statement specifies a group of named data objects that can then be referred to by a single name for the purpose of data transfer (9.4, 10.9).

R543 *namelist-stmt* is NAMELIST / *namelist-group-name* /
■ *namelist-group-object-list*
■ [[,] / *namelist-group-name* / ■
■ *namelist-group-object-list*] ...

R544 *namelist-group-object* is *variable-name*

Constraint: A *namelist-group-object* must not be an array dummy argument with nonconstant bounds, a variable with assumed parameters, an automatic object, a pointer, a structure containing a pointer, an allocatable array, or a subobject of any of the preceding objects.

Constraint: If a *namelist-group-name* has the PUBLIC attribute, no item in the *namelist-group-object-list* may have the PRIVATE attribute.

The order in which the data objects (variables) are specified in the NAMELIST statement determines the order in which the values appear on output.

Any *namelist-group-name* may occur in more than one NAMELIST statement in a scoping unit. The *namelist-group-object-list* following each successive appearance of the same *namelist-group-name* in a scoping unit is treated as a continuation of the list for that *namelist-group-name*.

A namelist group object may be a member of more than one namelist group.

A namelist group object either must have its type, type parameters, and shape specified by a previous occurrence in a type declaration statement in the same scoping unit, or must be determined by the implicit typing rules currently in effect for the scoping unit. If a namelist group object is typed by the implicit typing rules, its appearance in any subsequent type declaration statement must confirm this implied type.

An example of a NAMELIST statement is:

```
NAMELIST /NLIST/ A, B, C
```

5.5 Storage Association of Data Objects. In general, the physical storage units or storage order for data objects is not specifiable. However, the EQUIVALENCE statement, the COMMON statement, and the SEQUENCE statement provide for control of the order and layout of storage units. The general mechanism of storage association is described in 14.6.3.

5.5.1 EQUIVALENCE Statement. An EQUIVALENCE statement is used to specify the sharing of storage units by two or more objects in a scoping unit. This causes storage association of the objects that share the storage units.

If the equivalenced objects have differing type or type attributes, the EQUIVALENCE statement does not cause type conversion or imply mathematical equivalence. If a scalar and an array are equivalenced, the scalar does not have array properties and the array does not have the properties of a scalar.

R545 *equivalence-stmt* is EQUIVALENCE *equivalence-set-list*

R546 *equivalence-set* is (*equivalence-object* , *equivalence-object-list*)

R547 *equivalence-object* is *variable-name*
or *array-element*
or *substring*

Constraint: An *equivalence-object* must not be a dummy argument, a pointer, an allocatable array, a nonsequence structure, a sequence structure containing a pointer, an automatic object, a function name, an entry name, a result name, or a subobject of any of the preceding objects.

Constraint: Each subscript or substring range expression in an *equivalence-object* must be an integer initialization expression (7.1.6.1).

Constraint: If an *equivalence-object* is of type default integer, default real, double precision real, default complex, default logical, or numeric sequence type, all of the objects in the equivalence set must be of these types.

Constraint: If an *equivalence-object* is of type default character or character sequence type, all of the objects in the equivalence set must be of these types.

Constraint: If an *equivalence-object* is of a derived type that is not a numeric sequence or character sequence type, all of the objects in the equivalence set must be of the same type.

Constraint: If an *equivalence-object* is of an intrinsic type other than default integer type, default real type, double precision real type, default complex type, default logical type, or default character type, all of the objects in the equivalence set must be of the same type with the same kind type parameter values.

5.5.1.1 Equivalence Association. An EQUIVALENCE statement specifies that the storage sequences (14.6.3.1) of the data objects specified in an *equivalence-set* are storage associated. All of the nonzero-sized sequences in the *equivalence-set*, if any, have the same first storage unit, and all of the zero-sized sequences in the *equivalence-set*, if any, are storage associated with one another and with the first storage unit of any nonzero-sized sequences. This causes the storage association of the data objects in the *equivalence-set* and may cause storage association of other data objects.

5.5.1.2 Equivalence of Character Objects. A data object of type character may be equivalenced only with other objects of type character. The lengths of the equivalenced objects are not required to be the same.

An EQUIVALENCE statement specifies that the storage sequences of all the character data objects specified in an *equivalence-set* are storage associated. All of the nonzero-sized sequences in the *equivalence-set*, if any, have the same first character storage unit, and all of the zero-sized sequences in the *equivalence-set*, if any, are storage associated with one another and with the first character storage unit of any nonzero-sized sequences. This causes the storage association of the data objects in the *equivalence-set* and may cause storage association of other data objects. For example, using the declarations:

```
CHARACTER   (LEN = 4) :: A, B
CHARACTER   (LEN = 3) :: C (2)
EQUIVALENCE (A, C (1)), (B, C (2))
```

the association of A, B, and C can be illustrated graphically as:

5.5.1.3 Array Names and Array Element Designators. For a nonzero-sized array, the use of the array name unqualified by a subscript list in an EQUIVALENCE statement has the same effect as using an array element designator that identifies the first element of the array.

5.5.1.4 Restrictions on EQUIVALENCE Statements. An EQUIVALENCE statement must not specify that the same storage unit is to occur more than once in a storage sequence. For example,

```
REAL, DIMENSION (2) :: A
REAL :: B
EQUIVALENCE (A (1), B), (A (2), B) ! Not standard conforming
```

is prohibited, because it would specify the same storage unit for A (1) and A (2). An EQUIVALENCE statement must not specify that consecutive storage units are to be nonconsecutive. For example, the following is prohibited:

```
REAL A (2)
DOUBLE PRECISION D (2)
EQUIVALENCE (A (1), D (1)), (A (2), D (2)) ! Not standard conforming
```

An EQUIVALENCE statement must not specify the sharing of storage units between objects declared in different scoping units. For example, the following is prohibited:

```
SUBROUTINE A
   USE MODULE, ONLY : XX
   INTEGER BB, EE
   EQUIVALENCE (EE, XX)  ! Not standard conforming
   ...
   CONTAINS
      SUBROUTINE C
         REAL DD
         EQUIVALENCE (BB, DD)  ! Not standard conforming
      END SUBROUTINE C
END SUBROUTINE A
```

5.5.2 COMMON Statement. The COMMON **statement** specifies blocks of physical storage, called **common blocks**, that may be accessed by any of the scoping units in an executable program. Thus, the COMMON statement provides a global data facility based on storage association (14.6.3). The common blocks specified by the COMMON statement may be named and are called **named common blocks**, or may be unnamed and are called **blank common**.

R548 *common-stmt* is COMMON [/ [*common-block-name*] /]
■ *common-block-object-list* ■
■ [[,] / [*common-block-name*] / ■
■ *common-block-object-list*] ...

R549 *common-block-object* is *variable-name* [(*explicit-shape-spec-list*)]

Constraint: Only one appearance of a given *variable-name* is permitted in all *common-block-object-lists* within a scoping unit.

Constraint: A *common-block-object* must not be a dummy argument, an allocatable array, an automatic object, a function name, an entry name, or a result name.

Constraint: Each bound in the *explicit-shape-spec* must be an integer initialization expression.

Constraint: If a *common-block-object* is of a derived type, it must be a sequence type (4.4.1).

Constraint: If a *variable-name* appears with an *explicit-shape-spec-list*, it must not have the POINTER attribute.

In each COMMON statement, the data objects whose names appear in a common block object list following a common block name are declared to be in that common block. If the first common block name is omitted, all data objects whose names appear in the first common block list are specified to be in blank common. Alternatively, the appearance of two slashes with no common block name between them declares the data objects whose names appear in the common block list that follows to be in blank common.

Any common block name or an omitted common block name for blank common may occur more than once in one or more COMMON statements in a scoping unit. The common block list following each successive appearance of the same common block name in a scoping unit is treated as a continuation of the list for that common block name. Similarly, each blank common block object list is treated as a continuation of blank common.

The form *variable-name* (*explicit-shape-spec-list*) declares *variable-name* to have the DIMENSION attribute and specifies the array properties that apply. If derived-type objects of numeric sequence type (4.4.1) or character sequence type (4.4.1) appear in common, it is as if the individual components were enumerated directly in the common list.

Examples of COMMON statements are:

```
COMMON /BLOCKA/ A, B, D (10, 30)
COMMON I, J, K
```

5.5.2.1 Common Block Storage Sequence. For each common block, a **common block storage sequence** is formed as follows:

(1) A storage sequence is formed consisting of the sequence of storage units contained in the storage sequences (14.6.3.1) of all data objects in the common block object lists for the common block. The order of the storage sequences is the same as the order of the appearance of the common block object lists in the scoping unit.

(2) The storage sequence formed in (1) is extended to include all storage units of any storage sequence associated with it by equivalence association. The sequence may be extended only by adding storage units beyond the last storage unit. Data objects associated with an entity in a common block are considered to be in that common block.

5.5.2.2 Size of a Common Block. The **size of a common block** is the size of its common block storage sequence, including any extensions of the sequence resulting from equivalence association.

5.5.2.3 Common Association. Within an executable program, the common block storage sequences of all nonzero-sized common blocks with the same name have the same first storage unit, and the common block storage sequences of all zero-sized common blocks with the same name are storage associated with one another. Within an executable program, the common block storage sequences of all nonzero-sized blank common blocks have the same first storage unit and the storage sequences of all zero-sized blank common blocks are associated with one another and with the first storage unit of any nonzero-sized blank common blocks. This results in the association of objects in different scoping units.

A nonpointer object of type default integer, default real, double precision real, default complex, default logical, or numeric sequence type must become associated only with nonpointer objects of these types.

A nonpointer object of type default character or character sequence type must become associated only with nonpointer objects of these types.

A nonpointer object of a derived type that is not a numeric sequence or character sequence type must become associated only with nonpointer objects of the same type.

A nonpointer object of intrinsic type other than default integer type, default real type, double precision real type, default complex type, default logical type, or default character type must become

associated only with nonpointer objects of the same type and type parameter.

A pointer must become associated only with pointers of the same type, kind parameter, and rank.

5.5.2.4 Differences between Named Common and Blank Common. A blank common block has the same properties as a named common block, except for the following:

(1) Execution of a RETURN or END statement may cause data objects in a named common block to become undefined unless the common block name has been declared in a SAVE statement, but never causes data objects in blank common to become undefined (14.7.6).

(2) Named common blocks of the same name must be of the same size in all scoping units of an executable program in which they appear, but blank common blocks may be of different sizes.

(3) A data object in a named common block may be initially defined by means of a DATA statement or type declaration statement in a block data program unit, but objects in blank common must not be initially defined (11.4).

5.5.2.5 Restrictions on Common and Equivalence. An EQUIVALENCE statement must not cause the storage sequences of two different common blocks to be associated. Equivalence association must not cause a common block storage sequence to be extended by adding storage units preceding the first storage unit of the first object specified in a COMMON statement for the common block. For example, the following is not permitted:

```
COMMON /X/ A
REAL B (2)
EQUIVALENCE (A, B (2))     ! Not standard conforming
```

A common block may be declared in a module (11.3). If it is, it must not be declared in another scoping unit that accesses entities from the module. The name of a PUBLIC data object accessible from a module must not appear in a COMMON or an EQUIVALENCE statement in the scoping unit containing the USE statement or in scoping units contained within the scoping unit containing the USE statement.

6. USE OF DATA OBJECTS

The appearance of a data object name or subobject designator in a context that requires its value is termed a **reference**. A reference is permitted only if the data object is defined. A reference to a pointer is permitted only if the pointer is associated with a target object that is defined. A data object becomes defined with a value when the data object name or subobject designator appears in certain contexts and when certain events occur (14.7).

A **variable** is a data object that may be defined and redefined during execution of an executable program.

R601 *variable* is *scalar-variable-name*
or *array-variable-name*
or *subobject*

Constraint: *array-variable-name* must be the name of a *variable* that is an array.

Constraint: *subobject* must not be a subobject designator (for example, a substring) whose parent is a constant.

R602 *subobject* is *array-element*
or *array-section*
or *structure-component*
or *substring*

R603 *logical-variable* is *variable*

Constraint: *logical-variable* must be of type logical.

R604 *default-logical-variable* is *variable*

Constraint: *default-logical-variable* must be of type default logical.

R605 *char-variable* is *variable*

Constraint: *char-variable* must be of type character.

R606 *default-char-variable* is *variable*

Constraint: *default-char-variable* must be of type default character.

R607 *int-variable* is *variable*

Constraint: *int-variable* must be of type integer.

R608 *default-int-variable* is *variable*

Constraint: *default-int-variable* must be of type default integer.

Pointers and allocatable arrays must not be defined in circumstances explained in 5.1.2.4.3. Dummy arguments or variables associated with dummy arguments must not be defined in circumstances explained in 12.5.2.1 and 12.5.2.8.

A literal constant is a scalar denoted by a syntactic form which indicates its type, type parameters, and value. A named constant is a constant that has been associated with a name with the PARAMETER attribute (5.1.2.1, 5.2.10). A reference to a constant is always permitted; redefinition of a constant is never permitted.

For example, given the declarations:

```
CHARACTER (10)  A, B (10)
TYPE (PERSON)  P   ! See 4.4.1
```

then A, B, B (1), B (1:5), P % AGE, and A (1:1) are all variables.

6.1 Scalars. A scalar (2.4.6) is a data entity that can be represented by a single value of the data type and that is not an array (6.2). Its value, if defined, is a single element from the set of values that characterize its data type.

A scalar has rank zero.

6.1.1 Substrings. A substring is a contiguous portion of a character string (4.3.2.1). The following rules define the forms of a substring:

R609 *substring* is *parent-string* (*substring-range*)

R610 *parent-string* is *scalar-variable-name*
or *array-element*
or *scalar-structure-component*
or *scalar-constant*

R611 *substring-range* is [*scalar-int-expr*] : [*scalar-int-expr*]

Constraint: *parent-string* must be of type character.

The first *scalar-int-expr* in *substring-range* is called the **starting point** and the second one is called the **ending point**. The length of a substring is the number of characters in the substring and is MAX (*ending-point* – *starting-point* + 1, 0).

Let the characters in the parent string be numbered 1, 2, 3, ..., *n*, where *n* is the length of the parent string. Then the characters in the substring are those from the parent string from the starting point and proceeding in sequence up to and including the ending point. Both the starting point and the ending point must be within the range 1, 2, ..., *n* unless the starting point exceeds the ending point, in which case the substring has length zero. If the starting point is not specified, the default value is 1. If the ending point is not specified, the default value is *n*.

If the parent is a variable, the substring is also a variable.

Examples of character substrings are:

```
B (1) (1:5)          array element as parent string
P % NAME (1:1)       structure component as parent string
ID (4:9)             scalar variable name as parent string
'0123456789' (N:N)   character constant as parent string
```

6.1.2 Structure Components. A *structure-component* is one of the components of a structure (4.4).

R612 *structure-component* is *parent-structure* % *component-name*

R613 *parent-structure* is *scalar-variable-name*
or *array-variable-name*
or *array-element*
or *array-section*
or *structure-component*
or *named-constant*

Constraint: If *parent-structure* is an array, the component must not be an array and must not have the pointer attribute.

Constraint: *parent-structure* must be of derived type.

Constraint: *component-name* must be a component from the derived-type definition of the type of *parent-structure*.

The type of the structure component is the same as the type declared for the component in the derived-type definition. Each type parameter, if any, of a structure component is declared for the component in the derived-type definition (4.4.1) and has a constant value. A component of a structure must not be referenced or defined before the structure is declared.

A structure component has the INTENT, TARGET, or PARAMETER attribute if the parent structure has the attribute. A structure component is a pointer only if the component was defined to have the pointer attribute.

The resulting data subobject is an array if either the parent structure is an array or the component is an array. Note that the effect of the first constraint is to prohibit both being arrays.

Examples of structure components are:

```
SCALAR_PARENT % SCALAR_FIELD          scalar component of scalar parent
ARRAY_PARENT (J) % SCALAR_FIELD       component of array element parent
ARRAY_PARENT (1:N) % SCALAR_FIELD     component of array section parent
SCALAR_PARENT % ARRAY_FIELD (J)       array element component
SCALAR_PARENT % ARRAY_FIELD (1:N)     array section component
```

6.2 Arrays. An **array** is a set of scalar data, all of the same type and type parameters, whose individual elements are arranged in a rectangular pattern. The scalar data that make up an array are the **array elements**.

No order of reference to the elements of an array is indicated by the appearance of the array name or designator, except where array element ordering (6.2.2.2) is specified.

6.2.1 Whole Arrays. A **whole array** is a named array.

A whole array is either a named constant or variable. A **whole array named constant** is the name of a constant expression (5.1.2.1 and 5.2.10) that is an array. A **whole array variable** is the name of a variable that is an array; the name does not have a subscript list appended to it.

The appearance of a whole array variable in an executable construct specifies all the elements of the array (2.4.7). An assumed-size array is permitted to appear as a whole array in an executable construct only as an actual argument in a procedure reference that does not require the shape.

The appearance of a whole array name in a nonexecutable statement specifies the entire array.

6.2.2 Array Elements and Array Sections.

R614 *array-element* is *parent-array* (*subscript-list*)

Constraint: The number of subscripts must equal the rank of the array.

R615 *array-section* is *parent-array* (*section-subscript-list*) [(*substring-range*)]

Constraint: If *substring-range* is present, *parent-array* must be of type character.

Constraint: At least one *section-subscript* must be a *subscript-triplet* or *vector-subscript*.

Constraint: The number of *section-subscript*s must equal the rank of the array.

R616 *parent-array* is *array-name*
or *structure-component*

Constraint: A *structure-component* may appear only if the component specified is an array.

R617 *subscript* is *scalar-int-expr*

R618 *section-subscript* is *subscript*
or *subscript-triplet*
or *vector-subscript*

R619 *subscript-triplet* is [*subscript*] : [*subscript*] [: *stride*]

R620 *stride* is *scalar-int-expr*

R621 *vector-subscript* is *int-expr*

Constraint: A *vector-subscript* must be an integer array expression of rank one.

Constraint: The second *subscript* must not be omitted from a *subscript-triplet* in the last dimension of an assumed-size array.

An array element is a scalar. An array section is an array. If a *substring-range* is present in an *array-section*, the object is an array of the shape specified by the *section-subscript-list* and each element is the designated substring of the corresponding element of the array section. For example, with the declarations:

```
REAL A (10, 10)
CHARACTER (LEN = 10) B (5, 5, 5)
```

A (1, 2) is an array element, A (1:N:2, M) is a rank-one array section, and B (:, :, :) (2:3) is an array of shape (5, 5, 5) whose elements are substrings of length 2 of the corresponding elements of B.

6.2.2.1 Array Elements. The value of a subscript in an array element must be within the bounds for that dimension.

6.2.2.2 Array Element Order. The elements of an array form a sequence known as the **array element order.** The position of an array element in this sequence is determined by the subscript order value of the subscript list designating the element. The subscript order value is computed from the formulas in Table 6.1.

Table 6.1 Subscript Order Value

Rank	Explicit Shape Specifier	Subscript List	Subscript Order Value
1	$j_1{:}k_1$	s_1	$1+(s_1-j_1)$
2	$j_1{:}k_1, j_2{:}k_2$	s_1, s_2	$1+(s_1-j_1)$ $+(s_2-j_2)\times d_1$
3	$j_1{:}k_1, j_2{:}k_2, j_3{:}k_3$	s_1, s_2, s_3	$1+(s_1-j_1)$ $+(s_2-j_2)\times d_1$ $+(s_3-j_3)\times d_2\times d_1$
.	.	.	.
.	.	.	.
.	.	.	.
7	$j_1{:}k_1, \ldots, j_7{:}k_7$	$s_1, \ldots, s_7$	$1+(s_1-j_1)$ $+(s_2-j_2)\times d_1$ $+(s_3-j_3)\times d_2\times d_1$ $+\cdots$ $+(s_7-j_7)\times d_6$ $\times d_5\times\cdots\times d_1$

Notes for Table 6.1:

(1) $d_i = \max(k_i - j_i + 1, 0)$ is the size of the ith dimension.

(2) If the size of the array is nonzero, $j_i \le s_i \le k_i$ for all $i = 1, 2, \ldots, 7$.

6.2.2.3 Array Sections. An **array section** is an array subobject designated by an array name or designator with a section subscript list, optionally followed by a substring range.

Each *subscript-triplet* and *vector-subscript* in the section subscript list indicates a sequence of subscripts which may be empty (6.2.2). Each subscript in such a sequence must be within the bounds for its dimension unless the sequence is empty. The array section is the set of elements from the array determined by all possible subscript lists obtainable from the single subscripts or sequences of subscripts specified by each section subscript.

The rank of the array section is the number of subscript triplets and vector subscripts in the section subscript list. The shape is the rank-one array whose *i*th element is the number of integer values in the sequence indicated by the *i*th subscript triplet or vector subscript. If any of these sequences is empty, the array section has size zero. The subscript order of the elements of an array section is that of the array data object that the array section represents.

6.2.2.3.1 Subscript Triplet. A subscript triplet designates a regular sequence of subscripts consisting of zero or more subscript values. The third expression in the subscript triplet is the increment between the subscript values and is called the **stride**. The subscripts and stride of a subscript triplet are optional. An omitted first subscript in a subscript triplet is equivalent to a subscript whose value is the lower bound for the array and an omitted second subscript is equivalent to the upper bound. An omitted stride is equivalent to a stride of 1.

The second subscript must not be omitted in the last dimension of an assumed-size array.

When the stride is positive, the subscripts specified by a triplet form a regularly spaced sequence of integers beginning with the first subscript and proceeding in increments of the stride to the largest such integer not exceeding the second subscript; the sequence is empty if the first subscript exceeds the second.

The stride must not be zero.

When the stride is negative, the sequence begins with the first subscript and proceeds in increments of the stride down to the smallest such integer equal to or exceeding the second subscript; the sequence is empty if the second subscript exceeds the first.

Note that a subscript in a subscript triplet need not be within the declared bounds for that dimension if all values used in selecting the array elements are within the declared bounds.

For example, if an array is declared as B (10), the array section B (3 : 11 : 7) is the array of shape (2) consisting of the elements B (3) and B (10), in that order. The section B (9 : 1 : –2) is the array of shape (5) whose elements are B (9), B (7), B (5), B (3), and B (1), in that order.

For another example, suppose an array is declared as A (5, 4, 3). The section A (3 : 5, 2, 1 : 2) is the array of shape (3, 2):

```
A (3, 2, 1)   A (3, 2, 2)
A (4, 2, 1)   A (4, 2, 2)
A (5, 2, 1)   A (5, 2, 2)
```

6.2.2.3.2 Vector Subscript. A **vector subscript** designates a sequence of subscripts corresponding to the values of the elements of the expression. Each element of the expression must be defined. A **many-one array section** is an array section with a vector subscript having two or more elements with the same value. A many-one array section must not appear on the left of the equals in an assignment statement.

For example, suppose Z is a two-dimensional array of shape (5, 7) and U and V are one-dimensional arrays of shape (3) and (4), respectively. Assume the values of U and V are:

```
U = (/ 1, 3, 2 /)
V = (/ 2, 1, 1, 3 /)
```

Then Z (3, V) consists of the elements from the third row of Z in the order:

```
Z (3, 2)   Z (3, 1)   Z (3, 1)   Z (3, 3)
```

and Z (U, 2) consists of the column elements:

```
Z (1, 2)   Z (3, 2)   Z (2, 2)
```

and Z (U, V) consists of the elements:

```
Z (1, 2)   Z (1, 1)   Z (1, 1)   Z (1, 3)
Z (3, 2)   Z (3, 1)   Z (3, 1)   Z (3, 3)
Z (2, 2)   Z (2, 1)   Z (2, 1)   Z (2, 3)
```

Because Z (3, V) and Z (U, V) contain duplicate elements from Z, the sections Z (3, V) and Z (U, V) must not be redefined as sections.

An internal file must not be an array section with a vector subscript. An array section with a vector subscript must not be argument associated with a dummy array that is defined or redefined. An array section with a vector subscript must not be the target in a pointer assignment statement.

6.3 Dynamic Association. Dynamic control over the creation, association, and deallocation of pointer targets is provided by the ALLOCATE, NULLIFY, and DEALLOCATE statements and pointer assignment. ALLOCATE (6.3.1) creates targets for pointers; pointer assignment (7.5.2) associates pointers with existing targets; NULLIFY (6.3.2) disassociates pointers from targets, and DEALLOCATE (6.3.3) deallocates targets. Dynamic association applies to scalars and arrays of any type.

6.3.1 ALLOCATE Statement. The **ALLOCATE statement** dynamically creates pointer targets and allocatable arrays.

R622 *allocate-stmt* is ALLOCATE (*allocation-list* ■
■ [, STAT = *stat-variable*])

R623 *stat-variable* is *scalar-int-variable*

Constraint: The *stat-variable* must not be allocated within the ALLOCATE statement in which it appears.

R624 *allocation* is *allocate-object* [(*explicit-shape-spec-list*)]

R625 *allocate-object* is *variable-name*
or *structure-component*

Constraint: Each *allocate-object* must be a pointer or an allocatable array.

Constraint: A bound in an *allocation explicit-shape-spec* must not be an expression involving as a primary an array inquiry function (13.10.15) whose argument is any other object in the same ALLOCATE statement.

Constraint: The number of *explicit-shape-specs* in an *allocation explicit-shape-spec-list* must be the same as the rank of the pointer or allocatable array.

An example of an ALLOCATE statement is:

```
ALLOCATE (X (N), B (-3 : M, 0:9), STAT = IERR_ALLOC)
```

At the time an ALLOCATE statement is executed for an array, the values of the lower bound and upper bound expressions in an explicit-shape specification (5.1.2.4.1) determine the bounds of the array. Subsequent redefinition or undefinition of any entities in the bound expressions do not affect the array shape. Note that zero-length character objects and zero-sized arrays are permitted in the ALLOCATE statement.

If the STAT= specifier is present, successful execution of the ALLOCATE statement causes the *stat-variable* to become defined with a value of zero. If an error condition occurs during the execution of the ALLOCATE statement, the *stat-variable* becomes defined with a processor-dependent positive integer value.

If an error condition occurs during execution of an ALLOCATE statement that does not contain the STAT= specifier, execution of the executable program is terminated.

6.3.1.1 Allocation of Allocatable Arrays. An allocatable array that has been allocated by an ALLOCATE statement and has not been subsequently deallocated (6.3.3) is **currently allocated** and is definable. Allocating a currently allocated allocatable array causes an error condition in the ALLOCATE statement. At the beginning of execution of an executable program, allocatable arrays have not been allocated and are not definable. The ALLOCATED intrinsic function (13.13.9) may be used to determine whether an allocatable array is currently allocated.

6.3.1.2 Allocation of Pointer Targets. Following successful execution of an ALLOCATE statement for a pointer, the pointer is associated with the target and may be used to reference or define the target. Additional pointer names may become associated with the pointer target or a part of the pointer target by pointer assignment. It is not an error to allocate a pointer that is currently associated with a target. In this case, a new pointer target is created as required by the attributes of the pointer and any array bounds specified in the ALLOCATE statement. The pointer is then associated with this new target. Any previous association with a target is broken. If the previous target had been created by allocation, it becomes inaccessible unless it can still be referred to by other pointer names that are currently associated with it. The ASSOCIATED intrinsic function (13.13.13) may be used to determine whether a pointer is currently associated.

At the beginning of execution of a function whose result is a pointer, the association status of the result pointer is undefined. Before such a function returns, it must either associate a target with this pointer or cause the allocation status of this pointer to become defined as disassociated.

6.3.2 NULLIFY Statement. The NULLIFY statement causes a pointer to be disassociated.

R626 *nullify-stmt* is NULLIFY (*pointer-object-list*)

R627 *pointer-object* is *variable-name*
or *structure-component*

Constraint: Each *pointer-object* must have the POINTER attribute.

6.3.3 DEALLOCATE Statement. The DEALLOCATE statement causes an allocatable array to be deallocated or a pointer target to be deallocated and the pointer to be disassociated.

R628 *deallocate-stmt* is DEALLOCATE (*allocate-object-list* ■
■ [, STAT = *stat-variable*])

Constraint: Each *allocate-object* must be a pointer or an allocatable array.

Constraint: The *stat-variable* must not be deallocated within the same DEALLOCATE statement.

If the STAT= specifier is present, successful execution of the DEALLOCATE statement causes the *stat-variable* to become defined with a value of zero. If an error condition occurs during the execution of the DEALLOCATE statement, the *stat-variable* becomes defined with a processor-dependent positive integer value.

If an error condition occurs during execution of a DEALLOCATE statement that does not contain the STAT= specifier, execution of the executable program is terminated.

An example of a DEALLOCATE statement is:

```
DEALLOCATE (X, B)
```

6.3.3.1 Deallocation of Allocatable Arrays. Deallocating an allocatable array that is not currently allocated causes an error condition in the DEALLOCATE statement. An allocatable array with the TARGET attribute must not be deallocated through an associated pointer. Deallocating an allocatable array with the TARGET attribute causes any pointer associated with it to become undefined.

When the execution of a procedure is terminated by execution of a RETURN or END statement, any allocatable array allocated within the procedure that is currently allocated becomes undefined and has an allocation status of undefined (14.8), unless it is one of the following:

(1) An allocatable array with the SAVE attribute,

(2) An allocatable array in the scoping unit of a module if the module also is accessed by another scoping unit that is currently in execution, or

(3) An allocatable array accessible by host association.

Such allocated arrays retain their definition status and allocation status at the execution of a RETURN or END statement.

If an allocatable *array-name* has an undefined allocation status, the allocatable *array-name* must not be subsequently referenced, defined, allocated, or deallocated.

6.3.3.2 Deallocation of Pointer Targets. If a pointer appears in *allocate-object-list*, its association status must be defined. Deallocating a pointer that is disassociated or whose target was not created by an ALLOCATE statement causes an error condition in the DEALLOCATE statement. If a pointer is currently associated with an allocatable array, the pointer must not be deallocated.

A pointer that is not currently associated with the whole of an allocated target object must not be deallocated. If a pointer is currently associated with a portion (2.4.3.2) of a target object that is independent of any other portion of the target object, it must not be deallocated. Deallocating a pointer target causes any other pointer that is associated with the target to become undefined.

When the execution of a procedure is terminated by execution of a RETURN or END statement, the pointer association status of a pointer declared or accessed in the procedure becomes undefined unless it is one of the following:

(1) A pointer with the SAVE attribute,

(2) A pointer in a named common block that appears in at least one other scoping unit that is currently in execution,

(3) A pointer declared in the scoping unit of a module if the module also is accessed by another scoping unit that is currently in execution,

(4) A pointer accessed by host association, or

(5) A pointer that is the returned value of a function declared to have the POINTER attribute.

7. EXPRESSIONS AND ASSIGNMENT

This section describes the formation, interpretation, and evaluation rules for expressions and the assignment statement.

7.1 Expressions. An expression represents either a data reference or a computation, and its value is either a scalar or an array. An expression is formed from operands, operators, and parentheses. Simple forms of an operand are constants and variables, such as:

```
3.0
.FALSE.
A
B (I)
C (I:J)
```

An operand is either a scalar or an array. An operation is either intrinsic (7.2) or defined (7.3). More complicated expressions can be formed using operands which are themselves expressions.

Examples of intrinsic operators are:

```
+
*
>
.AND.
```

7.1.1 Form of an Expression. Evaluation of an expression produces a value, which has a type, type parameters (if appropriate), and a shape (7.1.4).

Examples of expressions are:

```
A + B
(A - B) * C
A ** B
C .AND. D
F // G
```

An expression is defined in terms of several categories: primary, level-1 expression, level-2 expression, level-3 expression, level-4 expression, and level-5 expression.

These categories are related to the different operator precedence levels and, in general, are defined in terms of other categories. The simplest form of each expression category is a *primary*. The rules given below specify the syntax of an expression. The semantics are specified in 7.2 and 7.3.

7.1.1.1 Primary.

R701 *primary* is *constant*
or *constant-subobject*
or *variable*
or *array-constructor*
or *structure-constructor*
or *function-reference*
or (*expr*)

R702 *constant-subobject* is *subobject*

Constraint: *subobject* must be a subobject designator whose parent is a constant.

Constraint: A *variable* that is a *primary* must not be an assumed-size array.

Examples of a *primary* are:

Example	Syntactic Class
`1.0`	*constant*
`'ABCDEFGHIJKLMNOPQRSTUVWXYZ' (13:13)`	*constant-subobject*

```
A                              variable
(/ 1.0, 2.0 /)                 array-constructor
PERSON (12, 'Jones')           structure-constructor
F (X, Y)                       function-reference
(S + T)                        (expr)
```

7.1.1.2 Level-1 Expressions. Defined unary operators have the highest operator precedence (Table 7.7). Level-1 expressions are primaries optionally operated on by defined unary operators:

R703 *level-1-expr* is [*defined-unary-op*] *primary*

R704 *defined-unary-op* is . *letter* [*letter*] ... .

Constraint: A *defined-unary-op* must not contain more than 31 letters and must not be the same as any *intrinsic-operator* or *logical-literal-constant*.

Simple examples of a level-1 expression are:

Example	Syntactic Class
`A`	*primary* (R701)
`.INVERSE. B`	*level-1-expr* (R703)

A more complicated example of a level-1 expression is:

```
.INVERSE. (A + B)
```

7.1.1.3 Level-2 Expressions. Level-2 expressions are level-1 expressions optionally involving the numeric operators *power-op*, *mult-op*, and *add-op*.

R705 *mult-operand* is *level-1-expr* [*power-op mult-operand*]

R706 *add-operand* is [*add-operand mult-op*] *mult-operand*

R707 *level-2-expr* is [[*level-2-expr*] *add-op*] *add-operand*

R708 *power-op* is **

R709 *mult-op* is *
or /

R710 *add-op* is +
or -

Simple examples of a level-2 expression are:

Example	Syntactic Class	Remarks
`A`	*level-1-expr*	A is a *primary*. (R703)
`B ** C`	*mult-operand*	B is a *level-1-expr*, ** is a *power-op*, and C is a *mult-operand*. (R705)
`D * E`	*add-operand*	D is an *add-operand*, * is a *mult-op*, and E is a *mult-operand*. (R706)
`+1`	*level-2-expr*	+ is an *add-op* and 1 is an *add-operand*. (R707)
`F - I`	*level-2-expr*	F is a *level-2-expr*, - is an *add-op*, and I is an *add-operand*. (R707)

A more complicated example of a level-2 expression is:

```
- A + D * E + B ** C
```

7.1.1.4 Level-3 Expressions. Level-3 expressions are level-2 expressions optionally involving the character operator *concat-op*.

R711 *level-3-expr* is [*level-3-expr concat-op*] *level-2-expr*

R712 *concat-op* is //

Simple examples of a level-3 expression are:

Example	Syntactic Class
`A`	*level-2-expr* (R707)
`B // C`	*level-3-expr* (R711)

A more complicated example of a level-3 expression is:

```
X // Y // 'ABCD'
```

7.1.1.5 Level-4 Expressions. Level-4 expressions are level-3 expressions optionally involving the relational operators *rel-op*.

R713 *level-4-expr* is [*level-3-expr rel-op*] *level-3-expr*

R714 *rel-op* is .EQ.
or .NE.
or .LT.
or .LE.
or .GT.
or .GE.
or ==
or /=
or <
or <=
or >
or >=

Simple examples of a level-4 expression are:

Example	Syntactic Class
`A`	*level-3-expr* (R711)
`B .EQ. C`	*level-4-expr* (R713)
`D < E`	*level-4-expr* (R713)

A more complicated example of a level-4 expression is:

```
(A + B) .NE. C
```

7.1.1.6 Level-5 Expressions. Level-5 expressions are level-4 expressions optionally involving the logical operators *not-op*, *and-op*, *or-op*, and *equiv-op*.

R715 *and-operand* is [*not-op*] *level-4-expr*

R716 *or-operand* is [*or-operand and-op*] *and-operand*

R717 *equiv-operand* is [*equiv-operand or-op*] *or-operand*

R718 *level-5-expr* is [*level-5-expr equiv-op*] *equiv-operand*

R719 *not-op* is .NOT.

R720 *and-op* is .AND.

R721 *or-op* is .OR.

R722 *equiv-op* is .EQV.

or .NEQV.

Simple examples of a level-5 expression are:

Example	Syntactic Class
`A`	*level-4-expr* (R713)
`.NOT. B`	*and-operand* (R715)
`C .AND. D`	*or-operand* (R716)
`E .OR. F`	*equiv-operand* (R717)
`G .EQV. H`	*level-5-expr* (R718)
`S .NEQV. T`	*level-5-expr* (R718)

A more complicated example of a level-5 expression is:

```
A .AND. B .EQV. .NOT. C
```

7.1.1.7 General Form of an Expression. Expressions are level-5 expressions optionally involving defined binary operators. Defined binary operators have the lowest operator precedence (Table 7.7).

R723 *expr* is [*expr defined-binary-op*] *level-5-expr*

R724 *defined-binary-op* is . *letter* [*letter*] ... .

Constraint: A *defined-binary-op* must not contain more than 31 letters and must not be the same as any *intrinsic-operator* or *logical-literal-constant*.

Simple examples of an expression are:

Example	Syntactic Class
`A`	*level-5-expr* (R718)
`B .UNION. C`	*expr* (R723)

More complicated examples of an expression are:

```
(B .INTERSECT. C) .UNION. (X - Y)
A + B .EQ. C * D
.INVERSE. (A + B)
A + B .AND. C * D
E // G .EQ. H (1:10)
```

7.1.2 Intrinsic Operations. An **intrinsic operation** is either an intrinsic unary operation or an intrinsic binary operation. An **intrinsic unary operation** is an operation of the form *intrinsic-operator* x_2 where x_2 is of an intrinsic type (4.3) listed in Table 7.1 for the unary intrinsic operator.

An **intrinsic binary operation** is an operation of the form x_1 *intrinsic-operator* x_2 where x_1 and x_2 are of the intrinsic types (4.3) listed in Table 7.1 for the binary intrinsic operator and are in shape conformance (7.1.5).

A **numeric intrinsic operation** is an intrinsic operation for which the *intrinsic-operator* is a numeric operator (+, –, *, /, or **). A **numeric intrinsic operator** is the operator in a numeric intrinsic operation.

For numeric intrinsic binary operations, the two operands may be of different numeric types or different type parameters. Except for a value raised to an integer power, if the operands have different types or type parameters, the effect is as if each operand that differs in type or type parameter from those of the result is converted to the type and type parameter of the result before the operation is performed. When a value of type real or complex is raised to an integer power, the integer operand need not be converted.

A **character intrinsic operation**, **relational intrinsic operation**, and **logical intrinsic operation** are similarly defined in terms of a *character intrinsic operator* (//), *relational intrinsic operator* (.EQ., .NE., .GT., .GE., .LT., .LE., ==, /=, >, >=, <, and <=), and *logical intrinsic operator* (.AND., .OR., .NOT., .EQV., and .NEQV.), respectively. For the intrinsic operator //, the kind type parameters must be the same.

A **numeric relational intrinsic operation** is a relational intrinsic operation where the operands are of numeric type. A **character relational intrinsic operation** is a relational intrinsic operation where the operands are of type character and have the same kind type parameter value.

Table 7.1 Type of Operands and Result for the Intrinsic Operation $[x_1]$ *op* x_2

(The symbols I, R, Z, C, and L stand for the types integer, real, complex, character, and logical, respectively. Where more than one type for x_2 is given, the type of the result of the operation is given in the same relative position in the next column. For the intrinsic operators requiring operands of type character, the kind type parameters of the operands must be the same.)

Intrinsic Operator *op*	Type of x_1	Type of x_2	Type of $[x_1]$ *op* x_2
unary +, –		I, R, Z	I, R, Z
binary +, –, *, /, **	I	I, R, Z	I, R, Z
	R	I, R, Z	R, R, Z
	Z	I, R, Z	Z, Z, Z
//	C	C	C
.EQ., .NE., ==, /=	I	I, R, Z	L, L, L
	R	I, R, Z	L, L, L
	Z	I, R, Z	L, L, L
	C	C	L
.GT., .GE., .LT., .LE. >, >=, <, <=	I	I, R	L, L
	R	I, R	L, L
	C	C	L
.NOT.		L	L
.AND., .OR., .EQV., NEQV.	L	L	L

7.1.3 Defined Operations. A **defined operation** is either a defined unary operation or a defined binary operation. A **defined unary operation** is an operation of the form *defined-unary-op* x_2 where there exists a function whose interface is explicit (12.3.1) in the scoping unit containing *defined-unary-op* x_2 that specifies the operation (7.3) for the operator *defined-unary-op*, or of the form *intrinsic-operator* x_2 where the type of x_2 is not that required for a unary intrinsic operation (7.1.2), and there exists a function whose interface is explicit in the scoping unit containing *intrinsic-operator* x_2 that specifies the operation for the operator *intrinsic-operator*.

A **defined binary operation** is an operation of the form x_1 *defined-binary-op* x_2 where there exists a function whose interface is explicit in the scoping unit containing x_1 *defined-binary-op* x_2 that specifies the operation (7.3) for the operator *defined-binary-op*, or of the form x_1 *intrinsic-operator* x_2 where the types or ranks of either x_1 or x_2 or both are not those required for an intrinsic binary operation (7.1.2), and there exists a function whose interface is explicit in the scoping unit containing x_1 *intrinsic-operator* x_2 that specifies the operation for the operator *intrinsic-operator*.

Note that an intrinsic operator may be used as the operator in a defined operation. In such a case, the generic properties of the operator are extended.

An **extension operation** is a defined operation in which the operator is of the form *defined-unary-op* or *defined-binary-op*. Such an operator is called an **extension operator**. Note that the operator used

in an extension operation may be overloaded in that a generic interface for the operator may specify more than one function.

7.1.4 Data Type, Type Parameters, and Shape of an Expression. The data type and shape of an expression depend on the operators and on the data types and shapes of the primaries used in the expression, and are determined recursively from the syntactic form of the expression. The data type of an expression is one of the intrinsic types (4.3) or a derived type (4.4).

R725 *logical-expr* is *expr*

Constraint: *logical-expr* must be type logical.

R726 *char-expr* is *expr*

Constraint: *char-expr* must be type character.

R727 *default-char-expr* is *expr*

Constraint: *default-char-expr* must be of type default character.

R728 *int-expr* is *expr*

Constraint: *int-expr* must be type integer.

R729 *numeric-expr* is *expr*

Constraint: *numeric-expr* must be of type integer, real or complex.

An expression whose type is intrinsic has a kind type parameter. In addition, an expression of type character has a length type parameter. The type parameters for an expression are determined from the form of the expression.

7.1.4.1 Data Type, Type Parameters, and Shape of a Primary. The data type, type parameters, and shape of a primary are determined according to whether the primary is a constant, variable, array constructor, structure constructor, function reference, or parenthesized expression. If a primary is a constant, its type, type parameters, and shape are those of the constant (4.3). If it is a structure constructor, it is scalar and its type is determined by the constructor name. If it is an array constructor, its type, type parameters, and shape are as described in 4.5. If it is a variable or function reference, its type, type parameters, and shape are those of the variable (5.1.1, 5.1.2) or the function reference (12.4.2), respectively. Note that in the case of a function reference, the function may be generic (12.3.1, 13.10), in which case its type, type parameters, and rank are determined by the types, type parameters, and ranks of its actual arguments. If a primary is a parenthesized expression, its type, type parameters, and shape are those of the expression.

If a pointer appears as a primary, the associated target object is referenced. The type, type parameters, and shape of the primary are those of the current target. If the pointer is not associated with a target, it may appear as a primary only as an actual argument in a reference to a procedure whose corresponding dummy argument is declared to be a pointer.

7.1.4.2 Data Type, Type Parameters, and Shape of the Result of an Operation. The type of the result of an intrinsic operation $[x_1]$ *op* x_2 is specified by Table 7.1. The type of the result of a defined operation $[x_1]$ *op* x_2 is specified by the function subprogram defining the operation (7.3).

The shape of the result of an intrinsic operation is the shape of x_2 if *op* is unary or if x_1 is scalar, and is the shape of x_1 otherwise.

An expression of an intrinsic type has a kind type parameter. An expression of type character also has a length type parameter. For an expression x_1 // x_2 where x_1 and x_2 are of type character, the length type parameter is the sum of the lengths of the operands and the kind type parameter is the kind type parameter of x_1, which must be the same as the kind type parameter of x_2. For an expression *op* x_2 where *op* is a numeric intrinsic unary operator and x_2 is of type integer, real, or complex, the kind type parameter of the expression is that of the operand. For an expression x_1 *op* x_2 where *op* is a numeric intrinsic binary operator with one operand of type integer and the other of type real or complex, the kind type parameter of the expression is that of the real or complex

operand. In the case where both operands are integer with kind type parameters k_1 and k_2, the kind type parameter of the expression is max (k_1, k_2). In the case where both operands are any of type real or complex with kind type parameters k_1 and k_2, the kind type parameter of the expression is max (k_1, k_2). In the case where both operands are of type logical with kind type parameters k_1 and k_2, the kind type parameter of the expression is max (k_1, k_2).

7.1.5 Conformability Rules for Intrinsic Operations. Two entities are in **shape conformance** if both are arrays of the same shape, or one or both are scalars.

For all intrinsic binary operations, the two operands must be in shape conformance. In case one is a scalar and the other an array, the scalar is treated as if it were an array of the same shape as the array operand with every element, if any, of the array equal to the value of the scalar.

7.1.6 Scalar and Array Expressions. An expression is either a scalar expression or an array expression.

The following is an example of a scalar expression:

```
Q + 2.3 * R
```

where Q and R are scalars.

The following is an example of an array expression:

```
A (1:10) + B (2:11)
```

where A and B are arrays.

7.1.6.1 Constant Expression. A **constant expression** is an expression in which each operation is intrinsic and each primary is one of the following:

(1) A constant or subobject of a constant where each subscript, section subscript, substring starting point, and substring ending point is a constant expression.

(2) An array constructor where each element and the bounds and strides of each implied-DO are expressions whose primaries are either constant expressions or implied-DO variables,

(3) A structure constructor where each component is a constant expression,

(4) An elemental intrinsic function reference where each argument is a constant expression,

(5) A transformational intrinsic function reference where each argument is a constant expression,

(6) A reference to an array inquiry function (13.10.15) other than ALLOCATED, bit inquiry function (13.10.9), character inquiry function (13.10.5), kind inquiry function (13.10.6), or numeric inquiry function (13.10.8) where each argument is either a constant expression or a variable whose type parameters or bounds inquired about are not assumed or defined by an ALLOCATE statement or a pointer assignment, or

(7) A constant expression enclosed in parentheses.

A **character constant expression** is a constant expression whose type is character. An **integer constant expression** is a constant expression whose type is integer. A **logical constant expression** is a constant expression whose type is logical. A **numeric constant expression** is a constant expression whose type is integer, real, or complex.

An **initialization expression** is a constant expression in which the exponentiation operation is permitted only with an integer power, and each primary is one of the following:

(1) A constant or subobject of a constant where each subscript, section subscript, substring starting point, and substring ending point is an initialization expression,

(2) An array constructor where each element and the bounds and strides of each implied-DO are expressions whose primaries are either initialization expressions or implied-DO

variables,

(3) A structure constructor where each component is an initialization expression,

(4) An elemental intrinsic function reference of type integer or character where each argument is an initialization expression of type integer or character,

(5) A reference to one of the four transformational functions, REPEAT, TRIM, TRANSFER, or RESHAPE, where each argument is an initialization expression,

(6) A reference to any array inquiry function (13.10.15) other than ALLOCATED, bit inquiry function (13.10.9), character inquiry function (13.10.5), kind inquiry function (13.10.6), or numeric inquiry function (13.10.8) where each argument is either an initialization expression or a variable whose type parameters or bounds inquired about are not assumed or defined by an ALLOCATE statement or a pointer assignment, or

(7) An initialization expression enclosed in parentheses.

R730 *initialization-expr* is *expr*

R731 *char-initialization-expr* is *char-expr*

R732 *int-initialization-expr* is *int-expr*

R733 *logical-initialization-expr* is *logical-expr*

If an initialization expression includes a reference to an inquiry function for a type parameter or an array bound of an object specified in the same *specification-part*, the type parameter or array bound must be specified in a prior type declaration or specification statement of the *specification-part*. The prior specification may precede the inquiry in the same statement.

The following are examples of constant expressions:

```
3
-3 + 4
'AB'
'AB' // 'CD'
('AB' // 'CD') // 'EF'
SIZE (A)
DIGITS (X) + 4
```

where A is an explicit-shaped array with constant bounds and X is of type default real.

The following are examples of constant expressions that are not initialization expressions:

```
ABS (9.0)    ! Not an integer argument
3.0 ** 2.0   ! Not an integer power
DOT_PRODUCT ( (/ 2, 3 /), (/ 1, 7 /) )
```

7.1.6.2 Specification Expression. A **restricted expression** is an expression in which each operation is intrinsic and each primary is:

(1) A constant or subobject of a constant where each subscript, section subscript, substring starting point, and substring ending point is a restricted expression,

(2) A variable that is a dummy argument,

(3) A variable that is in a common block,

(4) A variable that is made accessible by use association or host association,

(5) An array constructor where each element and the bounds and strides of each implied-DO are expressions whose primaries are either restricted expressions or implied-DO variables,

(6) A structure constructor where each component is a restricted expression,

(7) An elemental intrinsic function reference of type integer or character where each argument is a restricted expression of type integer or character,

(8) One of the transformational functions REPEAT, TRIM, TRANSFER, and RESHAPE, where each argument is a restricted expression of type integer or character,

(9) A reference to any array inquiry function (13.10.15) other than ALLOCATED, bit inquiry function (13.10.9), character inquiry function (13.10.5), kind inquiry function (13.10.6), or numeric inquiry function (13.10.8) where each argument is either a restricted expression or a variable whose type parameters or bounds inquired about are not assumed or defined by an ALLOCATE statement or a pointer assignment, or

(10) A restricted expression enclosed in parentheses.

A **specification expression** (R509, R514, R515) is a restricted expression that is scalar and of type integer.

R734 *specification-expr* is *scalar-int-expr*

Constraint: The *scalar-int-expr* must be a restricted expression.

If a specification expression includes a reference to an inquiry function for a type parameter or an array bound of an entity specified in the same *specification-part*, the type parameter or array bound must be specified in a prior specification expression of the *specification-part*. The prior specification may be to the left of the inquiry function in the same statement.

The following are examples of specification expressions:

```
LBOUND (B, 1) + 5
M + LEN (C)
2 * PRECISION (A)
```

where B, M, and C are dummy arguments, B is an assumed-shape array, and A is a real variable made accessible by a USE statement.

7.1.7 Evaluation of Operations.

This section applies to both intrinsic and defined operations.

Any variable or function reference used as an operand in an expression must be defined at the time the reference is executed. If the variable is a pointer, it must be associated with a target object that is defined. An integer operand must be defined with an integer value rather than a statement label value. All of the characters in a character data object reference must be defined.

When a reference to an array or an array section is made, all of the selected elements must be defined. When a structure is referenced, all of the components must be defined.

Any numeric operation whose result is not mathematically defined is prohibited in the execution of an executable program. Examples are dividing by zero and raising a zero-valued primary to a zero-valued or negative-valued power. Raising a negative-valued primary of type real to a real power also is prohibited.

The evaluation of a function reference must neither affect nor be affected by the evaluation of any other entity within the statement. However, execution of a function reference in the logical expression of an IF statement (8.1.2.4) or WHERE statement (7.5.3.1) is permitted to define variables in the statement that is executed when the value of the expression is true. For example, in the statements:

```
IF (F (X)) A = X
WHERE (G (X)) B = X
```

F or G may define X. If a function reference causes definition or undefinition of an actual argument of the function, that argument or any associated entities must not appear elsewhere in the same statement. For example, the statements

```
A (I) = F (I)
Y = G (X) + X
```

are prohibited if the reference to F defines or undefines I or the reference to G defines or undefines X.

The type of an expression in which a function reference appears does not affect, and is not affected by, the evaluation of the actual arguments of the function, except that the result of a function may assume a type that depends on the type of its arguments as specified in Sections 12 and 13.

Execution of an array element reference requires the evaluation of its subscripts. The type of an expression in which the array element reference appears does not affect, and is not affected by, the evaluation of its subscripts. Execution of an array section reference requires the evaluation of its section subscripts. The type of an expression in which an array section appears does not affect, and is not affected by, the evaluation of the array section subscripts. Execution of a substring reference requires the evaluation of its substring expressions. The type of an expression in which a substring appears does not affect, and is not affected by, the evaluation of the substring expressions. It is not necessary for a processor to evaluate any subscript expressions or substring expressions for an array of zero size or a character entity of zero length.

The appearance of an array constructor requires the evaluation of the bounds and stride of any array constructor implied-DO it may contain. The type of an expression in which an array constructor appears does not affect, and is not affected by, evaluation of such bounds and stride expressions.

When an intrinsic binary operation is applied to a scalar and an array or to two arrays of the same shape, the operation is performed element-by-element on corresponding array elements of the array operands. For example, the array expression

```
A + B
```

produces an array the same shape as A and B. The individual array elements of the result have the values of the first element of A added to the first element of B, the second element of A added to the second element of B, etc. The processor may perform the element-by-element operations in any order.

When an intrinsic unary operator operates on an array operand, the operation is performed element-by-element, in any order, and the result is the same shape as the operand.

7.1.7.1 Evaluation of Operands. It is not necessary for a processor to evaluate all of the operands of an expression if the value of the expression can be determined otherwise. This principle is most often applicable to logical expressions, zero-sized arrays, and zero-length strings, but it applies to all expressions. For example, in evaluating the expression

```
X .GT. Y .OR. L (Z)
```

where X, Y, and Z are real and L is a function of type logical, the function reference L (Z) need not be evaluated if X is greater than Y. Similarly, in the array expression

```
W (Z) + X
```

where X is of size zero and W is a function, the function reference W (Z) need not be evaluated. If a statement contains a function reference in a part of an expression that need not be evaluated, all entities that would have become defined in the execution of that reference become undefined at the completion of evaluation of the expression containing the function reference. In the preceding examples, evaluation of these expressions causes Z to become undefined if L or W defines its argument.

7.1.7.2 Integrity of Parentheses. The sections that follow state certain conditions under which a processor may evaluate an expression that is different from the one specified by applying the rules given in 7.1.1, 7.2, and 7.3. However, any expression contained in parentheses must be treated as a data entity. For example, in evaluating the expression A + (B – C) where A, B, and C are of numeric types, the difference of B and C must be evaluated before the addition operation is performed; the processor must not evaluate the mathematically equivalent expression (A + B) – C.

7.1.7.3 Evaluation of Numeric Intrinsic Operations. The rules given in 7.2.1 specify the interpretation of a numeric intrinsic operation. Once the interpretation has been established in accordance with those rules, the processor may evaluate any mathematically equivalent expression, provided that the integrity of parentheses is not violated.

Two expressions of a numeric type are mathematically equivalent if, for all possible values of their primaries, their mathematical values are equal. However, mathematically equivalent expressions of numeric type may produce different computational results. For example, any difference between the values of the expressions (1./3.)*3. and 1. is a computational difference, not a mathematical difference.

The mathematical definition of integer division is given in 7.2.1.1. The difference between the values of the expressions 5/2 and 5./2. is a mathematical difference, not a computational difference.

The following are examples of expressions with allowable alternative forms that may be used by the processor in the evaluation of those expressions. A, B, and C represent arbitrary real or complex operands; I and J represent arbitrary integer operands; and X, Y, and Z represent arbitrary operands of numeric type.

Expression	Allowable Alternative Form
`X + Y`	`Y + X`
`X * Y`	`Y * X`
`-X + Y`	`Y - X`
`X + Y + Z`	`X + (Y + Z)`
`X - Y + Z`	`X - (Y - Z)`
`X * A / Z`	`X * (A / Z)`
`X * Y - X * Z`	`X * (Y - Z)`
`A / B / C`	`A / (B * C)`
`A / 5.0`	`0.2 * A`

The following are examples of expressions with forbidden alternative forms that must not be used by a processor in the evaluation of those expressions.

Expression	Nonallowable Alternative Form
`I / 2`	`0.5 * I`
`X * I / J`	`X * (I / J)`
`I / J / A`	`I / (J * A)`
`(X + Y) + Z`	`X + (Y + Z)`
`(X * Y) - (X * Z)`	`X * (Y - Z)`
`X * (Y - Z)`	`X * Y - X * Z`

In addition to the parentheses required to establish the desired interpretation, parentheses may be included to restrict the alternative forms that may be used by the processor in the actual evaluation of the expression. This is useful for controlling the magnitude and accuracy of intermediate values developed during the evaluation of an expression. For example, in the expression

```
A + (B - C)
```

the parenthesized expression (B – C) must be evaluated and then added to A.

Note that the inclusion of parentheses may change the mathematical value of an expression. For example, the two expressions:

```
A * I / J
A * (I / J)
```

may have different mathematical values if I and J are of type integer.

Each operand in a numeric intrinsic operation has a data type that may depend on the order of evaluation used by the processor. For example, in the evaluation of the expression

```
Z + R + I
```

where Z, R, and I represent data objects of complex, real, and integer data type, respectively, the data type of the operand that is added to I may be either complex or real, depending on which pair of operands (Z and R, R and I, or Z and I) is added first.

7.1.7.4 Evaluation of the Character Intrinsic Operation. The rules given in 7.2.2 specify the interpretation of a character intrinsic operation. A processor needs to evaluate only as much of the character intrinsic operation as is required by the context in which the expression appears. For example, the statements

```
CHARACTER (LEN = 2) C1, C2, C3, CF
C1 = C2 // CF (C3)
```

do not require the function CF to be evaluated, because only the value of C2 is needed to determine the value of C1 because C1 has a length of 2.

7.1.7.5 Evaluation of Relational Intrinsic Operations. The rules given in 7.2.3 specify the interpretation of relational intrinsic operations. Once the interpretation of an expression has been established in accordance with those rules, the processor may evaluate any other expression that is relationally equivalent, provided that the integrity of parentheses in any expression is not violated. For example, the processor may choose to evaluate the expression

```
I .GT. J
```

where I and J are integer variables, as

```
J - I .LT. 0
```

Two relational intrinsic operations are relationally equivalent if their logical values are equal for all possible values of their primaries.

7.1.7.6 Evaluation of Logical Intrinsic Operations. The rules given in 7.2.4 specify the interpretation of logical intrinsic operations. Once the interpretation of an expression has been established in accordance with those rules, the processor may evaluate any other expression that is logically equivalent, provided that the integrity of parentheses in any expression is not violated. For example, for the variables L1, L2, and L3 of type logical, the processor may choose to evaluate the expression

```
L1 .AND. L2 .AND. L3
```

as

```
L1 .AND. (L2 .AND. L3)
```

Two expressions of type logical are logically equivalent if their values are equal for all possible values of their primaries.

7.1.7.7 Evaluation of a Defined Operation. The rules given in 7.3 specify the interpretation of a defined operation. Once the interpretation of an expression has been established in accordance with those rules, the processor may evaluate any other expression that is equivalent, provided that the integrity of parentheses is not violated.

Two expressions of derived type are equivalent if their values are equal for all possible values of their primaries.

7.2 Interpretation of Intrinsic Operations.

The intrinsic operations are those defined in 7.1.2. These operations are divided into the following categories: numeric, character, relational, and logical. The interpretations defined in the following sections apply to both scalars and arrays; the interpretation for arrays is obtained by applying the interpretation for scalars element by element.

The type, type parameters, and interpretation of an expression that consists of an intrinsic unary or binary operation are independent of the context in which the expression appears. In particular, the type, type parameters, and interpretation of such an expression are independent of the type and type parameters of any other larger expression in which it appears. For example, if X is of type real, J is of type integer, and INT is the real-to-integer intrinsic conversion function, the expression INT (X + J) is an integer expression and X + J is a real expression.

7.2.1 Numeric Intrinsic Operations. A numeric operation is used to express a numeric computation. Evaluation of a numeric operation produces a numeric value. The permitted data types for operands of the numeric intrinsic operations are specified in 7.1.2.

The numeric operators and their interpretation in an expression are given in Table 7.2, where x_1 denotes the operand to the left of the operator and x_2 denotes the operand to the right of the operator.

Table 7.2 Interpretation of the Numeric Intrinsic Operators

Operator	Representing	Use of Operator	Interpretation
**	Exponentiation	$x_1 ** x_2$	Raise x_1 to the power x_2
/	Division	x_1 / x_2	Divide x_1 by x_2
*	Multiplication	$x_1 * x_2$	Multiply x_1 by x_2
–	Subtraction	$x_1 - x_2$	Subtract x_2 from x_1
–	Negation	$-x_2$	Negate x_2
+	Addition	$x_1 + x_2$	Add x_1 and x_2
+	Identity	$+x_2$	Same as x_2

The interpretation of a division depends on the data types of the operands (7.2.1.1).

If x_1 and x_2 are of type integer and x_2 has a negative value, the interpretation of $x_1 ** x_2$ is the same as the interpretation of $1/(x_1 ** \text{ABS}(x_2))$, which is subject to the rules of integer division (7.2.1.1). For example, $2 ** (-3)$ has the value of $1/(2 ** 3)$, which is zero.

7.2.1.1 Integer Division. One operand of type integer may be divided by another operand of type integer. Although the mathematical quotient of two integers is not necessarily an integer, Table 7.1 specifies that an expression involving the division operator with two operands of type integer is interpreted as an expression of type integer. The result of such an operation is the integer closest to the mathematical quotient and between zero and the mathematical quotient inclusively. For example, the expression (–8) / 3 has the value (–2).

7.2.1.2 Complex Exponentiation. In the case of a complex value raised to a complex power, the value of the operation $x_1 ** x_2$ is the principal value of $x_1^{x_2}$.

7.2.2 Character Intrinsic Operation. The character intrinsic operator // is used to concatenate two operands of type character with the same kind type parameter. Evaluation of the character intrinsic operation produces a result of type character.

The interpretation of the character intrinsic operator // when used to form an expression is given in Table 7.3, where x_1 denotes the operand to the left of the operator and x_2 denotes the operand to the right of the operator.

Table 7.3 Interpretation of the Character Intrinsic Operator //

Operator	Representing	Use of Operator	Interpretation
//	Concatenation	x_1 // x_2	Concatenate x_1 with x_2

The result of a character intrinsic operation is a character string whose value is the value of x_1 concatenated on the right with the value of x_2 and whose length is the sum of the lengths of x_1 and x_2. Parentheses used to specify the order of evaluation have no effect on the value of a character expression. For example, the value of ('AB' // 'CDE') // 'F' is the string 'ABCDEF'. Also, the value of 'AB' // ('CDE' // 'F') is the string 'ABCDEF'.

7.2.3 Relational Intrinsic Operations. A relational intrinsic operator is used to compare values of two operands using the relational intrinsic operators .LT., .LE., .GT., .GE., .EQ., .NE., <, <=, >, >=, ==, and /=. The permitted data types for operands of the relational intrinsic operators are specified in 7.1.2. Note, as shown in Table 7.1, that a relational intrinsic operator must not be used to compare the value of an expression of a numeric type with one of type character or logical. Also, two operands of type logical must not be compared, a complex operand may be compared with another numeric operand only when the operator is .EQ. .NE., ==, or /=, and two character operands must not be compared unless they have the same kind type parameter value.

Evaluation of a relational intrinsic operation produces a result of type default logical.

The interpretation of the relational intrinsic operators is given in Table 7.4, where x_1 denotes the operand to the left of the operator and x_2 denotes the operand to the right of the operator. The operators <, <=, >, >=, ==, and /= always have the same interpretations as the operators .LT., .LE., .GT., .GE., .EQ., and .NE., respectively.

Table 7.4 Interpretation of the Relational Intrinsic Operators

Operator	Representing	Use of Operator	Interpretation
.LT.	Less Than	x_1 .LT. x_2	x_1 less than x_2
<	Less Than	$x_1 < x_2$	x_1 less than x_2
.LE.	Less Than Or Equal To	x_1 .LE. x_2	x_1 less than or equal to x_2
<=	Less Than Or Equal To	$x_1 <= x_2$	x_1 less than or equal to x_2
.GT.	Greater Than	x_1 .GT. x_2	x_1 greater than x_2
>	Greater Than	$x_1 > x_2$	x_1 greater than x_2
.GE.	Greater Than Or Equal To	x_1 .GE. x_2	x_1 greater than or equal to x_2
>=	Greater Than Or Equal To	$x_1 >= x_2$	x_1 greater than or equal to x_2
.EQ.	Equal To	x_1 .EQ. x_2	x_1 equal to x_2
==	Equal To	$x_1 == x_2$	x_1 equal to x_2
.NE.	Not Equal To	x_1 .NE. x_2	x_1 not equal to x_2
/=	Not Equal To	$x_1 /= x_2$	x_1 not equal to x_2

A numeric relational intrinsic operation is interpreted as having the logical value true if the values of the operands satisfy the relation specified by the operator. A numeric relational intrinsic operation is interpreted as having the logical value false if the values of the operands do not satisfy the relation specified by the operator.

In the numeric relational operation

x_1 *rel-op* x_2

if the type or type parameters of x_1 and x_2 differ, their values are converted to the type and type parameters of the expression $x_1 + x_2$ before evaluation.

A character relational intrinsic operation is interpreted as having the logical value true if the values of the operands satisfy the relation specified by the operator. A character relational intrinsic operation is interpreted as having the logical value false if the values of the operands do not satisfy the relation specified by the operator.

For a character relational intrinsic operation, the operands are compared one character at a time in order, beginning with the first character of each character operand. If the operands are of unequal length, the shorter operand is treated as if it were extended on the right with blanks to the length of the longer operand. If both x_1 and x_2 are of zero length, x_1 is equal to x_2; if every character of x_1 is the same as the character in the corresponding position in x_2, x_1 is equal to x_2. Otherwise, at the first position where the character operands differ, the character operand x_1 is considered to be less than x_2 if the character value of x_1 at this position precedes the value of x_2 in the collating sequence (3.1.7); x_1 is greater than x_2 if the character value of x_1 at this position follows the value of x_2 in the collating sequence. Note that the collating sequence depends partially on the processor; however, the result of the use of the operators .EQ., .NE., ==, and /= does not depend on the collating sequence.

Note that for nondefault character types, the blank padding character is processor dependent.

7.2.4 Logical Intrinsic Operations. A logical operation is used to express a logical computation. Evaluation of a logical operation produces a result of type logical. The permitted data types for operands of the logical intrinsic operations are specified in 7.1.2.

The logical operators and their interpretation when used to form an expression are given in Table 7.5, where x_1 denotes the operand to the left of the operator and x_2 denotes the operand to the right of the operator.

Table 7.5 Interpretation of the Logical Intrinsic Operators

Operator	Representing	Use of Operator	Interpretation
.NOT.	Logical Negation	.NOT. x_2	True if x_2 is false
.AND.	Logical Conjunction	x_1 .AND. x_2	True if x_1 and x_2 are both true
.OR.	Logical Inclusive Disjunction	x_1 .OR. x_2	True if x_1 and/or x_2 is true
.NEQV.	Logical Non-equivalence	x_1 .NEQV. x_2	True if either x_1 or x_2 is true, but not both
.EQV.	Logical Equivalence	x_1 .EQV. x_2	True if both x_1 and x_2 are true or both are false

The values of the logical intrinsic operations are shown in Table 7.6.

Table 7.6 The Values of Operations Involving Logical Intrinsic Operators

x_1	x_2	.NOT. x_2	x_1 .AND. x_2	x_1 .OR. x_2	x_1 .EQV. x_2	x_1 .NEQV. x_2
true	true	false	true	true	true	false
true	false	true	false	true	false	true
false	true	false	false	true	false	true
false	false	true	false	false	true	false

7.3 Interpretation of Defined Operations. The interpretation of a defined operation is provided by the function subprogram that defines the operation. The type, type parameters, and interpretation of an expression that consists of a defined operation are independent of the type and type parameters of any larger expression in which it appears. The operators <, <=, >, >=, ==, and /= always have the same interpretations as the operators .LT., .LE., .GT., .GE., .EQ., and .NE., respectively.

7.3.1 Unary Defined Operation. A function subprogram defines the unary operation *op* x_2 if:

(1) The function subprogram is specified with a FUNCTION statement (12.5.2.2) that specifies one dummy argument d_2,

(2) The interface to the function subprogram is explicit (12.3.2.1) with a *generic-spec* of OPERATOR (*op*),

(3) The type of x_2 is the same as the type of dummy argument d_2,

(4) The type parameters, if any, of x_2 match those of d_2,

(5) The rank of x_2, and its shape if it is an array, match those of d_2.

7.3.2 Binary Defined Operation. A function subprogram defines the binary operation x_1 *op* x_2 if:

(1) The function subprogram is specified with a FUNCTION statement (12.5.2.2) that specifies two dummy arguments, d_1 and d_2,

(2) The interface to the function subprogram is explicit (12.3.2.1) with a *generic-spec* of OPERATOR (*op*),

(3) The types of x_1 and x_2 are the same as those of the dummy arguments d_1 and d_2, respectively,

(4) The type parameters, if any, of x_1 and x_2 match those of d_1 and d_2, respectively, and

(5) The ranks of x_1 and x_2, and their shapes if either or both are arrays, match those of d_1 and d_2, respectively.

7.4 Precedence of Operators.

There is a precedence among the intrinsic and extension operations implied by the general form in 7.1.1, which determines the order in which the operands are combined, unless the order is changed by the use of parentheses. This precedence order is summarized in Table 7.7.

Table 7.7 Categories of Operations and Relative Precedences

Category of Operation	Operators	Precedence
Extension	*defined-unary-op*	Highest
Numeric	**	.
Numeric	* or /	.
Numeric	unary + or –	.
Numeric	binary + or –	.
Character	//	.
Relational	.EQ., .NE., .LT., .LE., .GT., .GE. ==,/=, <, <=, >, >=	.
Logical	.NOT.	.
Logical	.AND.	.
Logical	.OR.	.
Logical	.EQV. or .NEQV.	.
Extension	*defined-binary-op*	Lowest

The precedence of a defined operation is that of its operator.

For example, in the expression

```
-A ** 2
```

the exponentiation operator (**) has precedence over the negation operator (–); therefore, the operands of the exponentiation operator are combined to form an expression that is used as the operand of the negation operator. The interpretation of the above expression is the same as the

interpretation of the expression

```
- (A ** 2)
```

The general form of an expression (7.1.1) also establishes a precedence among operators in the same syntactic class. This precedence determines the order in which the operands are to be combined in determining the interpretation of the expression unless the order is changed by the use of parentheses. For example, in interpreting a *level-2-expr* containing two or more binary operators + or –, each operand (*add-operand*) is combined from left to right. Similarly, the same left-to-right interpretation for a *mult-operand* in *add-operand*, as well as for other kinds of expressions, is a consequence of the general form. However, for interpreting a *mult-operand* expression when two or more exponentiation operators ** combine *level-1-expr* operands, each *level-1-expr* is combined from right to left. For example, the expressions

```
2.1 + 3.4 + 4.9
2.1 * 3.4 * 4.9
2.1 / 3.4 / 4.9
2 ** 3 ** 4
'AB' // 'CD' // 'EF'
```

have the same interpretations as the expressions

```
(2.1 + 3.4) + 4.9
(2.1 * 3.4) * 4.9
(2.1 / 3.4) / 4.9
2 ** (3 ** 4)
('AB' // 'CD') // 'EF'
```

As a consequence of the general form (7.1.1), only the first *add-operand* of a *level-2-expr* may be preceded by the identity (+) or negation (–) operator. These formation rules do not permit expressions containing two consecutive numeric operators, such as A ** –B or A + –B. However, expressions such as A ** (–B) and A + (–B) are permitted. The rules do allow a binary operator or an intrinsic unary operator to be followed by a defined unary operator, such as:

```
A * .INVERSE. B
- .INVERSE. (B)
```

As another example, in the expression

```
A .OR. B .AND. C
```

the general form implies a higher precedence for the .AND. operator than for the .OR. operator; therefore, the interpretation of the above expression is the same as the interpretation of the expression

```
A .OR. (B .AND. C)
```

An expression may contain more than one category of operator. For example, the logical expression

```
L .OR. A + B .GE. C
```

where A, B, and C are of type real, and L is of type logical, contains a numeric operator, a relational operator, and a logical operator. This expression would be interpreted the same as the expression

```
L .OR. ((A + B) .GE. C)
```

For example, if:

(1) The operator ** is extended to type logical,

(2) The operator .STARSTAR. is defined to duplicate the function of ** on type real,

(3) .MINUS. is defined to duplicate the unary operator –, and

(4) L1 and L2 are type logical and X and Y are type real,

then in precedence: L1 ** L2 is higher than X * Y; X * Y is higher than X .STARSTAR. Y; and .MINUS. X is higher than –X.

7.5 Assignment. Execution of an assignment statement causes a variable to become defined or redefined. Execution of a pointer assignment statement causes a pointer to become associated with a target. Execution of a WHERE statement or WHERE construct masks the evaluation of expressions and assignment of values in array assignment statements according to the value of a logical array expression.

7.5.1 Assignment Statement. A variable may be defined or redefined by execution of an assignment statement.

7.5.1.1 General Form.

R735 *assignment-stmt* is *variable* = *expr*

where *variable* is defined in R601 and *expr* is defined in R723.

Constraint: A *variable* in an *assignment-stmt* must not be an assumed-size array.

Examples of an assignment statement are:

```
A = 3.5 + X * Y
I = INT (A)
```

An assignment statement is either intrinsic or defined.

7.5.1.2 Intrinsic Assignment Statement. An **intrinsic assignment statement** is an assignment statement where the shapes of *variable* and *expr* conform and where:

(1) The types of *variable* and *expr* are intrinsic, as specified in Table 7.8 for assignment, or

(2) The types of *variable* and *expr* are of the same derived type.

A **numeric intrinsic assignment statement** is an intrinsic assignment statement for which *variable* and *expr* are of numeric type. A **character intrinsic assignment statement** is an intrinsic assignment statement for which *variable* and *expr* are of type character and have the same kind type parameter. A **logical intrinsic assignment statement** is an intrinsic assignment statement for which *variable* and *expr* are of type logical. A **derived-type intrinsic assignment statement** is an intrinsic assignment statement for which *variable* and *expr* are of the same derived type.

An **array intrinsic assignment statement** is an intrinsic assignment statement for which *variable* is an array. The *variable* must not be a many-one array section (6.2.2.3.2).

Table 7.8 Type Conformance for the Intrinsic Assignment Statement *variable* = *expr*

Type of *variable*	Type of *expr*
integer	integer, real, complex
real	integer, real, complex
complex	integer, real, complex
character	character of the same kind type parameter as *variable*
logical	logical
derived type	same derived type as *variable*

7.5.1.3 Defined Assignment Statement. A **defined assignment statement** is an assignment statement that is not an intrinsic assignment statement, and is defined by a subroutine whose interface is explicit (7.5.1.6).

7.5.1.4 Intrinsic Assignment Conformance Rules. For an intrinsic assignment statement, *variable* and *expr* must conform in shape, and if *expr* is an array, *variable* must also be an array. The types of *variable* and *expr* must conform with the rules of Table 7.8.

If *variable* is a pointer, it must be associated with a definable target such that the type, type parameters, and shape of the target and *expr* conform.

For a numeric intrinsic assignment statement, *variable* and *expr* may have different numeric types or different type parameters, in which case the value of *expr* is converted to the type and type parameters of *variable* according to the rules of Table 7.9.

Table 7.9 Numeric Conversion and Assignment Statement *variable* = *expr*

Type of *variable*	Value Assigned
integer	INT (*expr*, KIND = *scalar-int-restricted-constant-expr*)
real	REAL (*expr*, KIND = *scalar-int-restricted-constant-expr*)
complex	CMPLX (*expr*, KIND = *scalar-int-restricted-constant-expr*)

(The functions INT, REAL, and CMPLX are the generic functions defined in 13.13.)

For a character intrinsic assignment statement, *variable* and *expr* must have the same kind type parameter value, but may have different length type parameters in which case the conversion of *expr* to the length of *variable* is:

(1) If the length of *variable* is less than that of *expr*, the value of *expr* is truncated from the right until it is the same length as *variable*;

(2) If the length of *variable* is greater than that of *expr*, the value of *expr* is extended on the right with blanks until it is the same length as *variable*.

Note that for nondefault character types, the blank padding character is processor dependent.

7.5.1.5 Interpretation of Intrinsic Assignments. Execution of an intrinsic assignment causes, in effect, the evaluation of the expression *expr* and all expressions within *variable* (7.1.7), the possible conversion of *expr* to the type and type parameters of *variable* (Table 7.9), and the definition of *variable* with the resulting value. The execution of the assignment must have the same effect as if the evaluation of all operations in *expr* and, if present, all operations in the subscripts or section subscripts of *variable* occurred before any portion of *variable* is defined by the assignment. The evaluation of expressions within *variable* must neither affect nor be affected by the evaluation of *expr*. No value is assigned to *variable* if *variable* is of type character and zero length, or is an array of size zero.

If *variable* is a pointer, the value of *expr* is assigned to the target of *variable*.

Both *variable* and *expr* may contain references to any portion of *variable*. For example, in the character intrinsic assignment statement:

```
STRING (2:5) = STRING (1:4)
```

the assignment of the first character of STRING to the second character does not affect the evaluation of STRING (1:4). That is, if the value of STRING prior to the assignment was 'ABCDEF', the value following the assignment is 'AABCDF'.

If *expr* in an assignment is a scalar and *variable* is an array, the *expr* is treated as if it were an array of the same shape as *variable* with every element of the array equal to the scalar value of *expr*.

When a *variable* in an intrinsic assignment is an array, the assignment is performed element-by-element on corresponding array elements of *variable* and *expr*. For example, where A and B are arrays of the same shape, the array intrinsic assignment

```
A = B
```

assigns the corresponding elements of B to those of A; that is, the first element of B is assigned to the first element of A, the second element of B is assigned to the second element of A, etc. The processor may perform the element-by-element assignment in any order.

For example, the following program segment results in the values of the elements of array X being reversed:

```
REAL X (10)
   ...
X (1:10) = X (10:1:-1)
```

A derived-type intrinsic assignment is performed as if each component of *expr* were assigned to the corresponding component of *variable* using pointer assignment (7.5.2) for pointer components, and intrinsic assignment for nonpointer components. The processor may perform the component-by-component assignment in any order or by any means that has the same effect.

For an example of a derived-type intrinsic assignment statement, if C and D are of the same derived type with components S, T, U, and V of type integer, logical, character, and another derived type, respectively, the intrinsic assignment

```
C = D
```

assigns D % S to C % S using the numeric intrinsic assignment statement, D % T to C % T using the logical intrinsic assignment statement, D % U to C % U using the character intrinsic assignment statement, and D % V to C % V using the derived-type intrinsic assignment statement.

When *variable* is a subobject, the assignment does not affect the definition status or value of other parts of the object. For example, if *variable* is an array section, the assignment does not affect the definition status or value of the elements of the parent array not specified by the array section.

7.5.1.6 Interpretation of Defined Assignment Statements. The interpretation of a defined assignment is provided by the subroutine subprogram that defines the operation.

A subroutine subprogram defines the defined assignment $x_1 = x_2$ if:

(1) The subroutine subprogram is specified with a SUBROUTINE statement (12.5.2.3) that specifies two dummy arguments, d_1 and d_2,

(2) The interface to the subroutine subprogram is explicit, (12.3.2.1) with a *generic-spec* of ASSIGNMENT (=),

(3) The types of x_1 and x_2 are the same as those of the dummy arguments d_1 and d_2, respectively,

(4) The type parameters, if any, of x_1 and x_2 match those of d_1 and d_2, respectively, and

(5) The ranks of x_1 and x_2, and their shapes if either or both are arrays, match those of d_1 and d_2, respectively.

Note that x_1 and x_2 must not have the same type or both be numeric.

7.5.2 Pointer Assignment.

R736 *pointer-assignment-stmt* is *pointer-object* => *target*

R737 *target* is *variable*
or *function-reference*

Constraint: The *pointer-object* must have the POINTER attribute. The target object must have one of the attributes TARGET or POINTER or it must be a subobject of an object with one of these attributes.

Constraint: The *target* must be of the same type, type parameters, and rank as the pointer.

Constraint: The *target* must not be an array section with a vector subscript.

Constraint: The *function-reference* must deliver a pointer result.

A pointer assignment statement associates a pointer with a target. If the target is itself a pointer that is associated, the pointer is associated with the same object as the target. If the target is a pointer that is disassociated, the pointer also becomes disassociated.

If the target is a pointer with undefined association status, the pointer also acquires an undefined association status.

Any previous association between the pointer and a target is broken.

In addition to pointer assignment, a pointer becomes associated with a target by allocation of the pointer.

A pointer must not be referenced or defined unless it is associated with a target that may be referenced or defined.

The following are examples of pointer assignment statements.

```
NEW_NODE % LEFT => CURRENT_NODE
SIMPLE_NAME => STRUCTURE % SUBSTRUCT % COMPONENT
ROW => MAT2D (N, :)
WINDOW => MAT2D (I-1:I+1, J-1:J+1)
POINTER_OBJECT => POINTER_FUNCTION (ARG_1, ARG_2)
EVERY_OTHER => VECTOR (1:N:2)
```

Pointer assignment for a pointer component of a structure also may take place by execution of an intrinsic assignment statement for the structure (7.5.1.5).

7.5.3 Masked Array Assignment—WHERE. The masked array assignment is used to mask the evaluation of expressions and assignment of values in array assignment statements, according to the value of a logical array expression.

7.5.3.1 General Form of the Masked Array Assignment. A masked array assignment is either a WHERE statement or WHERE construct.

R738 *where-stmt* is WHERE (*mask-expr*) *assignment-stmt*

R739 *where-construct* is *where-construct-stmt*
[*assignment-stmt*] ...
[*elsewhere-stmt*
[*assignment-stmt*] ...]
end-where-stmt

R740 *where-construct-stmt* is WHERE (*mask-expr*)

R741 *mask-expr* is *logical-expr*

R742 *elsewhere-stmt* is ELSEWHERE

R743 *end-where-stmt* is END WHERE

Constraint: In each *assignment-stmt*, the *mask-expr* and the variable being defined must be arrays of the same shape.

Examples of a masked array assignment are:

```
WHERE (TEMP > 100.0) TEMP = TEMP - REDUCE_TEMP

WHERE (PRESSURE <= 1.0)
   PRESSURE = PRESSURE + INC_PRESSURE
   TEMP = TEMP - 5.0
ELSEWHERE
   RAINING = .TRUE.
END WHERE
```

7.5.3.2 Interpretation of Masked Array Assignments. When the *assignment-stmt* in a *where-stmt* is executed, the *expr* of the *assignment-stmt* is evaluated for all the elements where *mask-expr* is true and the result is assigned to the corresponding elements of *variable* following the rules of intrinsic assignment (7.5.1.5). When a *where-construct* is executed, the *mask-expr* is evaluated and the result kept by the processor. Each *assignment-stmt* in the where block is evaluated, in sequence, as if it were WHERE (*mask-expr*) *assignment-stmt* and then each *assignment-stmt* in the ELSEWHERE block is evaluated, in sequence, as if it were WHERE (.NOT. *mask-expr*) *assignment-stmt*.

If a nonelemental function reference occurs in the *expr* of an *assignment-stmt*, the function is evaluated without any masked control by the *mask-expr*; that is, all of its argument expressions are fully evaluated and the function is fully evaluated. If the result is an array, elements corresponding to true values in *mask-expr* (false in the *mask-expr* after ELSEWHERE) are selected for use in evaluating each *expr*.

If an elemental intrinsic function reference (12.4.3) occurs in the *expr* of an *assignment-stmt* and is not within the argument list of a nonelemental function reference, the function is evaluated only for the elements corresponding to true values in *mask-expr* (false values after ELSEWHERE).

In a masked array assignment, only a WHERE statement or a WHERE construct statement may be a branch target statement. The value of *mask-expr* evaluated at the beginning of the masked array assignment governs the masking in the execution of the masked array assignment; subsequent changes to entities in *mask-expr* have no effect on the masking. The execution of a function reference in the mask expression of a WHERE statement is permitted to affect entities in the assignment statement. Execution of an END WHERE has no effect.

Examples of function references in masked array assignments are:

```
WHERE (A > 0.0)
   A = LOG (A)             ! LOG is invoked only for positive elements.
   A = A / SUM (LOG (A))   ! LOG is invoked for all elements.
END WHERE
```

8. EXECUTION CONTROL

The execution sequence may be controlled by constructs containing blocks and by certain executable statements that are used to alter the execution sequence.

8.1 Executable Constructs Containing Blocks. The following are executable constructs that contain blocks and may be used to control the execution sequence:

(1) IF Construct

(2) CASE Construct

(3) DO Construct

There is also a nonblock form of the DO construct.

A **block** is a sequence of executable constructs that is treated as a unit.

R801 *block* is [*execution-part-construct*] ...

Executable constructs may be used to control which blocks of a program are executed or how many times a block is executed. Blocks are always bounded by statements that are particular to the construct in which they are embedded; however, in some forms of the DO construct, a sequence of executable constructs without a terminating boundary statement must obey all other rules governing blocks (8.1.1). Note that a block need not contain any executable constructs. Execution of such a block has no effect.

Any of these three constructs may be named. If a construct is named, the name must be the first lexical token of the first statement of the construct and the last lexical token of the construct. In fixed source form, the name preceding the construct must be placed after column 6.

A statement **belongs** to the innermost construct in which it appears unless it contains a construct name, in which case it belongs to the named construct.

An example of a construct containing a block is:

```
IF (A > 0.0) THEN
   B = SQRT (A)   ! These two statements
   C = LOG (A)    ! form a block.
END IF
```

8.1.1 Rules Governing Blocks.

8.1.1.1 Executable Constructs in Blocks. If a block contains an executable construct, the executable construct must be contained entirely within the block.

8.1.1.2 Control Flow in Blocks. Transfer of control to the interior of a block from outside the block is prohibited. Transfers within a block and transfers from the interior of a block to outside the block may occur. For example, if a statement inside the block has a statement label, a GO TO statement using that label may appear in the same block. Subroutine and function references may appear in a block (12.4.2, 12.4.3, 12.4.4, 12.4.5).

8.1.1.3 Execution of a Block. Execution of a block begins with the execution of the first executable construct in the block. Unless there is a transfer of control out of the block, the execution of the block is completed when the last executable construct in the sequence is executed. The action that takes place at the terminal boundary depends on the particular construct and on the block within that construct. It is usually a transfer of control.

8.1.2 IF Construct. The IF construct selects for execution no more than one of its constituent blocks. The IF statement controls the execution of a single statement (8.1.2.4).

8.1.2.1 Form of the IF Construct.

R802 *if-construct* is *if-then-stmt*
block
[*else-if-stmt*
block] ...
[*else-stmt*
block]
end-if-stmt

R803 *if-then-stmt* is [*if-construct-name* :] IF (*scalar-logical-expr*) THEN

R804 *else-if-stmt* is ELSE IF (*scalar-logical-expr*) THEN [*if-construct-name*]

R805 *else-stmt* is ELSE [*if-construct-name*]

R806 *end-if-stmt* is END IF [*if-construct-name*]

Constraint: If the *if-then-stmt* of an *if-construct* is identified by an *if-construct-name*, the corresponding *end-if-stmt* must specify the same *if-construct-name*. If the *if-then-stmt* of an *if-construct* is not identified by an *if-construct-name*, the corresponding *end-if-stmt* must not specify an *if-construct-name*. If an *else-if-stmt* or *else-stmt* is identified by an *if-construct-name*, the corresponding *if-then-stmt* must specify the same *if-construct-name*.

8.1.2.2 Execution of an IF Construct. At most one of the blocks contained within the IF construct is executed. If there is an ELSE statement in the construct, exactly one of the blocks contained within the construct will be executed. The scalar logical expressions are evaluated in the order of their appearance in the construct until a true value is found or an ELSE statement or END IF statement is encountered. If a true value or an ELSE statement is found, the block immediately following is executed and this completes the execution of the construct. The scalar logical expressions in any remaining ELSE IF statements of the IF construct are not evaluated. If none of the evaluated expressions is true and there is no ELSE statement, the execution of the construct is completed without the execution of any blocks within the construct.

An ELSE IF statement or an ELSE statement must not be a branch target statement. It is permissible to branch to an END IF statement from within the IF construct, and also from outside the construct. Execution of an END IF statement has no effect.

8.1.2.3 Examples of IF Constructs.

```
IF (CVAR .EQ. 'RESET') THEN
   I = 0; J = 0; K = 0
END IF

PROOF_DONE: IF (PROP) THEN
   WRITE (3, '("QED")')
   STOP
ELSE
   PROP = NEXTPROP
END IF PROOF_DONE

IF (A .GT. 0) THEN
   B = C/A
   IF (B .GT. 0) THEN
      D = 1.0
   END IF
ELSE IF (C .GT. 0) THEN
   B = A/C
   D = -1.0
```

```
ELSE
   B = ABS (MAX (A, C))
   D = 0
END IF
```

8.1.2.4 IF Statement. The IF statement controls a single action statement (R216).

R807 *if-stmt* is IF (*scalar-logical-expr*) *action-stmt*

Constraint: The *action-stmt* in the *if-stmt* must not be an *if-stmt*, *end-program-stmt*, *end-function-stmt*, or *end-subroutine-stmt*.

Execution of an IF statement causes evaluation of the scalar logical expression. If the value of the expression is true, the action statement is executed. If the value is false, the action statement is not executed and execution continues as though a CONTINUE statement (8.3) were executed.

The execution of a function reference in the scalar logical expression is permitted to affect entities in the action statement.

An example of an IF statement is:

```
IF (A > 0.0) A = LOG (A)
```

8.1.3 CASE Construct. The CASE construct selects for execution at most one of its constituent blocks.

8.1.3.1 Form of the CASE Construct.

R808 *case-construct* is *select-case-stmt*
[*case-stmt*
block] ...
end-select-stmt

R809 *select-case-stmt* is [*case-construct-name* :] SELECT CASE (*case-expr*)

R810 *case-stmt* is CASE *case-selector* [*case-construct-name*]

R811 *end-select-stmt* is END SELECT [*case-construct-name*]

Constraint: If the *select-case-stmt* of a *case-construct* is identified by a *case-construct-name*, the corresponding *end-select-stmt* must specify the same *case-construct-name*. If the *select-case-stmt* of a *case-construct* is not identified by a *case-construct-name*, the corresponding *end-select-stmt* must not specify a *case-construct-name*. If a *case-stmt* is identified by a *case-construct-name*, the corresponding *select-case-stmt* must specify the same *case-construct-name*.

R812 *case-expr* is *scalar-int-expr*
or *scalar-char-expr*
or *scalar-logical-expr*

R813 *case-selector* is (*case-value-range-list*)
or DEFAULT

Constraint: No more than one of the selectors of one of the CASE statements may be DEFAULT.

R814 *case-value-range* is *case-value*
or *case-value* :
or : *case-value*
or *case-value* : *case-value*

R815 *case-value* is *scalar-int-initialization-expr*
or *scalar-char-initialization-expr*
or *scalar-logical-initialization-expr*

Constraint: For a given *case-construct*, each *case-value* must be of the same type as *case-expr*. For character type, length differences are allowed, but the kind type parameters must be

the same.

Constraint: A *case-value-range* using a colon must not be used if *case-expr* is of type logical.

Constraint: For a given *case-construct*, the *case-value-ranges* must not overlap; that is, there must be no possible value of the *case-expr* that matches more than one *case-value-range*.

8.1.3.2 Execution of a CASE Construct. The execution of the SELECT CASE statement causes the case expression to be evaluated. The resulting value is called the **case index**. For a case value range list, a match occurs if the case index matches any of the case value ranges in the list. For a case index with a value of *c*, a match is determined as follows:

(1) If the case value range contains a single value *v* without a colon, a match occurs for data type logical if the expression *c* .EQV. *v* is true, and a match occurs for data type integer or character if the expression *c* .EQ. *v* is true.

(2) If the case value range is of the form *low* : *high*, a match occurs if the expression *low* .LE. *c* .AND. *c* .LE. *high* is true.

(3) If the case value range is of the form *low* :, a match occurs if the expression *low* .LE. *c* is true.

(4) If the case value range is of the form : *high*, a match occurs if the expression *c* .LE. *high* is true.

(5) If no other selector matches and a DEFAULT selector is present, it matches the case index.

(6) If no other selector matches and the DEFAULT selector is absent, there is no match. Execution continues with the statement following the CASE construct.

The block following the CASE statement containing the matching selector, if any, is executed. This completes execution of the construct.

At most one of the blocks of a CASE construct is executed.

A CASE statement must not be a branch target statement. It is permissible to branch to an END SELECT statement only from within the CASE construct.

8.1.3.3 Examples of CASE Constructs. An integer signum function:

```
INTEGER FUNCTION SIGNUM (N)
SELECT CASE (N)
CASE (:-1)
   SIGNUM = -1
CASE (0)
   SIGNUM = 0
CASE (1:)
   SIGNUM = 1
END SELECT
END
```

A code fragment to check for balanced parentheses:

```
CHARACTER (80) :: LINE
   ...
LEVEL=0
DO I = 1, 80
   CHECK_PARENS: SELECT CASE (LINE (I:I))
   CASE ('(')
      LEVEL = LEVEL + 1
```

```
      CASE (')')
         LEVEL = LEVEL - 1
         IF (LEVEL .LT. 0) THEN
            PRINT *, 'UNEXPECTED RIGHT PARENTHESIS'
            EXIT
         END IF
      CASE DEFAULT
         ! Ignore all other characters
      END SELECT CHECK_PARENS
   END DO
   IF (LEVEL .GT. 0) THEN
      PRINT *, 'MISSING RIGHT PARENTHESIS'
   END IF
```

The following three fragments are equivalent:

```
IF (SILLY .EQ. 1) THEN
   CALL THIS
ELSE
   CALL THAT
END IF

SELECT CASE (SILLY .EQ. 1)
CASE (.TRUE.)
   CALL THIS
CASE (.FALSE.)
   CALL THAT
END SELECT

SELECT CASE (SILLY)
CASE DEFAULT
   CALL THAT
CASE (1)
   CALL THIS
END SELECT
```

A code fragment showing several selections of one block:

```
SELECT CASE (N)
CASE (1, 3:5, 8)  ! Selects 1, 3, 4, 5, 8
   CALL SUB
CASE DEFAULT
   CALL OTHER
END SELECT
```

8.1.4 DO Construct. The DO construct specifies the repeated execution of a sequence of executable constructs. Such a repeated sequence is called a **loop**. The EXIT and CYCLE statements may be used to modify the execution of a loop.

The number of iterations of a loop may be determined at the beginning of execution of the DO construct, or may be left indefinite ("DO forever" or DO WHILE). In either case, an EXIT statement (8.1.4.4.4) anywhere in the DO construct may be executed to terminate the loop immediately. A particular iteration of the loop may be curtailed by executing a CYCLE statement (8.1.4.4.3).

8.1.4.1 Forms of the DO Construct. The DO construct may be written in either a block form or a nonblock form.

R816 *do-construct* is *block-do-construct*
or *nonblock-do-construct*

8.1.4.1.1 Form of the Block DO Construct.

R817 *block-do-construct* is *do-stmt*
do-block
end-do

R818 *do-stmt* is *label-do-stmt*
or *nonlabel-do-stmt*

R819 *label-do-stmt* is [*do-construct-name* :] DO *label* [*loop-control*]

R820 *nonlabel-do-stmt* is [*do-construct-name* :] DO [*loop-control*]

R821 *loop-control* is [,] *do-variable* = *scalar-numeric-expr* , ■ *scalar-numeric-expr* [, *scalar-numeric-expr*]
or [,] WHILE (*scalar-logical-expr*)

R822 *do-variable* is *scalar-variable*

Constraint: The *do-variable* must be a scalar integer, default real, or double precision real named variable.

Constraint: Each *scalar-numeric-expr* in *loop-control* must be of type integer, default real, or double precision real.

R823 *do-block* is *block*

R824 *end-do* is *end-do-stmt*
or *continue-stmt*

R825 *end-do-stmt* is END DO [*do-construct-name*]

Constraint: If the *do-stmt* of a *block-do-construct* is identified by a *do-construct-name*, the corresponding *end-do* must be an *end-do-stmt* specifying the same *do-construct-name*. If the *do-stmt* of a *block-do-construct* does not so specify a *do-construct-name*, the corresponding *end-do* must not specify a *do-construct-name*.

Constraint: If the *do-stmt* is a *nonlabel-do-stmt*, the corresponding *end-do* must be an *end-do-stmt*.

Constraint: If the *do-stmt* is a *label-do-stmt*, the corresponding *end-do* must be identified with the same *label*.

8.1.4.1.2 Form of the Nonblock DO Construct.

R826 *nonblock-do-construct* is *action-term-do-construct*
or *outer-shared-do-construct*

R827 *action-term-do-construct* is *label-do-stmt*
do-body
do-term-action-stmt

R828 *do-body* is [*execution-part-construct*] ...

R829 *do-term-action-stmt* is *action-stmt*

Constraint: A *do-term-action-stmt* must not be a *continue-stmt*, a *goto-stmt*, a *return-stmt*, a *stop-stmt*, an *exit-stmt*, a *cycle-stmt*, an *end-function-stmt*, an *end-subroutine-stmt*, an *end-program-stmt*, an *arithmetic-if-stmt*, or an *assigned-goto-stmt*.

Constraint: The *do-term-action-stmt* must be identified with a label and the corresponding *label-do-stmt* must refer to the same label.

R830 *outer-shared-do-construct* is *label-do-stmt*
do-body
shared-term-do-construct

R831 *shared-term-do-construct* is *outer-shared-do-construct*
or *inner-shared-do-construct*

R832 *inner-shared-do-construct* is *label-do-stmt*

do-body
do-term-shared-stmt

R833 *do-term-shared-stmt* is *action-stmt*

Constraint: A *do-term-shared-stmt* must not be a *goto-stmt*, a *return-stmt*, a *stop-stmt*, an *exit-stmt*, a *cycle-stmt*, an *end-function-stmt*, an *end-subroutine-stmt*, an *end-program-stmt*, an *arithmetic-if-stmt*, or an *assigned-goto-stmt*.

Constraint: The *do-term-shared-stmt* must be identified with a label and all of the *label-do-stmts* of the *shared-term-do-construct* must refer to the same label.

The *do-term-action-stmt*, *do-term-shared-stmt*, or *shared-term-do-construct* following the *do-body* of a nonblock DO construct is called the **DO termination** of that construct.

Within a scoping unit, all DO constructs whose DO statements refer to the same label are nonblock DO constructs, and are said to **share** the statement identified by that label.

8.1.4.2 Range of the DO Construct. The range of a block DO construct is the *do-block* which must satisfy the rules for blocks (8.1.1). In particular, transfer of control to the interior of such a block from outside the block is prohibited. It is permissible to branch to the *end-do* of a block DO construct only from within the range of that DO construct.

The range of a nonblock DO construct consists of the *do-body* and the following DO termination. The end of such a range is not bounded by a particular statement as for the other executable constructs (e.g., END IF); nevertheless, the range satisfies the rules for blocks (8.1.1). Transfer of control into the *do-body* or to the DO termination from outside the range is prohibited; in particular, it is permissible to branch to a *do-term-shared-stmt* only from within the range of the corresponding *inner-shared-do-construct*.

8.1.4.3 Active and Inactive DO Constructs. A DO construct is either **active** or **inactive**. Initially inactive, a DO construct becomes active only when its DO statement is executed.

Once active, the DO construct becomes inactive only when the construct it specifies is terminated (8.1.4.4.4). When an active DO construct becomes inactive, the *do-variable*, if any, retains its last defined value.

8.1.4.4 Execution of a DO Construct. A DO construct specifies a loop, that is, a sequence of executable constructs that is executed repeatedly. There are three phases in the execution of a DO construct: initiation of the loop, execution of the loop range, and termination of the loop.

8.1.4.4.1 Loop Initiation. When the DO statement is executed, the DO construct becomes active. If *loop-control* is

[,] *do-variable* = *scalar-numeric-expr*$_1$, *scalar-numeric-expr*$_2$ [, *scalar-numeric-expr*$_3$]

the following steps are performed in sequence:

(1) The initial parameter m_1, the terminal parameter m_2, and the incrementation parameter m_3 are established by evaluating *scalar-numeric-expr*$_1$, *scalar-numeric-expr*$_2$, and *scalar-numeric-expr*$_3$, respectively, including, if necessary, conversion to the type and kind type parameter of the *do-variable* according to the rules for numeric conversion (Table 7.9). If *scalar-numeric-expr*$_3$ does not appear, m_3 is of type default integer and its value is 1. The value m_3 must not be zero.

(2) The DO variable becomes defined with the value of the initial parameter m_1.

(3) The **iteration count** is established and is the value of the expression

$$\mathrm{MAX}(\mathrm{INT}((m_2 - m_1 + m_3) / m_3), 0)$$

Note that the iteration count is zero whenever:

$m_1 > m_2$ and $m_3 > 0$, or
$m_1 < m_2$ and $m_3 < 0$.

If *loop-control* is omitted or is WHILE, no iteration count is calculated. The effect is as if a large positive iteration count, impossible to decrement to zero, were established. If *loop-control* is [,] WHILE (*scalar-logical-expr*), the effect is as if *loop-control* were omitted and the following statement inserted as the first statement of the *do-block*:

```
IF (.NOT. (scalar-logical-expr)) EXIT
```

At the completion of the execution of the DO statement, the execution cycle begins.

8.1.4.4.2 The Execution Cycle. The **execution cycle** of a DO construct consists of the following steps performed in sequence repeatedly until termination:

(1) The iteration count, if any, is tested. If the iteration count is zero, the loop terminates and the DO construct becomes inactive. If *loop-control* is [,] WHILE (*scalar-logical-expr*), the *scalar-logical-expr* is evaluated; if the value of this expression is false, the loop terminates and the DO construct becomes inactive. If, as a result, all of the DO constructs sharing the *do-term-shared-stmt* are inactive, the execution of all of these constructs is complete. However, if some of the DO constructs sharing the *do-term-shared-stmt* are active, execution continues with step (3) of the execution cycle of the active DO construct whose DO statement was most recently executed.

(2) If the iteration count is nonzero, the range of the loop is executed.

(3) The iteration count, if any, is decremented by one. The DO variable, if any, is incremented by the value of the incrementation parameter m_3.

Except for the incrementation of the DO variable that occurs in step (3), the DO variable must neither be redefined nor become undefined while the DO construct is active.

8.1.4.4.3 CYCLE Statement. Step (2) in the above execution cycle may be curtailed by executing a CYCLE statement from within the range of the loop.

R834 *cycle-stmt* is CYCLE [*do-construct-name*]

Constraint: If a *cycle-stmt* refers to a *do-construct-name*, it must be within the range of that *do-construct*; otherwise, it must be within the range of at least one *do-construct*

A CYCLE statement belongs to a particular DO construct. If the CYCLE statement refers to a DO construct name, it belongs to that DO construct; otherwise, it belongs to the innermost DO construct in which it appears.

Execution of a CYCLE statement causes immediate progression to step (3) of the current execution cycle of the DO construct to which it belongs. If this construct is a nonblock DO construct, the *do-term-action-stmt* or *do-term-shared-stmt* is not executed.

In a block DO construct, a transfer of control to the *end-do* has the same effect as execution of a CYCLE statement belonging to that construct. In a nonblock DO construct, transfer of control to the *do-term-action-stmt* or *do-term-shared-stmt* causes that statement or construct itself to be executed. Unless a further transfer of control results, step (3) of the current execution cycle of the DO construct is then executed.

8.1.4.4.4 Loop Termination. The EXIT statement provides one way of terminating a loop.

R835 *exit-stmt* is EXIT [*do-construct-name*]

Constraint: If an *exit-stmt* refers to a *do-construct-name*, it must be within the range of that *do-construct*; otherwise, it must be within the range of at least one *do-construct*.

An EXIT statement belongs to a particular DO construct. If the EXIT statement refers to a DO construct name, it belongs to that DO construct; otherwise, it belongs to the innermost DO construct in which it appears.

The loop terminates, and the DO construct becomes inactive, when any of the following occurs:

(1) Determination that the iteration count is zero when tested during step (1) of the above execution cycle

(2) Execution of an EXIT statement belonging to the DO construct

(3) Execution of an EXIT statement or a CYCLE statement that is within the range of the DO construct, but that belongs to an outer DO construct

(4) Transfer of control from a statement within the range of a DO construct to a statement that is neither the *end-do* nor within the range of the same DO construct

(5) Execution of a RETURN statement within the range of the DO construct

(6) Execution of a STOP statement anywhere in the program; or termination of the program for any other reason.

When a DO construct becomes inactive, the DO-variable, if any, of the DO construct retains its last defined value.

8.1.4.5 Examples of DO Constructs. The following are all valid examples of block DO constructs.

Example 1:

```
DO I = 1, M
   DO J = 1, N
      C (I, J) = SUM (A (I, J, :) * B (:, I, J))
   END DO
END DO
```

The above program fragment computes a tensor product of two arrays.

Example 2:

```
READ (IUN, '(1X, G14.7)', IOSTAT = IOS) X
DO WHILE (IOS .EQ. 0)
   IF (X .GE. 0.) THEN
      CALL SUBA (X)
      CALL SUBB (X)
           ...
      CALL SUBZ (X)
   ENDIF
   READ (IUN, '(1X, G14.7)', IOSTAT = IOS) X
END DO
```

The above program fragment contains a DO construct that uses the WHILE form of *loop-control*. The loop will continue to execute until an end-of-file or input/output error is encountered, at which point the DO statement terminates the loop. When a negative value of X is read, the program skips immediately to the next READ statement, bypassing most of the range of the loop.

Example 3:

```
DO   ! A "DO WHILE + 1/2" loop
   READ (IUN, '(1X, G14.7)', IOSTAT = IOS) X
   IF (IOS .NE. 0) EXIT
   IF (X < 0.) CYCLE
   CALL SUBA (X)
   CALL SUBB (X)
        ...
   CALL SUBZ (X)
END DO
```

Example 3 behaves exactly the same as example 2. However, the READ statement has been moved to the interior of the range, so that only one READ statement is required. Also, a CYCLE statement has been used to avoid an extra level of IF nesting.

Example 4:

```
      SUM = 0.0
      READ (IUN) N
      OUTER: DO L = 1, N            ! A DO with a construct name
         READ (IUN) IQUAL, M, ARRAY (1:M)
         IF (IQUAL < IQUAL_MIN) CYCLE OUTER    ! Skip inner loop
         INNER: DO 40 I = 1, M      ! A DO with a label and a name
            CALL CALCULATE (ARRAY (I), RESULT)
            IF (RESULT < 0.0) CYCLE
            SUM = SUM + RESULT
            IF (SUM > SUM_MAX) EXIT OUTER
   40    END DO INNER
      END DO OUTER
```

The outer loop has an iteration count of MAX (N, 0), and will execute that number of times unless SUM exceeds SUM_MAX, in which case the EXIT OUTER statement terminates both loops. The inner loop is skipped by the first CYCLE statement if the quality flag, IQUAL, is too low. If CALCULATE returns a negative RESULT, the second CYCLE statement prevents it from being summed. Note that both loops have construct names and the inner loop also has a label. A construct name is required on the EXIT statement in order to terminate both loops, but is optional on the CYCLE statements because each belongs to its innermost loop.

Example 5:

```
      N = 0
      DO 50, I = 1, 10
         J = I
         DO K = 1, 5
            L = K
            N = N + 1  ! This statement executes 50 times
         END DO        ! Nonlabeled DO inside a labeled DO
   50 CONTINUE
```

After execution of the above program fragment, I = 11, J = 10, K = 6, L = 5, and N = 50.

Example 6:

```
      N = 0
      DO I = 1, 10
         J = I
         DO 60, K = 5, 1  ! This inner loop is never executed
            L = K
            N = N + 1
   60    CONTINUE         ! Labeled DO inside a nonlabeled DO
      END DO
```

After execution of the above program fragment, I = 11, J = 10, K = 5, N = 0, and L is not defined by these statements.

The following are all valid examples of nonblock DO constructs:

Example 7:

```
      DO 70
         READ (IUN, '(1X, G14.7)', IOSTAT = IOS) X
         IF (IOS .NE. 0) EXIT
         IF (X < 0.) GOTO 70
         CALL SUBA (X)
         CALL SUBB (X)
              ...
         CALL SUBY (X)
         CYCLE
   70    CALL SUBNEG (X)  ! SUBNEG called only when X < 0.
```

This is not a block DO construct because it ends with a statement other than END DO or CONTINUE. The loop will continue to execute until an end-of-file condition or input/output error occurs.

Example 8:

```
      SUM = 0.0
      READ (IUN) N
      DO 80, L = 1, N
         READ (IUN) IQUAL, M, ARRAY (1:M)
         IF (IQUAL < IQUAL_MIN) M = 0  ! Skip inner loop
         DO 80 I = 1, M
            CALL CALCULATE (ARRAY (I), RESULT)
            IF (RESULT < 0.) CYCLE
            SUM = SUM + RESULT
            IF (SUM > SUM_MAX) GOTO 81
   80    CONTINUE  ! This CONTINUE is shared by both loops
   81 CONTINUE
```

This example is similar to Example 3 above, except that the two loops are not block DO constructs because they share the CONTINUE statement with the label 80. The terminal construct of the outer DO is the entire inner DO construct. The inner loop is skipped by forcing M to zero. If SUM grows too large, both loops are terminated by branching to the CONTINUE statement labeled 81. The CYCLE statement in the inner loop may still be used to skip negative values of RESULT.

Example 9:

```
      N = 0
      DO 100 I = 1, 10
         J = I
         DO 100 K = 1, 5
            L = K
  100       N = N + 1  ! This statement executes 50 times
```

In this example, the two loops share an assignment statement. After execution of this program fragment, I = 11, J = 10, K = 6, L = 5, and N = 50.

Example 10:

```
      N = 0
      DO 200 I = 1, 10
         J = I
         DO 200 K = 5, 1  ! This inner loop is never executed
            L = K
  200       N = N + 1
```

This example is very similar to the previous one, except that the inner loop is never executed. After execution of this program fragment, I = 11, J = 10, K = 5, N = 0, and L is not defined by these statements.

8.2 Branching.

Branching is used to alter the normal execution sequence. A branch causes a transfer of control from one statement in a scoping unit to a labeled branch target statement in the same scoping unit. A **branch target statement** is an *action-stmt*, an *if-then-stmt*, an *end-if-stmt*, a *select-case-stmt*, an *end-select-stmt*, a *do-stmt*, an *end-do-stmt*, a *do-term-action-stmt*, a *do-term-shared-stmt*, or a *where-construct-stmt*.

It is permissible to branch to an END SELECT statement only from within its CASE construct.

It is permissible to branch to an END IF statement from within its IF construct, and also from outside the construct.

It is permissible to branch to an *end-do-stmt*, a *do-term-action-stmt*, or a *do-term-shared-stmt* only from within its DO construct.

8.2.1 Statement Labels. A statement label provides a means of referring to an individual statement. Any statement not forming part of another statement may be identified with a label, but only branch target statements, FORMAT statements, and DO terminations may be referred to by the use of statement labels (3.2.5).

8.2.2 GO TO Statement.

R836 *goto-stmt* is GO TO *label*

Constraint: The *label* must be the statement label of a branch target statement that appears in the same scoping unit as the *goto-stmt*.

Execution of a GO TO statement causes a transfer of control so that the branch target statement identified by the label is executed next.

8.2.3 Computed GO TO Statement.

R837 *computed-goto-stmt* is GO TO (*label-list*) [,] *scalar-int-expr*

Constraint: Each *label* in *label-list* must be the statement label of a branch target statement that appears in the same scoping unit as the *computed-goto-stmt*.

The same statement label may appear more than once in a label list.

Execution of a computed GO TO statement causes evaluation of the scalar integer expression. If this value is i such that $1 \le i \le n$ where n is the number of labels in *label-list*, a transfer of control occurs so that the next statement executed is the one identified by the ith label in the list of labels. If i is less than 1 or greater than n, the execution sequence continues as though a CONTINUE statement were executed.

8.2.4 ASSIGN and Assigned GO TO Statement.

R838 *assign-stmt* is ASSIGN *label* TO *scalar-int-variable*

Constraint: The *label* must be the statement label of a branch target statement or *format-stmt* that appears in the same scoping unit as the *assign-stmt*.

Constraint: *scalar-int-variable* must be of type default integer.

R839 *assigned-goto-stmt* is GO TO *scalar-int-variable* [[,] (*label-list*)]

Constraint: Each *label* in *label-list* must be the statement label of a branch target statement that appears in the same scoping unit as the *assigned-goto-stmt*.

Constraint: *scalar-int-variable* must be of type default integer.

Execution of an ASSIGN statement causes a statement label to be assigned to an integer variable. While defined with a statement label value, the integer variable may be referenced only in the context of an assigned GO TO statement or as a format specifier in an input/output statement. An integer variable defined with a statement label value may be redefined with a statement label value or an integer value.

When an input/output statement containing the integer variable as a format specifier (9.4.1.1) is executed, the integer variable must be defined with the label of a FORMAT statement.

At the time of execution of an assigned GO TO statement, the integer variable must be defined with the value of a statement label of a branch target statement that appears in the same scoping unit. Note that the variable may be defined with a statement label value only by an ASSIGN statement in the same scoping unit as the assigned GO TO statement.

The execution of the assigned GO TO statement causes a transfer of control so that the branch target statement identified by the statement label currently assigned to the integer variable is executed next.

If the parenthesized list is present, the statement label assigned to the integer variable must be one of the statement labels in the list. A label may appear more than once in the label list of an assigned GOTO statement.

8.2.5 Arithmetic IF Statement.

R840 *arithmetic-if-stmt* is IF (*scalar-numeric-expr*) *label* , *label* , *label*

Constraint: Each *label* must be the label of a branch target statement that appears in the same scoping unit as the *arithmetic-if-stmt*.

Constraint: The *scalar-numeric-expr* must not be of type complex.

The same label may appear more than once in one arithmetic IF statement.

Execution of an arithmetic IF statement causes evaluation of the numeric expression followed by a transfer of control. The branch target statement identified by the first label, the second label, or the third label is executed next as the value of the numeric expression is less than zero, equal to zero, or greater than zero, respectively.

8.3 CONTINUE Statement.

Execution of a CONTINUE statement has no effect.

R841 *continue-stmt* is CONTINUE

8.4 STOP Statement.

R842 *stop-stmt* is STOP [*stop-code*]

R843 *stop-code* is *scalar-char-constant*
or *digit* [*digit* [*digit* [*digit* [*digit*]]]]

Constraint: *scalar-char-constant* must be of type default character.

Execution of a STOP statement causes termination of execution of the executable program. At the time of termination, the stop code, if any, is available in a processor-dependent manner. Leading zero digits are not significant.

8.5 PAUSE Statement.

R844 *pause-stmt* is PAUSE [*stop-code*]

Execution of a PAUSE statement causes a suspension of execution of the executable program. Execution must be resumable. At the time of suspension of execution, the stop code, if any, is available in a processor-dependent manner. Leading zero digits in the stop code are not significant. Resumption of execution is not under control of the program. If execution is resumed, the execution sequence continues as though a CONTINUE statement were executed.

9. INPUT/OUTPUT STATEMENTS

Input statements provide the means of transferring data from external media to internal storage or from an internal file to internal storage. This process is called **reading. Output statements** provide the means of transferring data from internal storage to external media or from internal storage to an internal file. This process is called **writing.** Some input/output statements specify that editing of the data is to be performed.

In addition to the statements that transfer data, there are auxiliary input/output statements to manipulate the external medium, or to describe or inquire about the properties of the connection to the external medium.

The input/output statements are the OPEN, CLOSE, READ, WRITE, PRINT, BACKSPACE, ENDFILE, REWIND, and INQUIRE statements.

The READ statement is a **data transfer input statement.** The WRITE statement and the PRINT statement are **data transfer output statements.** The OPEN statement and the CLOSE statement are **file connection statements.** The INQUIRE statement is a **file inquiry statement.** The BACKSPACE, ENDFILE, and REWIND statements are **file positioning statements.**

9.1 Records. A **record** is a sequence of values or a sequence of characters. For example, a line on a terminal is usually considered to be a record. However, a record does not necessarily correspond to a physical entity. There are three kinds of records:

(1) Formatted

(2) Unformatted

(3) Endfile

9.1.1 Formatted Record. A **formatted record** consists of a sequence of characters that are capable of representation in the processor. The length of a formatted record is measured in characters and depends primarily on the number of characters put into the record when it is written. However, it may depend on the processor and the external medium. The length may be zero. Formatted records may be read or written only by formatted input/output statements.

Formatted records may be prepared by means other than Fortran; for example, by some manual input device.

9.1.2 Unformatted Record. An **unformatted record** consists of a sequence of values in a processor-dependent form and may contain data of any type or may contain no data. The length of an unformatted record is measured in processor-dependent units and depends on the output list (9.4.2) used when it is written, as well as on the processor and the external medium. The length may be zero. Unformatted records may be read or written only by unformatted input/output statements.

9.1.3 Endfile Record. An **endfile record** is written explicitly by the ENDFILE statement; the file must be connected for sequential access. An endfile record is written implicitly to a file connected for sequential access when the last reference to the file is a data transfer output statement or a file positioning output statement, and:

(1) A REWIND or BACKSPACE statement references the unit to which the file is connected, or

(2) The unit (file) is closed, either explicitly by a CLOSE statement or implicitly by a program termination not caused by an error condition.

An endfile record may occur only as the last record of a file. An endfile record does not have a length property.

9.2 Files. A file is a sequence of records.

There are two kinds of files:

(1) External

(2) Internal

9.2.1 External Files. An **external file** is any file that exists in a medium external to the executable program.

At any given time, there is a processor-dependent **set of allowed access methods**, a processor-dependent **set of allowed forms**, a processor-dependent **set of allowed actions**, and a processor-dependent **set of allowed record lengths** for a file.

A file may have a name; a file that has a name is called a **named file**. The name of a named file is a character string. The set of allowable names for a file is processor dependent.

An external file that is connected to a unit has a **position** property (9.2.1.3).

9.2.1.1 File Existence. At any given time, there is a processor-dependent set of external files that are said to **exist** for an executable program. A file may be known to the processor, yet not exist for an executable program at a particular time. For example, there may be security reasons that prevent a file from existing for an executable program. A file may exist and contain no records; an example is a newly created file not yet written.

To **create a file** means to cause a file to exist that did not exist previously. To **delete a file** means to terminate the existence of the file.

All input/output statements may refer to files that exist. An INQUIRE, OPEN, CLOSE, WRITE, PRINT, REWIND, or ENDFILE statement also may refer to a file that does not exist. Execution of a WRITE or PRINT statement referring to a preconnected file that does not exist creates the file.

9.2.1.2 File Access. There are two methods of accessing the records of an external file, sequential and direct. Some files may have more than one allowed access method; other files may be restricted to one access method. For example, a processor may allow only sequential access to a file on magnetic tape. Thus, the set of allowed access methods depends on the file and the processor.

The method of accessing the file is determined when the file is connected to a unit (9.3.2) or when the file is created if the file is preconnected (9.3.3).

9.2.1.2.1 Sequential Access. When connected for **sequential access**, an external file has the following properties:

(1) The order of the records is the order in which they were written if the direct access method is not a member of the set of allowed access methods for the file. If the direct access method is also a member of the set of allowed access methods for the file, the order of the records is the same as that specified for direct access. In this case, the first record accessed by sequential access is the record whose record number is 1 for direct access. The second record accessed by sequential access is the record whose record number is 2 for direct access, etc. A record that has not been written since the file was created must not be read.

(2) The records of the file are either all formatted or all unformatted, except that the last record of the file may be an endfile record. Unless the previous reference to the file was a data transfer output statement or a file positioning statement, the last record, if any, of the file must be an endfile record.

(3) The records of the file must not be read or written by direct access input/output statements.

9.2.1.2.2 Direct Access. When connected for **direct access**, an external file has the following properties:

(1) Each record of the file is uniquely identified by a positive integer called the **record number**. The record number of a record is specified when the record is written. Once established, the record number of a record can never be changed. Note that a record may not be deleted; however, a record may be rewritten. The order of the records is the order of their record numbers.

(2) The records of the file are either all formatted or all unformatted. If the sequential access method is also a member of the set of allowed access methods for the file, its endfile record, if any, is not considered to be part of the file while it is connected for direct access. If the sequential access method is not a member of the set of allowed access methods for the file, the file must not contain an endfile record.

(3) Reading and writing records is accomplished only by direct access input/output statements.

(4) All records of the file have the same length.

(5) Records need not be read or written in the order of their record numbers. Any record may be written into the file while it is connected to a unit. For example, it is permissible to write record 3, even though records 1 and 2 have not been written. Any record may be read from the file while it is connected to a unit, provided that the record has been written since the file was created.

(6) The records of the file must not be read or written using list-directed formatting (10.8), namelist formatting (10.9), or a nonadvancing input/output statement.

9.2.1.3 File Position. Execution of certain input/output statements affects the position of an external file. Certain circumstances can cause the position of a file to become indeterminate.

The **initial point** of a file is the position just before the first record. The **terminal point** is the position just after the last record. If there are no records in the file, the initial point and the terminal point are the same position.

If a file is positioned within a record, that record is the **current record**; otherwise, there is no current record.

Let n be the number of records in the file. If $1 < i \leq n$ and a file is positioned within the ith record or between the $(i-1)$th record and the ith record, the $(i-1)$th record is the **preceding record**. If $n \geq 1$ and the file is positioned at its terminal point, the preceding record is the nth and last record. If $n = 0$ or if a file is positioned at its initial point or within the first record, there is no preceding record.

If $1 \leq i < n$ and a file is positioned within the ith record or between the ith and $(i+1)$th record, the $(i+1)$th record is the **next record**. If $n \geq 1$ and the file is positioned at its initial point, the first record is the next record. If $n = 0$ or if a file is positioned at its terminal point or within the nth (last) record, there is no next record.

9.2.1.3.1 Advancing and Nonadvancing Input/Output. An **advancing input/output statement** always positions the file after the last record read or written, unless there is an error condition.

A **nonadvancing input/output statement** may position the file at a character position within the current record. Using nonadvancing input/output, it is possible to read or write a record of the file by a sequence of input/output statements, each accessing a portion of the record. It is also possible to read variable-length records and be notified of their lengths.

9.2.1.3.2 File Position Prior to Data Transfer. The positioning of the file prior to data transfer depends on the method of access: sequential or direct.

For sequential access on input, if there is a current record, the file position is not changed. Otherwise, the file is positioned at the beginning of the next record and this record becomes the current record. Input must not occur if there is no next record or if there is a current record and the last data transfer statement accessing the file performed output.

If the file contains an endfile record, the file must not be positioned after the endfile record prior to data transfer. However, a REWIND or BACKSPACE statement may be used to reposition the file.

For sequential access on output, if there is a current record, the file position is not changed and the current record becomes the last record of the file. Otherwise, a new record is created as the next record of the file; this new record becomes the last and current record of the file and the file is positioned at the beginning of this record.

For direct access, the file is positioned at the beginning of the record specified by the record specifier. This record becomes the current record.

9.2.1.3.3 File Position After Data Transfer. If an error condition (9.4.1.5) occurred, the position of the file is indeterminate. If no error condition occurred, but an end-of-file condition (9.4.1.6) occurred as a result of reading an endfile record, the file is positioned after the endfile record.

If no error condition or end-of-file condition occurs, but an end-of-record condition (9.4.1.7) occurs, the file is positioned after the record just read. If no error condition, end-of-file condition, or end-of-record condition occurs, and the data transfer was a nonadvancing input or output statement, the file position is not changed. In all other cases, the file is positioned after the record just read or written and that record becomes the preceding record.

9.2.2 Internal Files. Internal files provide a means of transferring and converting data from internal storage to internal storage.

9.2.2.1 Internal File Properties. An internal file has the following properties:

(1) The file is a variable of default character type that is not an array section with a vector subscript.

(2) A record of an internal file is a scalar character variable.

(3) If the file is a scalar character variable, it consists of a single record whose length is the same as the length of the scalar character variable. If the file is a character array, it is treated as a sequence of character array elements. Each array element, if any, is a record of the file. The ordering of the records of the file is the same as the ordering of the array elements in the array (6.2.2.2) or the array section (6.2.2.3). Every record of the file has the same length, which is the length of an array element in the array.

(4) A record of the internal file becomes defined by writing the record. If the number of characters written in a record is less than the length of the record, the remaining portion of the record is filled with blanks. The number of characters to be written must not exceed the length of the record.

(5) A record may be read only if the record is defined.

(6) A record of an internal file may become defined (or undefined) by means other than an output statement. For example, the character variable may become defined by a character assignment statement.

(7) An internal file is always positioned at the beginning of the first record prior to data transfer. This record becomes the current record.

(8) On input, blanks are treated as though the format had an initial BN edit descriptor (10.6.6) and records are padded with blanks if necessary (9.4.4.4.2).

(9) On list-directed output, character constants are not delimited (10.8.2).

9.2.2.2 Internal File Restrictions. An internal file has the following restrictions:

(1) Reading and writing records must be accomplished only by sequential access formatted input/output statements that do not specify namelist formatting.

(2) An internal file must not be specified in a file connection statement, a file positioning statement, or a file inquiry statement.

9.3 File Connection.

A unit, specified by an *io-unit*, provides a means for referring to a file.

R901	*io-unit*	is	*external-file-unit*
		or	*
		or	*internal-file-unit*
R902	*external-file-unit*	is	*scalar-int-expr*
R903	*internal-file-unit*	is	*default-char-variable*

Constraint: The *char-variable* must not be an array section with a vector subscript.

A unit is either an external unit or an internal unit. An **external unit** is used to refer to an external file and is specified by an *external-file-unit* or an asterisk. An **internal unit** is used to refer to an internal file and is specified by an *internal-file-unit*.

If a character variable that identifies an internal file unit is a pointer, it must be associated. If the character variable is an allocatable array or a subobject of such an array, the array must be currently allocated.

A scalar integer expression that identifies an external file unit must be zero or positive.

The *io-unit* in a file positioning statement, a file connection statement, or a file inquiry statement must be an *external-file-unit*.

The external unit identified by the value of the *scalar-int-expr* is the same external unit in all program units of the executable program. In the example:

```
SUBROUTINE A
   READ (6) X
   .
   .
   .
SUBROUTINE B
   N = 6
   REWIND N
```

the value 6 used in both program units identifies the same external unit.

An asterisk identifies particular processor-dependent external units that are preconnected for formatted sequential access (9.4.4.2).

9.3.1 Unit Existence. At any given time, there is a processor-dependent set of external units that are said to exist for an executable program.

All input/output statements may refer to units that exist. The INQUIRE statement and the CLOSE statement also may refer to units that do not exist.

9.3.2 Connection of a File to a Unit. An external unit has a property of being **connected** or not connected. If connected, it refers to an external file. An external unit may become connected by preconnection or by the execution of an OPEN statement. The property of connection is symmetric; if a unit is connected to a file, the file is connected to the unit.

All input/output statements except an OPEN, a CLOSE, or an INQUIRE statement must refer to a unit that is connected to a file and thereby make use of or affect that file.

A file may be connected and not exist. An example is a preconnected external file that has not yet been written (9.2.1.1).

A unit must not be connected to more than one file at the same time, and a file must not be connected to more than one unit at the same time. However, means are provided to change the status of an external unit and to connect a unit to a different file.

After an external unit has been disconnected by the execution of a CLOSE statement, it may be connected again within the same executable program to the same file or to a different file. After an external file has been disconnected by the execution of a CLOSE statement, it may be connected again within the same executable program to the same unit or to a different unit. Note, however, that the only means of referencing a file that has been disconnected is by the appearance of its name in an OPEN or INQUIRE statement. There may be no means of reconnecting an unnamed file once it is disconnected.

An internal unit is always connected to the internal file designated by the variable of default character type that identifies the unit.

9.3.3 Preconnection. **Preconnection** means that the unit is connected to a file at the beginning of execution of the executable program and therefore it may be specified in input/output statements without the prior execution of an OPEN statement.

9.3.4 The OPEN Statement. An OPEN statement initiates or modifies the connection between an external file and a specified unit. The OPEN statement may be used to connect an existing file to a unit, create a file that is preconnected, create a file and connect it to a unit, or change certain specifiers of a connection between a file and a unit.

An external unit may be connected by an OPEN statement in any program unit of an executable program and, once connected, a reference to it may appear in any program unit of the executable program.

If a unit is connected to a file that exists, execution of an OPEN statement for that unit is permitted. If the FILE= specifier is not included in such an OPEN statement, the file to be connected to the unit is the same as the file to which the unit is already connected.

If the file to be connected to the unit does not exist but is the same as the file to which the unit is preconnected, the properties specified by an OPEN statement become a part of the connection.

If the file to be connected to the unit is not the same as the file to which the unit is connected, the effect is as if a CLOSE statement without a STATUS= specifier had been executed for the unit immediately prior to the execution of an OPEN statement.

If the file to be connected to the unit is the same as the file to which the unit is connected, only the BLANK=, DELIM=, PAD=, ERR=, and IOSTAT= specifiers may have values different from those currently in effect. Execution of such an OPEN statement causes any new value of the BLANK=, DELIM=, or PAD= specifiers to be in effect, but does not cause any change in any of the unspecified specifiers and the position of the file is unaffected. The ERR= and IOSTAT= specifiers from any previously executed OPEN statement have no effect on any currently executed OPEN statement.

If a file is already connected to a unit, execution of an OPEN statement on that file and a different unit is not permitted.

R904 *open-stmt* is OPEN (*connect-spec-list*)

R905 *connect-spec* is [UNIT=] *external-file-unit*
or IOSTAT= *scalar-default-int-variable*
or ERR= *label*
or FILE= *file-name-expr*
or STATUS= *scalar-default-char-expr*
or ACCESS= *scalar-default-char-expr*
or FORM= *scalar-default-char-expr*
or RECL= *scalar-int-expr*

or BLANK= *scalar-default-char-expr*
or POSITION= *scalar-default-char-expr*
or ACTION= *scalar-default-char-expr*
or DELIM= *scalar-default-char-expr*
or PAD= *scalar-default-char-expr*

R906 *file-name-expr* is *scalar-default-char-expr*

Constraint: If the optional characters UNIT= are omitted from the unit specifier, the unit specifier must be the first item in the *connect-spec-list*.

Constraint: Each specifier must not appear more than once in a given *open-stmt*; an *external-file-unit* must be specified.

Constraint: The *label* used in the ERR= specifier must be the statement label of a branch target statement that appears in the same scoping unit as the OPEN statement.

If the STATUS= specifier has the value OLD, NEW, or REPLACE, the FILE= specifier must be present. If the STATUS= specifier has the value SCRATCH, the FILE= specifier must be absent.

A specifier that requires a *scalar-default-char-expr* may have a limited list of character values. These values are listed for each such specifier. Any trailing blanks are ignored. If a processor is capable of representing letters in both upper and lower case, the value specified is without regard to case. Some specifiers have a default value if the specifier is omitted.

The IOSTAT= specifier and ERR= specifier are described in 9.4.1.4 and 9.4.1.5, respectively.

An example of an OPEN statement is:

```
OPEN (10, FILE = 'employee.names', ACTION = 'READ', PAD = 'YES')
```

9.3.4.1 FILE= Specifier in the OPEN Statement. The value of the FILE= specifier is the name of the file to be connected to the specified unit. Any trailing blanks are ignored. The *file-name-expr* must be a name that is allowed by the processor. If this specifier is omitted and the unit is not connected to a file, the STATUS= specifier must be specified with a value of SCRATCH; in this case the connection is made to a processor-dependent file. If a processor is capable of representing letters in both upper and lower case, the interpretation of case is processor dependent.

9.3.4.2 STATUS= Specifier in the OPEN Statement. The *scalar-default-char-expr* must evaluate to OLD, NEW, SCRATCH, REPLACE, or UNKNOWN. If OLD is specified, the file must exist. If NEW is specified, the file must not exist.

Successful execution of an OPEN statement with NEW specified creates the file and changes the status to OLD. If REPLACE is specified and the file does not already exist, the file is created and the status is changed to OLD. If REPLACE is specified and the file does exist, the file is deleted, a new file is created with the same name, and the status is changed to OLD. If SCRATCH is specified, the file is created and connected to the specified unit for use by the executable program but is deleted at the execution of a CLOSE statement referring to the same unit or at the termination of the executable program. Note that SCRATCH must not be specified with a named file. If UNKNOWN is specified, the status is processor dependent. If this specifier is omitted, the default value is UNKNOWN.

9.3.4.3 ACCESS= Specifier in the OPEN Statement. The *scalar-default-char-expr* must evaluate to SEQUENTIAL or DIRECT. The ACCESS= specifier specifies the access method for the connection of the file as being sequential or direct. If this specifier is omitted, the default value is SEQUENTIAL. For an existing file, the specified access method must be included in the set of allowed access methods for the file. For a new file, the processor creates the file with a set of allowed access methods that includes the specified method.

9.3.4.4 FORM= Specifier in the OPEN Statement. The *scalar-default-char-expr* must evaluate to FORMATTED or UNFORMATTED. The FORM= specifier determines whether the file is being connected for formatted or unformatted input/output. If this specifier is omitted, the default value is UNFORMATTED if the file is being connected for direct access, and the default value is FORMATTED if the file is being connected for sequential access. For an existing file, the specified form must be included in the set of allowed forms for the file. For a new file, the processor creates the file with a set of allowed forms that includes the specified form.

9.3.4.5 RECL= Specifier in the OPEN Statement. The value of the RECL= specifier must be positive. It specifies the length of each record in a file being connected for direct access, or specifies the maximum length of a record in a file being connected for sequential access. This specifier must be present when a file is being connected for direct access. If this specifier is omitted when a file is being connected for sequential access, the default value is processor dependent. If the file is being connected for formatted input/output, the length is the number of characters for all records that contain only characters of type default character. If the file is being connected for unformatted input/output, the length is measured in processor-dependent units. For an existing file, the value of the RECL= specifier must be included in the set of allowed record lengths for the file. For a new file, the processor creates the file with a set of allowed record lengths that includes the specified value.

9.3.4.6 BLANK= Specifier in the OPEN Statement. The *scalar-default-char-expr* must evaluate to NULL or ZERO. The BLANK= specifier is permitted only for a file being connected for formatted input/output. If NULL is specified, all blank characters in numeric formatted input fields on the specified unit are ignored, except that a field of all blanks has a value of zero. If ZERO is specified, all blanks other than leading blanks are treated as zeros. If this specifier is omitted, the default value is NULL.

9.3.4.7 POSITION= Specifier in the OPEN Statement. The *scalar-default-char-expr* must evaluate to ASIS, REWIND, or APPEND. The connection must be for sequential access. A file that did not exist previously (a new file, either specified explicitly or by default) is positioned at its initial point. REWIND positions an existing file at its initial point. APPEND positions an existing file such that the endfile record is the next record, if it has one. If an existing file does not have an endfile record, APPEND positions the file at its terminal point. ASIS leaves the position unchanged if the file exists and already is connected. ASIS leaves the position unspecified if the file exists but is not connected. If this specifier is omitted, the default value is ASIS.

9.3.4.8 ACTION= Specifier in the OPEN Statement. The *scalar-default-char-expr* must evaluate to READ, WRITE, or READWRITE. READ specifies that the WRITE, PRINT, and ENDFILE statements must not refer to this connection. WRITE specifies that READ statements must not refer to this connection. READWRITE permits any I/O statements to refer to this connection. If this specifier is omitted, the default value is processor dependent. If READWRITE is included in the set of allowable actions for a file, both READ and WRITE also must be included in the set of allowed actions for that file. For an existing file, the specified action must be included in the set of allowed actions for the file. For a new file, the processor creates the file with a set of allowed actions that includes the specified action.

9.3.4.9 DELIM= Specifier in the OPEN Statement. The *scalar-default-char-expr* must evaluate to APOSTROPHE, QUOTE, or NONE. If APOSTROPHE is specified, the apostrophe will be used to delimit character constants written with list-directed or namelist formatting and all internal apostrophes will be doubled. If QUOTE is specified, the quotation mark will be used to delimit character constants written with list-directed or namelist formatting and all internal quotation marks will be doubled. If APOSTROPHE or QUOTE is specified, a *kind-param* and underscore will be used to precede the leading delimiter of a nondefault character constant. If the value of this specifier is NONE, a character constant when written will not be delimited by apostrophes or quotation marks, nor will any internal apostrophes or quotation marks be doubled. If this specifier is omitted, the default value is NONE. This specifier is permitted only for a file being connected for formatted input/output. This specifier is ignored during input of a formatted record.

9.3.4.10 PAD= Specifier in the OPEN Statement. The *scalar-default-char-expr* must evaluate to YES or NO. If YES is specified, a formatted input record is padded with blanks (9.4.4.4.2) when an input list is specified and the format specification requires more data from a record than the record contains. If NO is specified, the input list and the format specification must not require more characters from a record than the record contains. If this specifier is omitted, the default value is YES. This specifier is permitted only for a file being connected for formatted input/output. This specifier is ignored during output of a formatted record.

Note that for nondefault character types, the blank padding character is processor dependent.

9.3.5 The CLOSE Statement. The CLOSE statement is used to terminate the connection of a specified unit to an external file.

Execution of a CLOSE statement that refers to a unit may occur in any program unit of an executable program and need not occur in the same program unit as the execution of an OPEN statement referring to that unit.

Execution of a CLOSE statement specifying a unit that does not exist or has no file connected to it is permitted and affects no file.

After a unit has been disconnected by execution of a CLOSE statement, it may be connected again within the same executable program, either to the same file or to a different file. After a named file has been disconnected by execution of a CLOSE statement, it may be connected again within the same executable program, either to the same unit or to a different unit, provided that the file still exists.

At termination of execution of an executable program for reasons other than an error condition, all units that are connected are closed. Each unit is closed with status KEEP unless the file status prior to termination of execution was SCRATCH, in which case the unit is closed with status DELETE. Note that the effect is as though a CLOSE statement without a STATUS= specifier were executed on each connected unit.

R907 *close-stmt* is CLOSE (*close-spec-list*)

R908 *close-spec* is [UNIT=] *external-file-unit*
or IOSTAT= *scalar-default-int-variable*
or ERR= *label*
or STATUS= *scalar-default-char-expr*

Constraint: If the optional characters UNIT= are omitted from the unit specifier, the unit specifier must be the first item in the *close-spec-list*.

Constraint: Each specifier must not appear more than once in a given *close-stmt*; an *external-file-unit* must be specified.

Constraint: The *label* used in the ERR= specifier must be the statement label of a branch target statement that appears in the same scoping unit as the CLOSE statement.

The *scalar-default-char-expr* has a limited list of character values. Any trailing blanks are ignored. If a processor is capable of representing letters in both upper and lower case, the value specified is without regard to case.

The IOSTAT= specifier and ERR= specifier are described in 9.4.1.4 and 9.4.1.5, respectively.

An example of a CLOSE statement is:

```
CLOSE (10, STATUS = 'KEEP')
```

9.3.5.1 STATUS= Specifier in the CLOSE Statement. The *scalar-default-char-expr* must evaluate to KEEP or DELETE. The STATUS= specifier determines the disposition of the file that is connected to the specified unit. KEEP must not be specified for a file whose status prior to execution of a CLOSE statement is SCRATCH. If KEEP is specified for a file that exists, the file continues to exist after the execution of a CLOSE statement. If KEEP is specified for a file that does not exist, the file will not exist after the execution of a CLOSE statement. If DELETE is specified, the file will not

exist after the execution of a CLOSE statement. If this specifier is omitted, the default value is KEEP, unless the file status prior to execution of the CLOSE statement is SCRATCH, in which case the default value is DELETE.

9.4 Data Transfer Statements.

The **READ statement** is the data transfer input statement. The **WRITE statement** and the **PRINT statement** are the data transfer output statements.

R909 *read-stmt* is READ (*io-control-spec-list*) [*input-item-list*]
or READ *format* [, *input-item-list*]

R910 *write-stmt* is WRITE (*io-control-spec-list*) [*output-item-list*]

R911 *print-stmt* is PRINT *format* [, *output-item-list*]

Examples of data transfer statements are:

```
   READ (6, *) SIZE
   READ 10, A, B
   WRITE (6, 10) A, S, J
   PRINT 10, A, S, J
10 FORMAT (2E16.3, I5)
```

9.4.1 Control Information List.

The *io-control-spec-list* is a **control information list** that includes:

(1) A reference to the source or destination of the data to be transferred

(2) Optional specification of editing processes

(3) Optional specification to identify a record

(4) Optional specification of exception handling

(5) Optional return of count of null values

(6) Optional return of status

(7) Optional record advancing specification

(8) Optional return of number of characters read

The control information list governs the data transfer.

R912 *io-control-spec* is [UNIT=] *io-unit*
or [FMT=] *format*
or [NML=] *namelist-group-name*
or REC= *scalar-int-expr*
or IOSTAT= *scalar-default-int-variable*
or ERR= *label*
or END= *label*
or ADVANCE= *scalar-default-char-expr*
or SIZE= *scalar-default-int-variable*
or EOR= *label*

Constraint: An *io-control-spec-list* must contain exactly one *io-unit* and may contain at most one of each of the other specifiers.

Constraint: An END=, EOR=, or SIZE= specifier must not appear in a *write-stmt*.

Constraint: The *label* in the ERR=, EOR=, or END= specifier must be the statement label of a branch target statement that appears in the same scoping unit as the data transfer statement.

Constraint: A *namelist-group-name* must not be present if an *input-item-list* or an *output-item-list* is present in the data transfer statement.

Constraint: An *io-control-spec-list* must not contain both a *format* and a *namelist-group-name*.

Constraint: If the optional characters UNIT= are omitted from the unit specifier, the unit specifier must be the first item in the control information list.

Constraint: If the optional characters FMT= are omitted from the format specifier, the format specifier must be the second item in the control information list and the first item must be the unit specifier without the optional characters UNIT=.

Constraint: If the optional characters NML= are omitted from the namelist specifier, the namelist specifier must be the second item in the control information list and the first item must be the unit specifier without the optional characters UNIT=.

Constraint: If the unit specifier specifies an internal file, the *io-control-spec-list* must not contain a REC= specifier or a *namelist-group-name*.

Constraint: If the REC= specifier is present, an END= specifier must not appear, a *namelist-group-name* must not appear, and the *format*, if any, must not be an asterisk specifying list-directed input/output.

Constraint: An ADVANCE= specifier may be present only in a formatted sequential input/output statement with explicit format specification (10.1) whose control information list does not contain an internal file unit specifier.

Constraint: If an EOR= specifier is present, and ADVANCE= specifier also must appear.

A SIZE= specifier may be present only in an input statement that contains an ADVANCE= specifier with the value NO.

An EOR= specifier may be present only in an input statement that contains an ADVANCE= specifier with the value NO.

If the data transfer statement contains a *format* or *namelist-group-name*, the statement is a **formatted input/output statement**; otherwise, it is an **unformatted input/output statement.**

In a data transfer statement, the variable specified in an IOSTAT= specifier, if any, must not be associated with any entity in the data transfer input/output list (9.4.2) or *namelist-group-object-list*, nor with a *do-variable* of an *io-implied-do* in the data transfer input/output list.

In a data transfer statement, if a variable specified in an IOSTAT= specifier is an array element reference, its subscript values must not be affected by the data transfer, the *io-implied-do* processing, or the definition or evaluation of any other specifier in the *io-control-spec-list*.

For the ADVANCE= specifier, the *scalar-default-char-expr* has a limited list of character values. Any trailing blanks are ignored. If a processor is capable of representing letters in both upper and lower case, the value specified is without regard to case.

An example of a READ statement is:

```
READ (IOSTAT = IOS, UNIT = 6, FMT = '(10F8.2)') A, B
```

9.4.1.1 Format Specifier.

R913 *format* is *default-char-expr*
or *label*
or *
or *scalar-default-int-variable*

Constraint: The *label* must be the label of a FORMAT statement that appears in the same scoping unit as the statement containing the format specifier.

The *scalar-default-int-variable* must have been assigned (8.2.4) the statement label of a FORMAT statement that appears in the same scoping unit as the *format*.

The *default-char-expr* must evaluate to a valid format specification (10.1.1 and 10.1.2). Note that *default-char-expr* includes a character constant.

If *default-char-expr* is an array, it is treated as if all of the elements of the array were specified in array element order and were concatenated.

If *format* is *, the statement is a **list-directed input/output statement.**

An example in which the format is a character expression is:

```
READ (6, FMT = "(" // CHAR_FMT // ")" )  X, Y, Z
```

where CHAR_FMT is a default character variable.

9.4.1.2 Namelist Specifier. The NML= specifier supplies the *namelist-group-name* (5.4). This name identifies a specific collection of data objects on which transfer is to be performed.

If a *namelist-group-name* is present, the statement is a **namelist input/output statement.**

9.4.1.3 Record Number. The REC= specifier specifies the number of the record that is to be read or written. This specifier may be present only in an input/output statement that specifies a unit connected for direct access. If the control information list contains a REC= specifier, the statement is a **direct access input/output statement**; otherwise, it is a **sequential access input/output statement.**

9.4.1.4 Input/Output Status. Execution of an input/output statement containing the IOSTAT= specifier causes the variable specified in the IOSTAT= specifier to become defined:

(1) With a zero value if neither an error condition, an end-of-file condition, nor an end-of-record condition occurs

(2) With a processor-dependent positive integer value if an error condition occurs,

(3) With a processor-dependent negative integer value if an end-of-file condition occurs and no error condition occurs, or

(4) With a processor-dependent negative integer value different from the end-of-file value if an end-of-record condition occurs and no error condition or end-of-file condition occurs.

Note that an end-of-file condition may occur only during execution of a sequential input statement and an end-of-record condition may occur only during execution of a nonadvancing input statement.

Consider the example:

```
READ (FMT = "(E8.3)", UNIT=3, IOSTAT = IOSS) X
   !
IF (IOSS < 0) THEN
   !
   ! Perform end-of-file processing on the file
   ! connected to unit 3.
   CALL END_PROCESSING
   !
ELSE IF (IOSS > 0) THEN
   !
   ! Perform error processing
   CALL ERROR_PROCESSING
   !
END IF
```

9.4.1.5 Error Branch. If an input/output statement contains an ERR= specifier and an error condition occurs during execution of the statement:

(1) Execution of the input/output statement terminates,

(2) The position of the file specified in the input/output statement becomes indeterminate,

(3) If the input/output statement also contains an IOSTAT= specifier, the variable specified becomes defined with a processor-dependent positive integer value,

(4) If the statement is a READ statement and it contains a SIZE= specifier, the variable becomes defined with an integer value (9.4.1.9), and

(5) Execution continues with the statement specified in the ERR= specifier.

9.4.1.6 End-of-File Branch. If an input statement contains an END= specifier and an end-of-file condition occurs and no error condition occurs during execution of the statement:

(1) Execution of the input statement terminates,

(2) If the file specified in the input statement is an external file, it is positioned after the endfile record.

(3) If the input statement also contains an IOSTAT= specifier, the variable specified becomes defined with a processor-dependent negative integer value, and

(4) Execution continues with the statement specified in the END= specifier.

In a WRITE statement, the control information list must not contain an END= specifier.

9.4.1.7 End-of-Record Branch. If an input statement contains an EOR= specifier and an end-of-record condition occurs and no error condition occurs during execution of the statement:

(1) If the PAD= specifier has the value YES, the record is padded with blanks to satisfy the input list item (9.4.4.4.2) and corresponding data edit descriptor that requires more characters than the record contains,

(2) Execution of the input statement terminates,

(3) The file specified in the input statement is positioned after the current record,

(4) If the input statement also contains an IOSTAT= specifier, the variable specified becomes defined with a processor-dependent negative integer value,

(5) If the input statement contains a SIZE= specifier, the variable becomes defined with an integer value (9.4.1.9), and

(6) Execution continues with the statement specified in the EOR= specifier.

In a WRITE statement, the control information list must not contain an EOR= specifier.

9.4.1.8 Advance Specifier. The *scalar-default-char-expr* must evaluate to YES or NO. The ADVANCE= specifier determines whether nonadvancing input/output occurs for this input/output statement. If NO is specified, nonadvancing input/output occurs. If YES is specified, advancing formatted sequential input/output occurs. If this specifier is omitted, the default value is YES.

9.4.1.9 Character Count. When a nonadvancing input statement terminates, the variable specified in the SIZE= specifier becomes defined with the count of the characters transferred by data edit descriptors during execution of the current input statement. Blanks inserted as padding (9.4.4.4.2) are not counted.

9.4.2 Data Transfer Input/Output List. An input/output list specifies the entities whose values are transferred by a data transfer input/output statement.

R914	*input-item*	is	*variable*
		or	*io-implied-do*
R915	*output-item*	is	*expr*
		or	*io-implied-do*
R916	*io-implied-do*	is	(*io-implied-do-object-list* , *io-implied-do-control*)
R917	*io-implied-do-object*	is	*input-item*
		or	*output-item*

R918 *io-implied-do-control* is *do-variable* = *scalar-numeric-expr* , ■
■ *scalar-numeric-expr* [, *scalar-numeric-expr*]

Constraint: A *variable* that is an *input-item* must not be an assumed-size array.

Constraint: The *do-variable* must be a scalar of type integer, default real, or double precision real.

Constraint: Each *scalar-numeric-expr* in an *io-implied-do-control* must be of type integer, default real, or double precision real.

Constraint: In an *input-item-list*, an *io-implied-do-object* must be an *input-item*. In an *output-item-list*, an *io-implied-do-object* must be an *output-item*.

An *input-item* must not appear as, nor be associated with, the *do-variable* of any *io-implied-do* that contains the *input-item*.

If an input item is a pointer, it must be currently associated with a definable target and data are transferred from the file to the associated target. If an output item is a pointer, it must be currently associated with a target and data are transferred from the target to the file.

The *do-variable* of an *io-implied-do* that is contained within another *io-implied-do* must not appear as, nor be associated with, the *do-variable* of the containing *io-implied-do*.

If an array appears as an input/output list item, it is treated as if the elements, if any, were specified in array element order (6.2.2.2). However, no element of that array may affect the value of any expression in the *input-item*, nor may any element appear more than once. For example:

```
INTEGER A (100), J (100)
   ...
READ *, A (A)                              ! Not allowed
READ *, A (LBOUND (A) : UBOUND (A))        ! Allowed
READ *, A (J)                              ! Allowed
READ *, A (A (1) : A (10))                 ! Not allowed
```

A derived-type object must not appear as an input/output list item if any component ultimately contained within the object is not accessible within the scoping unit containing the input/output statement. An example is a structure accessed from a module within which its type is PUBLIC but its components are PRIVATE.

If a derived type ultimately contains a pointer component, an object of this type must not appear as an input item nor as the result of the evaluation of an output list item.

If a derived-type object appears as an input/output list item in a formatted input/output statement, it is treated as if all of the components of the object were specified in the same order as in the definition of the derived type.

An input/output list item of derived type in an unformatted input/output statement is treated as a single value in a processor-dependent form. Note that, in this case, the appearance of a derived-type object as an input/output list item is not equivalent to the list of its components.

For an implied-DO, the loop initialization and execution is the same as for a DO construct (8.1.4.4).

An input/output list must not contain an item of nondefault character type if the input/output statement specifies an internal file.

Note that a constant, an expression involving operators or function references, or an expression enclosed in parentheses may appear as an output list item but must not appear as an input list item.

An example of an output list with an implied-DO is:

```
WRITE (LP, FMT = '(10F8.2)') (LOG (A (I)), I = 1, N + 9, K), G
```

9.4.3 Error, End-of-Record, and End-of-File Conditions. The set of input/output error conditions is processor dependent.

An **end-of-record condition** occurs when a nonadvancing input statement attempts to transfer data from a position beyond the end of the current record.

An **end-of-file condition** occurs in either of the following cases:

(1) When an endfile record is encountered during the reading of a file connected for sequential access.

(2) When an attempt is made to read a record beyond the end of an internal file.

An end-of-file condition may occur at the beginning of execution of an input statement. An end-of-file condition also may occur during execution of a formatted input statement when more than one record is required by the interaction of the input list and the format.

If an error condition or an end-of-file condition occurs during execution of an input/output statement, execution of the input/output statement terminates and any implied-DO variables become undefined. If an error condition occurs during execution of an input/output statement, the position of the file becomes indeterminate.

If an error or end-of-file condition occurs on input, all list items become undefined.

If an end-of-record condition occurs during execution of a nonadvancing input statement, the following occurs: if the PAD= specifier has the value YES, the record is padded with blanks (9.4.4.4.2) to satisfy the input list item and corresponding data edit descriptor that require more characters than the record contains; execution of the input statement terminates; and the file specified in the input statement is positioned after the current record.

Execution of the executable program is terminated if an error condition occurs during execution of an input/output statement that contains neither an IOSTAT= nor an ERR= specifier, or if an end-of-file condition occurs during execution of a READ statement that contains neither an IOSTAT= specifier nor an END= specifier, or if an end-of-record condition occurs during execution of a nonadvancing READ statement that contains neither an IOSTAT= specifier nor an EOR= specifier.

9.4.4 Execution of a Data Transfer Input/Output Statement. The effect of executing a data transfer input/output statement must be as if the following operations were performed in the order specified:

(1) Determine the direction of data transfer

(2) Identify the unit

(3) Establish the format if one is specified

(4) Position the file prior to data transfer (9.2.1.3.2)

(5) Transfer data between the file and the entities specified by the input/output list (if any) or namelist

(6) Determine whether an error condition, an end-of-file condition, or an end-of-record condition has occurred.

(7) Position the file after data transfer (9.2.1.3.3)

(8) Cause any variables specified in the IOSTAT= and SIZE= specifiers to become defined.

9.4.4.1 Direction of Data Transfer. Execution of a READ statement causes values to be transferred from a file to the entities specified by the input list, if any, or specified within the file itself for namelist input. Execution of a WRITE or PRINT statement causes values to be transferred to a file from the entities specified by the output list and format specification, if any, or by the *namelist-group-name* for namelist output. Execution of a WRITE or PRINT statement for a file that does not exist creates the file unless an error condition occurs.

9.4.4.2 Identifying a Unit. A data transfer input/output statement that contains an input/output control list includes a unit specifier that identifies an external unit or an internal file. A READ statement that does not contain an input/output control list specifies a particular processor-dependent unit, which is the same as the unit identified by * in a READ statement that contains an input/output control list. The PRINT statement specifies some other processor-dependent unit, which is the same as the unit identified by * in a WRITE statement. Thus, each data transfer input/output statement identifies an external unit or an internal file.

The unit identified by a data transfer input/output statement must be connected to a file when execution of the statement begins. Note that the file may be preconnected.

9.4.4.3 Establishing a Format. If the input/output control list contains * as a format, list-directed formatting is established. If *namelist-group-name* is present, namelist formatting is established. If no *format* or *namelist-group-name* is specified, unformatted data transfer is established. Otherwise, the format specification identified by the format specifier is established. If the format is an array, the effect is as if all elements of the array were concatenated in array element order.

On output, if an internal file has been specified, a format specification that is in the file or is associated with the file must not be specified.

9.4.4.4 Data Transfer. Data are transferred between records and entities specified by the input/output list or namelist. The list items are processed in the order of the input/output list for all data transfer input/output statements except namelist formatted data transfer statements. The next item to be processed in the list is called the **next effective item**. Zero-sized arrays, zero-sized array sections, and implied-DO lists with iteration counts of zero are ignored in determining the next effective item. The list items for a namelist input statement are processed in the order of the entities specified within the input records. The list items for a namelist output statement are processed in the order in which the data objects (variables) are specified in the *namelist-group-object-list*.

All values needed to determine which entities are specified by an input/output list item are determined at the beginning of the processing of that item.

All values are transmitted to or from the entities specified by a list item prior to the processing of any succeeding list item for all data transfer input/output statements. In the example,

```
READ (N) N, X (N)
```

the old value of N identifies the unit, but the new value of N is the subscript of X.

All values following the *name*= part of the namelist entity (10.9) within the input records are transmitted to the matching entity specified in the *namelist-group-object-list* prior to processing any succeeding entity within the input record for namelist input statements. If an entity is specified more than once within the input record during a namelist formatted data transfer input statement, the last occurrence of the entity specifies the value or values to be used for that entity.

An input list item, or an entity associated with it, must not contain any portion of an established format specification.

If the input/output item is a pointer, data are transferred between the file and the associated target.

If an internal file has been specified, an input/output list item must not be in the file or associated with the file. Note that the file is a data object.

A DO variable becomes defined and its iteration count established at the beginning of processing of the items that constitute the range of an *io-implied-do*.

On output, every entity whose value is to be transferred must be defined.

9.4.4.4.1 Unformatted Data Transfer. During unformatted data transfer, data are transferred without editing between the current record and the entities specified by the input/output list. Exactly one record is read or written.

Objects of intrinsic or derived types may be transferred by means of an unformatted data transfer statement.

On input, the file must be positioned so that the record read is an unformatted record or an endfile record. The number of values required by the input list must be less than or equal to the number of values in the record. Each value in the record must be of the same type as the corresponding entity in the input list, except that one complex value may correspond to two real list entities or two real values may correspond to one complex list entity. The type parameters of the corresponding entities must be the same. Note that if an entity in the input list is of type character, the character entity must have the same length and the same kind type parameter as the character value. Also note that if two real values correspond to one complex entity or one complex value corresponds to two real entities, all three must have the same kind type parameter value.

On output to a file connected for direct access, the output list must not specify more values than can fit into the record. If the file is connected for direct access and the values specified by the output list do not fill the record, the remainder of the record is undefined.

If the file is connected for sequential access, the record is created with a length sufficient to hold the values from the output list. This length must be one of the set of allowed record lengths for the file and must not exceed the value specified in the RECL= specifier, if any, of the OPEN statement that established the connection.

If the file is connected for formatted input/output, unformatted data transfer is prohibited.

The unit specified must be an external unit.

9.4.4.4.2 Formatted Data Transfer. During formatted data transfer, data are transferred with editing between the file and the entities specified by the input/output list or by the *namelist-group-name*, if any. Format control is initiated and editing is performed as described in Section 10. The current record and possibly additional records are read or written.

Values may be transmitted by means of a formatted data transfer statement to or from objects of intrinsic or derived types. In the latter case, the transfer is in the form of values of intrinsic types to or from the components of intrinsic types that ultimately comprise these structured objects.

On input, the file must be positioned so that the record read is a formatted record or an endfile record.

If the file is connected for unformatted input/output, formatted data transfer is prohibited.

During advancing input from a file whose PAD= specifier has the value NO, the input list and format specification must not require more characters from the record than the record contains.

During advancing input from a file whose PAD= specifier has the value YES, or during input from an internal file, blank characters are supplied by the processor if the input list and format specification require more characters from the record than the record contains.

During nonadvancing input from a file whose PAD= specifier has the value NO, an end-of-record condition (9.4.3) occurs if the input list and format specification require more characters from the record than the record contains.

During nonadvancing input from a file whose PAD= specifier has the value YES, an end-of-record condition occurs and blank characters are supplied by the processor if the input list and format specification require more characters from the record than the record contains.

If the file is connected for direct access, the record number is increased by one as each succeeding record is read or written.

On output, if the file is connected for direct access or is an internal file and the characters specified by the output list and format do not fill a record, blank characters are added to fill the record.

On output, the output list and format specification must not specify more characters for a record than have been specified by a RECL= specifier in the OPEN statement or the record length of an internal file.

9.4.4.5 List-Directed Formatting. If list-directed formatting has been established, editing is performed as described in 10.8.

9.4.4.6 Namelist Formatting. If namelist formatting has been established, editing is performed as described in 10.9.

9.4.5 Printing of Formatted Records. The transfer of information in a formatted record to certain devices determined by the processor is called **printing**. If a formatted record is printed, the first character of the record is not printed. The remaining characters of the record, if any, are printed in one line beginning at the left margin.

The first character of such a record must be of default character type and determines vertical spacing as follows:

Character	Vertical Spacing Before Printing
Blank	One Line
0	Two Lines
1	To First Line of Next Page
+	No Advance

If there are no characters in the record, the vertical spacing is one line and no characters other than blank are printed in that line.

The PRINT statement does not imply that printing will occur, and the WRITE statement does not imply that printing will not occur.

9.4.6 Termination of Data Transfer Statements. Termination of an input/output data transfer statement occurs when any of the following conditions are met:

(1) Format processing encounters a data edit descriptor and there are no remaining elements in the *input-item-list* or *output-item-list*.

(2) Unformatted or list-directed data transfer exhausts the *input-item-list* or *output-item-list*.

(3) Namelist output exhausts the *namelist-group-object-list* or namelist input reaches the end of a record after having processed a name-value subsequence for every item in the *namelist-group-object-list*.

(4) An error condition occurs.

(5) An end-of-file condition occurs.

(6) A slash (/) is encountered as a value separator (10.8, 10.9) in the record being read during list-directed or namelist input.

(7) An end-of-record condition occurs during execution of a nonadvancing input/output statement.

9.5 File Positioning Statements.

R919 *backspace-stmt* is BACKSPACE *external-file-unit*
or BACKSPACE (*position-spec-list*)

R920 *endfile-stmt* is ENDFILE *external-file-unit*
or ENDFILE (*position-spec-list*)

R921 *rewind-stmt* is REWIND *external-file-unit*
or REWIND (*position-spec-list*)

A file that is not connected for sequential access must not be referred to by a BACKSPACE, an ENDFILE, or a REWIND statement.

R922 *position-spec* is [UNIT =] *external-file-unit*

or IOSTAT = *scalar-default-int-variable*
or ERR = *label*

Constraint: The *label* in the ERR= specifier must be the statement label of a branch target statement that appears in the same scoping unit as the file positioning statement.

Constraint: If the optional characters UNIT= are omitted from the unit specifier, the unit specifier must be the first item in the *position-spec-list*.

Constraint: A *position-spec-list* must contain exactly one *external-file-unit* and may contain at most one of each of the other specifiers.

The IOSTAT= and ERR= specifiers are described in 9.4.1.4 and 9.4.1.5, respectively.

9.5.1 BACKSPACE Statement. Execution of a BACKSPACE statement causes the file connected to the specified unit to be positioned before the current record if there is a current record, or before the preceding record if there is no current record. If there is no current record and no preceding record, the position of the file is not changed. Note that if the preceding record is an endfile record, the file is positioned before the endfile record. If a BACKSPACE statement causes the implicit writing of an endfile record, the file is positioned before the record that precedes the endfile record.

Backspacing a file that is connected but does not exist is prohibited.

Backspacing over records written using list-directed or namelist formatting is prohibited.

An example of a BACKSPACE statement is:

```
BACKSPACE (10, ERR = 20)
```

9.5.2 ENDFILE Statement. Execution of an ENDFILE statement writes an endfile record as the next record of the file. The file is then positioned after the endfile record which becomes the last record of the file. If the file also may be connected for direct access, only those records before the endfile record are considered to have been written. Thus, only those records may be read during subsequent direct access connections to the file.

After execution of an ENDFILE statement, a BACKSPACE or REWIND statement must be used to reposition the file prior to execution of any data transfer input/output statement or ENDFILE statement.

Execution of an ENDFILE statement for a file that is connected but does not exist creates the file prior to writing the endfile record.

An example of an ENDFILE statement is:

```
ENDFILE K
```

9.5.3 REWIND Statement. Execution of a REWIND statement causes the specified file to be positioned at its initial point. Note that if the file is already positioned at its initial point, execution of this statement has no effect on the position of the file.

Execution of a REWIND statement for a file that is connected but does not exist is permitted and has no effect.

An example of a REWIND statement is:

```
REWIND 10
```

9.6 File Inquiry. The INQUIRE statement may be used to inquire about properties of a particular named file or of the connection to a particular unit. There are three forms of the INQUIRE statement: **inquire by file**, which uses the FILE= specifier, **inquire by unit**, which uses the UNIT= specifier, and **inquire by output list**, which uses only the IOLENGTH= specifier. All specifier value assignments are performed according to the rules for assignment statements.

An INQUIRE statement may be executed before, while, or after a file is connected to a unit. All values assigned by an INQUIRE statement are those that are current at the time the statement is executed.

R923 *inquire-stmt* is INQUIRE (*inquire-spec-list*)
or INQUIRE (IOLENGTH = *scalar-default-int-variable*) ■
■ *output-item-list*

Examples of INQUIRE statements are:

```
INQUIRE (IOLENGTH = IOL) A (1:N)
INQUIRE (UNIT = JOAN, OPENED = LOG_01, NAMED = LOG_02, &
   FORM = CHAR_VAR, IOSTAT = IOS)
```

9.6.1 Inquiry Specifiers. Unless constrained, the following inquiry specifiers may be used in either of the inquire by file or inquire by unit forms of the INQUIRE statement:

R924 *inquire-spec* is [UNIT =] *external-file-unit*
or FILE = *file-name-expr*
or IOSTAT = *scalar-default-int-variable*
or ERR = *label*
or EXIST = *scalar-default-logical-variable*
or OPENED = *scalar-default-logical-variable*
or NUMBER = *scalar-default-int-variable*
or NAMED = *scalar-default-logical-variable*
or NAME = *scalar-default-char-variable*
or ACCESS = *scalar-default-char-variable*
or SEQUENTIAL = *scalar-default-char-variable*
or DIRECT = *scalar-default-char-variable*
or FORM = *scalar-default-char-variable*
or FORMATTED = *scalar-default-char-variable*
or UNFORMATTED = *scalar-default-char-variable*
or RECL = *scalar-default-int-variable*
or NEXTREC = *scalar-default-int-variable*
or BLANK = *scalar-default-char-variable*
or POSITION = *scalar-default-char-variable*
or ACTION = *scalar-default-char-variable*
or READ = *scalar-default-char-variable*
or WRITE = *scalar-default-char-variable*
or READWRITE = *scalar-default-char-variable*
or DELIM = *scalar-default-char-variable*
or PAD = *scalar-default-char-variable*

Constraint: An *inquire-spec-list* must contain one FILE= specifier or one UNIT= specifier, but not both, and at most one of each of the other specifiers.

Constraint: In the inquire by unit form of the INQUIRE statement, if the optional characters UNIT= are omitted from the unit specifier, the unit specifier must be the first item in the *inquire-spec-list*.

When a returned value of a specifier other than the NAME= specifier is of type character and the processor is capable of representing letters in both upper and lower case, the value returned is in upper case.

If an error condition occurs during execution of an INQUIRE statement, all of the inquiry specifier variables become undefined, except for the variable in the IOSTAT= specifier (if any).

The IOSTAT= and ERR= specifiers are described in 9.4.1.4 and 9.4.1.5, respectively.

9.6.1.1 FILE= Specifier in the INQUIRE Statement. The value of the *file-name-expr* in the FILE= specifier specifies the name of the file being inquired about. The named file need not exist or be connected to a unit. The value of the *file-name-expr* must be of a form acceptable to the processor as a file name. Any trailing blanks are ignored. If a processor is capable of representing letters in both upper and lower case, the interpretation of case is processor dependent.

9.6.1.2 EXIST= Specifier in the INQUIRE Statement. Execution of an INQUIRE by file statement causes the *scalar-default-logical-variable* in the EXIST= specifier to be assigned the value true if there exists a file with the specified name; otherwise, false is assigned. Execution of an INQUIRE by unit statement causes true to be assigned if the specified unit exists; otherwise, false is assigned.

9.6.1.3 OPENED= Specifier in the INQUIRE Statement. Execution of an INQUIRE by file statement causes the *scalar-default-logical-variable* in the OPENED= specifier to be assigned the value true if the file specified is connected to a unit; otherwise, false is assigned. Execution of an INQUIRE by unit statement causes the *scalar-default-logical-variable* to be assigned the value true if the specified unit is connected to a file; otherwise, false is assigned.

9.6.1.4 NUMBER= Specifier in the INQUIRE Statement. The *scalar-default-int-variable* in the NUMBER= specifier is assigned the value of the external unit identifier of the unit that is currently connected to the file. If there is no unit connected to the file, the value –1 is assigned.

9.6.1.5 NAMED= Specifier in the INQUIRE Statement. The *scalar-default-logical-variable* in the NAMED= specifier is assigned the value true if the file has a name; otherwise, it is assigned the value false.

9.6.1.6 NAME= Specifier in the INQUIRE Statement. The *scalar-default-char-variable* in the NAME= specifier is assigned the value of the name of the file if the file has a name; otherwise, it becomes undefined. Note that if this specifier appears in an INQUIRE by file statement, its value is not necessarily the same as the name given in the FILE= specifier. For example, the processor may return a file name qualified by a user identification. However, the value returned must be suitable for use as the value of the *file-name-expr* in the FILE= specifier in an OPEN statement. If a processor is capable of representing letters in both upper and lower case, the case of the characters assigned to *scalar-default-char-variable* is processor dependent.

9.6.1.7 ACCESS= Specifier in the INQUIRE Statement. The *scalar-default-char-variable* in the ACCESS= specifier is assigned the value SEQUENTIAL if the file is connected for sequential access, and DIRECT if the file is connected for direct access. If there is no connection, it is assigned the value UNDEFINED.

9.6.1.8 SEQUENTIAL= Specifier in the INQUIRE Statement. The *scalar-default-char-variable* in the SEQUENTIAL= specifier is assigned the value YES if SEQUENTIAL is included in the set of allowed access methods for the file, NO if SEQUENTIAL is not included in the set of allowed access methods for the file, and UNKNOWN if the processor is unable to determine whether or not SEQUENTIAL is included in the set of allowed access methods for the file.

9.6.1.9 DIRECT= Specifier in the INQUIRE Statement. The *scalar-default-char-variable* in the DIRECT= specifier is assigned the value YES if DIRECT is included in the set of allowed access methods for the file, NO if DIRECT is not included in the set of allowed access methods for the file, and UNKNOWN if the processor is unable to determine whether or not DIRECT is included in the set of allowed access methods for the file.

9.6.1.10 FORM= Specifier in the INQUIRE Statement. The *scalar-default-char-variable* in the FORM= specifier is assigned the value FORMATTED if the file is connected for formatted input/output, and is assigned the value UNFORMATTED if the file is connected for unformatted input/output. If there is no connection, it is assigned the value UNDEFINED.

9.6.1.11 FORMATTED= Specifier in the INQUIRE Statement. The *scalar-default-char-variable* in the FORMATTED= specifier is assigned the value YES if FORMATTED is included in the set of allowed forms for the file, NO if FORMATTED is not included in the set of allowed forms for the file, and UNKNOWN if the processor is unable to determine whether or not FORMATTED is included in the set of allowed forms for the file.

9.6.1.12 UNFORMATTED= Specifier in the INQUIRE Statement. The *scalar-default-char-variable* in the UNFORMATTED= specifier is assigned the value YES if UNFORMATTED is included in the set of allowed forms for the file, NO if UNFORMATTED is not included in the set of allowed forms for the file, and UNKNOWN if the processor is unable to determine whether or not UNFORMATTED is included in the set of allowed forms for the file.

9.6.1.13 RECL= Specifier in the INQUIRE Statement. The *scalar-default-int-variable* in the RECL= specifier is assigned the value of the maximum record length of the file. If the file is connected for formatted input/output, the length is the number of characters for all records that contain only characters of type default character. If the file is connected for unformatted input/output, the length is measured in processor-dependent units. If there is no connection, the *scalar-default-int-variable* becomes undefined.

9.6.1.14 NEXTREC= Specifier in the INQUIRE Statement. The *scalar-default-int-variable* in the NEXTREC= specifier is assigned the value $n+1$, where n is the record number of the last record read or written on the file connected for direct access. If the file is connected but no records have been read or written since the connection, the *scalar-default-int-variable* is assigned the value 1. If the file is not connected for direct access or if the position of the file is indeterminate because of a previous error condition, the *scalar-default-int-variable* becomes undefined.

9.6.1.15 BLANK= Specifier in the INQUIRE Statement. The *scalar-default-char-variable* in the BLANK= specifier is assigned the value NULL if null blank control is in effect for the file connected for formatted input/output, and is assigned the value ZERO if zero blank control is in effect for the file connected for formatted input/output. If there is no connection, or if the connection is not for formatted input/output, the *scalar-default-char-variable* is assigned the value UNDEFINED.

9.6.1.16 POSITION= Specifier in the INQUIRE Statement. The *scalar-default-char-variable* in the POSITION= specifier is assigned the value REWIND if the file is connected by an OPEN statement for positioning at its initial point, APPEND if the file is connected for positioning before its endfile record or at its terminal point, and ASIS if the file is connected without changing its position. If there is no connection or if the file is connected for direct access, the *scalar-default-char-variable* is assigned the value UNDEFINED. If the file has been repositioned since the connection, the *scalar-default-char-variable* is assigned a processor-dependent value, which must not be REWIND unless the file is positioned at its initial point and must be APPEND unless the file is positioned before its endfile record or at its terminal point.

9.6.1.17 ACTION= Specifier in the INQUIRE Statement. The *scalar-default-char-variable* in the ACTION= specifier is assigned the value READ if the file is connected for input only, WRITE if the file is connected for output only, and READWRITE if it is connected for both input and output. If there is no connection, the *scalar-default-char-variable* is assigned the value UNDEFINED.

9.6.1.18 READ= Specifier in the INQUIRE Statement. The *scalar-default-char-variable* in the READ= specifier is assigned the value YES if READ is included in the set of allowed actions for the file, NO if READ is not included in the set of allowed actions for the file, and UNKNOWN if the processor is unable to determine whether or not READ is included in the set of allowed actions for the file.

9.6.1.19 WRITE= Specifier in the INQUIRE Statement. The *scalar-default-char-variable* in the WRITE= specifier is assigned the value YES if WRITE is included in the set of allowed actions for the file, NO if WRITE is not included in the set of allowed actions for the file, and UNKNOWN if the processor is unable to determine whether or not WRITE is included in the set of allowed actions for the file.

9.6.1.20 READWRITE= Specifier in the INQUIRE Statement. The *scalar-default-char-variable* in the READWRITE= specifier is assigned the value YES if READWRITE is included in the set of allowed actions for the file, NO if READWRITE is not included in the set of allowed actions for the file, and UNKNOWN if the processor is unable to determine whether or not READWRITE is included in the set of allowed actions for the file.

9.6.1.21 DELIM= Specifier in the INQUIRE Statement. The *scalar-default-char-variable* in the DELIM= specifier is assigned the value APOSTROPHE if the apostrophe is to be used to delimit character data written by list-directed or namelist formatting. If the quotation mark is used to delimit such data, the value QUOTE is assigned. If neither the apostrophe nor the quote is used to delimit the character data, the value NONE is assigned. If there is no connection or if the connection is not for formatted input/output, the *scalar-default-char-variable* is assigned the value UNDEFINED.

9.6.1.22 PAD= Specifier in the INQUIRE Statement. The *scalar-default-char-variable* in the PAD= specifier is assigned the value NO if the connection of the file to the unit included the PAD= specifier and its value was NO. Otherwise, the *scalar-default-char-variable* is assigned the value YES.

9.6.2 Restrictions on Inquiry Specifiers. A variable that may become defined or undefined as a result of its use in a specifier in an INQUIRE statement, or any associated entity, must not appear in another specifier in the same INQUIRE statement.

The *inquire-spec-list* in an INQUIRE by file statement must contain exactly one FILE= specifier and must not contain a UNIT= specifier. The *inquire-spec-list* in an INQUIRE by unit statement must contain exactly one UNIT= specifier and must not contain a FILE= specifier. The unit specified need not exist or be connected to a file. If it is connected to a file, the inquiry is being made about the connection and about the file connected.

9.6.3 Inquire by Output List. The inquire by output list form of the INQUIRE statement does not include a FILE= or UNIT= specifier, and includes only an IOLENGTH= specifier and an output list. The *scalar-default-int-variable* in the IOLENGTH= specifier is assigned the processor-dependent value that would result from the use of the output list in an unformatted output statement. The value must be suitable as a RECL= specifier in an OPEN statement that connects a file for unformatted direct access when there are input/output statements with the same input/output list.

9.7 Restrictions on Function References and List Items. A function reference must not appear in an expression anywhere in an input/output statement if such a reference causes another input/output statement to be executed. Note that restrictions in the evaluation of expressions (7.1.7) prohibit certain side effects.

9.8 Restriction on Input/Output Statements. If a unit, or a file connected to a unit, does not have all of the properties required for the execution of certain input/output statements, those statements must not refer to the unit.

10. INPUT/OUTPUT EDITING

A format used in conjunction with an input/output statement provides information that directs the editing between the internal representation of data and the characters of a sequence of formatted records.

A format specifier (9.4.1.1) in an input/output statement may refer to a FORMAT statement or to a character expression that contains a format specification. A format specification provides explicit editing information. The format specifier also may be an asterisk (*) which indicates list-directed formatting (10.8). Instead of a format specifier, a *namelist-group-name* may be specified which indicates namelist formatting (10.9).

10.1 Explicit Format Specification Methods. Explicit format specification may be given:

(1) In a FORMAT statement, or

(2) In a character expression.

10.1.1 FORMAT Statement.

R1001 *format-stmt* **is** FORMAT *format-specification*

R1002 *format-specification* **is** ([*format-item-list*])

Constraint: The *format-stmt* must be labeled.

Constraint: The comma used to separate *format-items* in a *format-item-list* may be omitted as follows:

(1) Between a P edit descriptor and an immediately following F, E, EN, D, or G edit descriptor (10.6.5)

(2) Before a slash edit descriptor when the optional repeat specification is not present (10.6.2)

(3) After a slash edit descriptor

(4) Before or after a colon edit descriptor (10.6.3)

Blank characters may precede the initial left parenthesis of the format specification. Additional blank characters may appear at any point within the format specification, with no effect on the interpretation of the format specification, except within a character string edit descriptor (10.7.1, 10.7.2).

Examples of FORMAT statements are:

```
5     FORMAT (1PE12.4, I10)
9     FORMAT (I12, /, ' Dates: ', 2 (2I3, I5))
```

10.1.2 Character Format Specification. A character expression used as a format specifier in a formatted input/output statement must evaluate to a character string whose leading part is a valid format specification. Note that the format specification begins with a left parenthesis and ends with a right parenthesis.

All character positions up to and including the final right parenthesis of the format specification must be defined at the time the input/output statement is executed, and must not become redefined or undefined during the execution of the statement. Character positions, if any, following the right parenthesis that ends the format specification need not be defined and may contain any character data with no effect on the interpretation of the format specification.

If the format specifier references a character array, it is treated as if all of the elements of the array were specified in array element order and were concatenated. However, if a format specifier references a character array element, the format specification must be contained entirely within that array element.

10.2 Form of a Format Item List.

R1003 *format-item* is [*r*] *data-edit-desc*
or *control-edit-desc*
or *char-string-edit-desc*
or [*r*] (*format-item-list*)

R1004 *r* is *int-literal-constant*

Constraint: *r* must be positive.

Constraint: *r* must not have a kind parameter specified for it.

The integer literal constant *r* is called a **repeat specification.**

10.2.1 Edit Descriptors. An edit descriptor is a **data edit descriptor,** a **control edit descriptor,** or **a character string edit descriptor.**

R1005 *data-edit-desc* is I *w* [. *m*]
or B *w* [. *m*]
or O *w* [. *m*]
or Z *w* [. *m*]
or F *w* . *d*
or E *w* . *d* [E *e*]
or EN *w* . *d* [E *e*]
or ES *w* . *d* [E *e*]
or G *w* . *d* [E *e*]
or L *w*
or A [*w*]
or D *w* . *d*

R1006 *w* is *int-literal-constant*

R1007 *m* is *int-literal-constant*

R1008 *d* is *int-literal-constant*

R1009 *e* is *int-literal-constant*

Constraint: *w* and *e* must be positive and *d* and *m* must be zero or positive.

Constraint: *w*, *m*, *d*, and *e* must not have kind parameters specified for them.

The value of *d*, *e*, or *m* in a *data-edit-desc* must not exceed the value of *w*. I, B, O, Z, F, E, EN, ES, G, L, A, and D indicate the manner of editing.

R1010 *control-edit-desc* is *position-edit-desc*
or [*r*] /
or :
or *sign-edit-desc*
or *k* P
or *blank-interp-edit-desc*

R1011 *k* is *signed-int-literal-constant*

Constraint: *k* must not have a kind parameter specified for it.

R1012 *position-edit-desc* is T *n*
or TL *n*
or TR *n*
or *n* X

R1013 *n* is *int-literal-constant*

Constraint: *n* must be positive.

Constraint: *n* must not have a kind parameter specified for it.

R1014 *sign-edit-desc* is S
or SP
or SS

R1015 *blank-interp-edit-desc* is BN
or BZ

In *k*P, *k* is called the **scale factor.**

T, TL, TR, X, slash, colon, S, SP, SS, P, BN, and BZ indicate the manner of editing.

R1016 *char-string-edit-desc* is *char-literal-constant*
or *c* H *rep-char* [*rep-char*] ...

R1017 *c* is *int-literal-constant*

Constraint: *c* must be positive.

Constraint: *c* must not have a kind parameter specified for it.

Constraint: The *rep-char* in the *c*H form must be of default character type.

Constraint: The *char-literal-constant* must not have a kind parameter specified for it.

Each *rep-char* in a character string edit descriptor must be one of the characters capable of representation by the processor.

The character string edit descriptors provide constant data to be output, and are not valid for input.

Within a character literal constant, appearances of the delimiter character itself, apostrophe or quote, must be as consecutive pairs without intervening blanks. Each such pair represents a single occurrence of the delimiter character.

In the H edit descriptor, *c* specifies the number of characters following the H.

If a processor is capable of representing letters in both upper and lower case, the edit descriptors are without regard to case except for the characters following the H in the H edit descriptor and the characters in the character constants.

10.2.2 Fields. A field is a part of a record that is read on input or written on output when format control encounters a data edit descriptor or a character string edit descriptor. The **field width** is the size in characters of the field.

10.3 Interaction Between Input/Output List and Format.

The beginning of formatted data transfer using a format specification initiates **format control** (9.4.4.4.2). Each action of format control depends on information jointly provided by:

(1) The next edit descriptor contained in the format specification, and

(2) The next effective item in the input/output list, if one exists.

If an input/output list specifies at least one list item, at least one data edit descriptor must exist in the format specification. Note that an empty format specification of the form ( ) may be used only if the input/output list is empty or each item is of zero size or length; in this case, one input record is skipped or one output record containing no characters is written.

Except for a format item preceded by a repeat specification *r*, a format specification is interpreted from left to right.

A format item preceded by a repeat specification is processed as a list of *r* items, each identical to the format item but without the repeat specification and separated by commas. Note that an omitted repeat specification is treated in the same way as a repeat specification whose value is one.

To each data edit descriptor interpreted in a format specification, there corresponds one effective item specified by the input/output list (9.4.2), except that an input/output list item of type complex requires the interpretation of two F, E, EN, ES, D, or G edit descriptors. For each control edit descriptor or character edit descriptor, there is no corresponding item specified by the input/output list, and format control communicates information directly with the record.

Whenever format control encounters a data edit descriptor in a format specification, it determines whether there is a corresponding effective item specified by the input/output list. If there is such an item, it transmits appropriately edited information between the item and the record, and then format control proceeds. If there is no such item, format control terminates.

If format control encounters a colon edit descriptor in a format specification and another effective input/output list item is not specified, format control terminates.

If format control encounters the rightmost parenthesis of a complete format specification and another effective input/output list item is not specified, format control terminates. However, if another effective input/output list item is specified, the file is positioned in a manner identical to the way it is positioned when a slash edit descriptor is processed (10.6.2). Format control then reverts to the beginning of the format item terminated by the last preceding right parenthesis. If there is no such preceding right parenthesis, format control reverts to the first left parenthesis of the format specification. If any reversion occurs, the reused portion of the format specification must contain at least one data edit descriptor. If format control reverts to a parenthesis that is preceded by a repeat specification, the repeat specification is reused. Reversion of format control, of itself, has no effect on the scale factor (10.6.5.1), the sign control edit descriptors (10.6.4), or the blank interpretation edit descriptors (10.6.6).

Example: The format specification:

```
10 FORMAT (1X, 2(F10.3, I5))
```

with an output list of

```
WRITE (10,10) 10.1, 3, 4.7, 1, 12.4, 5, 5.2, 6
```

produces the same output as the format specification:

```
10 FORMAT (1X, F10.3, I5, F10.3, I5/F10.3, I5, F10.3, I5)
```

10.4 Positioning by Format Control. After each data edit descriptor or character string edit descriptor is processed, the file is positioned after the last character read or written in the current record.

After each T, TL, TR, or X edit descriptor is processed, the file is positioned as described in 10.6.1. After each slash edit descriptor is processed, the file is positioned as described in 10.6.2.

If format control reverts as described in 10.3, the file is positioned in a manner identical to the way it is positioned when a slash edit descriptor is processed (10.6.2).

During a read operation, any unprocessed characters of the current record are skipped whenever the next record is read.

10.5 Data Edit Descriptors. Data edit descriptors cause the conversion of data to or from its internal representation. Characters in the record must be of default kind if they correspond to the value of a numeric, logical, or default character data entity, and must be of nondefault kind if they correspond to the value of a data entity of nondefault character type. Characters transmitted to a record as a result of processing a character string edit descriptor must be of default kind. On input, the specified variable becomes defined unless an error condition, an end-of-file condition, or an end-of-record condition occurs. On output, the specified expression is evaluated.

10.5.1 Numeric Editing. The I, B. O. Z, F, E, EN, ES, D, and G edit descriptors may be used to specify the input/output of integer, real, and complex data. The following general rules apply:

(1) On input, leading blanks are not significant. The interpretation of blanks, other than leading blanks, is determined by a combination of any BLANK= specifier (9.3.4.6), the default for a preconnected or internal file, and any BN or BZ blank control that is currently in effect for the unit (10.6.6). Plus signs may be omitted. A field containing only blanks is considered to be zero.

(2) On input, with F, E, EN, ES, D, and G editing, a decimal point appearing in the input field overrides the portion of an edit descriptor that specifies the decimal point location. The input field may have more digits than the processor uses to approximate the value of the datum.

(3) On output with I, F, E, EN, ES, D, and G editing, the representation of a positive or zero internal value in the field may be prefixed with a plus, as controlled by the S, SP, and SS edit descriptors or the processor. The representation of a negative internal value in the field must be prefixed with a minus. However, the processor must not produce a negative signed zero in a formatted output record.

(4) On output, the representation is right-justified in the field. If the number of characters produced by the editing is smaller than the field width, leading blanks are inserted in the field.

(5) On output, if the number of characters produced exceeds the field width or if an exponent exceeds its specified length using the E*w.dEe*, EN*w.dEe*, ES*w.dEe*, or G*w.dEe* edit descriptor, the processor must fill the entire field of width *w* with asterisks. However, the processor must not produce asterisks if the field width is not exceeded when optional characters are omitted. Note that when an SP edit descriptor is in effect, a plus is not optional.

10.5.1.1 Integer Editing. The I*w*, I*w.m*, B*w*, B*w.m*, O*w*, O*w.m*, Z*w*, and Z*w.m* edit descriptors indicate that the field to be edited occupies *w* positions. The specified input/output list item must be of type integer. The G edit descriptor also may be used to edit integer data (10.5.4.1.1).

On input, *m* has no effect.

In the input field for the I edit descriptor, the character string must be in the form of an optionally signed integer constant, except for the interpretation of blanks. For the B, O, and Z edit descriptors, the character string must consist of binary, octal, or hexadecimal digits (R408, R409, R410) in the respective input field.

The output field for the I*w* edit descriptor consists of zero or more leading blanks followed by a minus if the value of the internal datum is negative, or an optional plus otherwise, followed by the magnitude of the internal value in the form of an unsigned integer constant without leading zeros. Note that an integer constant always consists of at least one digit.

The output field for the B*w*, O*w*, and Z*w* descriptors consists of zero or more leading blanks followed by the internal value in a form identical to the digits of a binary, octal, or hexadecimal constant, respectively, with the same value and without leading zeros. Note that a binary, octal, or hexadecimal constant always consists of at least one digit.

The output field for the I*w.m*, B*w.m*, O*w.m*, and Z*w.m* edit descriptor is the same as for the I*w*, B*w*, O*w*, and Z*w* edit descriptor, respectively, except that the unsigned integer constant consists of at least *m* digits. If necessary, sufficient leading zeros are included to achieve the minimum of *m* digits. The value of *m* must not exceed the value of *w*. If *m* is zero and the value of the internal datum is zero, the output field consists of only blank characters, regardless of the sign control in effect.

10.5.1.2 Real and Complex Editing. The F, E, EN, ES, and D edit descriptors specify the editing of real and complex data. An input/output list item corresponding to an F, E, EN, ES, or D edit descriptor must be real or complex. The G edit descriptor also may be used to edit real and complex data (10.5.4.1.2).

10.5.1.2.1 F Editing. The F*w.d* edit descriptor indicates that the field occupies *w* positions, the fractional part of which consists of *d* digits.

The input field consists of an optional sign, followed by a string of digits optionally containing a decimal point, including any blanks interpreted as zeros. The *d* has no effect on input if the input field contains a decimal point. If the decimal point is omitted, the rightmost *d* digits of the string, with leading zeros assumed if necessary, are interpreted as the fractional part of the value represented. The string of digits may contain more digits than a processor uses to approximate the value of the constant. The basic form may be followed by an exponent of one of the following forms:

(1) Explicitly signed integer constant

(2) E followed by zero or more blanks, followed by an optionally signed integer constant

(3) D followed by zero or more blanks, followed by an optionally signed integer constant

An exponent containing a D is processed identically to an exponent containing an E.

Note that if the input field does not contain an exponent, the effect is as if the basic form were followed by an exponent with a value of $-k$, where k is the established scale factor (10.6.5.1).

The output field consists of blanks, if necessary, followed by a minus if the internal value is negative, or an optional plus otherwise, followed by a string of digits that contains a decimal point and represents the magnitude of the internal value, as modified by the established scale factor and rounded to *d* fractional digits. Leading zeros are not permitted except for an optional zero immediately to the left of the decimal point if the magnitude of the value in the output field is less than one. The optional zero must appear if there would otherwise be no digits in the output field.

10.5.1.2.2 E and D Editing. The E*w.d*, D*w.d*, and E*w.d*E*e* edit descriptors indicate that the external field occupies *w* positions, the fractional part of which consists of *d* digits, unless a scale factor greater than one is in effect, and the exponent part consists of *e* digits. The *e* has no effect on input and *d* has no effect on input if the input field contains a decimal point.

The form and interpretation of the input field is the same as for F editing (10.5.1.2.1).

The form of the output field for a scale factor of zero is:

$$[\pm]\,[0]\,.\,x_1x_2\cdots x_d\,exp$$

where:

± signifies a plus or a minus.

$x_1x_2\cdots x_d$ are the *d* most significant digits of the datum value after rounding.

exp is a decimal exponent having one of the following forms:

Edit Descriptor	Absolute Value of Exponent	Form of Exponent
E*w.d*	$\|exp\| \le 99$	$E\pm z_1z_2$ *or* $\pm 0z_1z_2$
	$99 < \|exp\| \le 999$	$\pm z_1z_2z_3$
E*w.d*E*e*	$\|exp\| \le 10^e-1$	$E\pm z_1z_2\cdots z_e$
D*w.d*	$\|exp\| \le 99$	$D\pm z_1z_2$ or $E\pm z_1z_2$ or $\pm 0z_1z_2$
	$99 < \|exp\| \le 999$	$\pm z_1z_2z_3$

where each z is a digit.

The sign in the exponent is produced. A plus sign is produced if the exponent value is zero. The forms E*w.d* and D*w.d* must not be used if $|exp| > 999$.

The scale factor k controls the decimal normalization (10.2.1, 10.6.5.1). If $-d < k \le 0$, the output field contains exactly $|k|$ leading zeros and $d - |k|$ significant digits after the decimal point. If $0 < k < d+2$, the output field contains exactly k significant digits to the left of the decimal point and $d-k+1$ significant digits to the right of the decimal point. Other values of k are not permitted.

10.5.1.2.3 EN Editing. The EN edit descriptor produces an output field in the form of a real number in engineering notation such that the decimal exponent is divisible by three and the absolute value of the mantissa is greater than or equal to 1 and less than 1000, except when the output value is zero. The scale factor has no effect on output.

The forms of the edit descriptor are EN*w.d* and EN*w.d*E*e* indicating that the external field occupies *w* positions, the fractional part of which consists of *d* digits and the exponent part consists of *e* digits.

The form and interpretation of the input field is the same as for F editing (10.5.1.2.1).

The form of the output field is:

$$[\pm]\, yyy.x_1x_2\cdots x_d\, exp$$

where:

± signifies a plus or a minus.

yyy are the 1 to 3 decimal digits representative of the most significant digits of the value of the datum after rounding (*yyy* is an integer such that $1 \le yyy < 1000$ or, if the output value is zero, $yyy = 0$).

$x_1x_2\cdots x_d$ are the d next most significant digits of the value of the datum after rounding.

exp is a decimal exponent, divisible by three, of one of the following forms:

Edit Descriptor	Absolute Value of Exponent	Form of Exponent
EN*w.d*	$\mid exp \mid \leq 99$	$E\pm z_1z_2$ *or* $\pm 0z_1z_2$
	$99 < \mid exp \mid \leq 999$	$\pm z_1z_2z_3$
EN*w.d*E*e*	$\mid exp \mid \leq 10^e - 1$	$E\pm z_1z_2 \cdots z_e$

where each z is a digit.

The sign in the exponent is produced. A plus sign is produced if the exponent value is zero. The form EN*w.d* must not be used if $\mid exp \mid > 999$.

Examples:

Internal Value	Output field Using SS, EN12.3
6.421	6.421E+00
–.5	–500.000E–03
.00217	2.170E–03
4721.3	4.721E+03

10.5.1.2.4 ES Editing. The ES edit descriptor produces an output field in the form of a real number in scientific notation such that the absolute value of the mantissa is greater than or equal to 1 and less than 10, except when the output value is zero. The scale factor has no effect on output.

The forms of the edit descriptor are ES*w.d* and ES*w.d*E*e* indicating that the external field occupies *w* positions, the fractional part of which consists of *d* digits and the exponent part consists of *e* digits.

The form and interpretation of the input field is the same as for F editing (10.5.1.2.1).

The form of the output field is:

$$[\pm]\, y.x_1x_2 \cdots x_d\, exp$$

where:

± signifies a plus or a minus.

y is a decimal digit representative of the most significant digit of the value of the datum after rounding.

$x_1x_2 \cdots x_d$ are the *d* next most significant digits of the value of the datum after rounding.

exp is a decimal exponent having one of the following forms:

Edit Descriptor	Absolute Value of Exponent	Form of Exponent
ES*w.d*	$\mid exp \mid \leq 99$	$E\pm z_1z_2$ *or* $\pm 0z_1z_2$
	$99 < \mid exp \mid \leq 999$	$\pm z_1z_2z_3$
ES*w.d*E*e*	$\mid exp \mid \leq 10^e - 1$	$E\pm z_1z_2 \cdots z_e$

where each z is a digit.

The sign in the exponent is produced. A plus sign is produced if the exponent value is zero. The form ES*w.d* must not be used if $\mid exp \mid > 999$.

Examples:

Internal Value	Output field Using SS, EN12.3
6.421	6.421E+00
–.5	–5.000E–01
.00217	2.170E–03
4721.3	4.721E+03

10.5.1.2.5 Complex Editing. A complex datum consists of a pair of separate real data. The editing of a scalar datum of complex data type is specified by two edit descriptors each of which specifies the editing of real data. The first of the edit descriptors specifies the real part; the second specifies the imaginary part. The two edit descriptors may be different. Control and character string edit descriptors may be processed between the edit descriptor for the real part and the edit descriptor for the imaginary part.

10.5.2 Logical Editing. The L*w* edit descriptor indicates that the field occupies *w* positions. The specified input/output list item must be of type logical. The G edit descriptor also may be used to edit logical data (10.5.4.2).

The input field consists of optional blanks, optionally followed by a decimal point, followed by a T for true or F for false. The T or F may be followed by additional characters in the field. Note that the logical constants .TRUE. and .FALSE. are acceptable input forms.

The output field consists of $w - 1$ blanks followed by a T or F, depending on whether the value of the internal datum is true or false, respectively.

10.5.3 Character Editing. The A[*w*] edit descriptor is used with an input/output list item of type character as the data item in the input/output list. The G edit descriptor also may be used to edit character data (10.5.4.3). All characters transferred and converted under control of one A or G edit descriptor must have the same kind type parameter as the data item in the input/output list.

If a field width *w* is specified with the A edit descriptor, the field consists of *w* characters. If a field width *w* is not specified with the A edit descriptor, the number of characters in the field is the length of the corresponding list item, regardless of the value of the kind type parameter.

Let *len* be the length of the input/output list item. If the specified field width *w* for A input is greater than or equal to *len*, the rightmost *len* characters will be taken from the input field. If the specified field width *w* is less than *len*, the *w* characters will appear left-justified with $len - w$ trailing blanks in the internal representation.

If the specified field width *w* for A output is greater than *len*, the output field will consist of $w - len$ blanks followed by the *len* characters from the internal representation. If the specified field width *w* is less than or equal to *len*, the output field will consist of the leftmost *w* characters from the internal representation.

Note that for nondefault character types, the blank padding character is processor dependent.

10.5.4 Generalized Editing. The G*w.d* and G*w.d*E*e* edit descriptors are used with an input/output list item of any intrinsic type. These edit descriptors indicate that the external field occupies *w* positions, the fractional part of which consists of a maximum of *d* digits and the exponent part consists of *e* digits. When these edit descriptors are used to specify the input/output of integer, logical, or character data, *d* and *e* have no effect.

10.5.4.1 Generalized Numeric Editing. When used to specify the input/output of integer, real, and complex data, the G*w.d* and G*w.d*E*e* edit descriptors follow the general rules for numeric editing (10.5.1). Note that the G*w.d*E*e* edit descriptor follows any additional rules for the E*w.d*E*e* edit descriptor.

10.5.4.1.1 Generalized Integer Editing. When used to specify the input/output of integer data, the G*w.d* and G*w.d*E*e* edit descriptors follow the rules for the I*w* edit descriptor (10.5.1.1).

10.5.4.1.2 Generalized Real and Complex Editing. The form and interpretation of the input field is the same as for F editing (10.5.1.2.1).

The method of representation in the output field depends on the magnitude of the datum being edited. Let N be the magnitude of the internal datum. If $0 < N < 0.1\text{–}.5\times10^{-d-1}$ or $N \geq 10^{d}\text{–}.5$, G*w.d* output editing is the same as *k*PE*w.d* output editing and G*w.d*E*e* output editing is the same as *k*PE*w.d*E*e* output editing, where k is the scale factor (10.6.5.1) currently in effect. If $0.1\text{–}.5\times10^{-d-1} \leq N < 10^{d}\text{–}.5$ or N is identically 0, the scale factor has no effect, and the value of N determines the editing as follows:

Magnitude of Datum	Equivalent Conversion
$N=0$	F($w-n$).($d-1$), n('b')
$0.1\text{–}.5\times10^{-d} \leq N < 1\text{–}.5\times10^{-d-1}$	F($w-n$).d, n('b')
$1\text{–}.5\times10^{-d} \leq N < 10\text{–}.5\times10^{-d+1}$	F($w-n$).($d-1$), n('b')
$10\text{–}.5\times10^{-d+1} \leq N < 100\text{–}.5\times10^{-d+2}$	F($w-n$).($d-1$), n('b')
.	.
.	.
.	.
$10^{d-2}\text{–}.5\times10^{-2} \leq N < 10^{d-1}\text{–}.5\times10^{-1}$	F($w-n$).1, n('b')
$10^{d-1}\text{–}.5\times10^{-1} \leq N < 10^{d}\text{–}.5$	F($w-n$).0, n('b')

where *b* is a blank. *n* is 4 for G*w.d* and *e* + 2 for G*w.d*E*e*.

Note that the scale factor has no effect unless the magnitude of the datum to be edited is outside the range that permits effective use of F editing.

10.5.4.2 Generalized Logical Editing. When used to specify the input/output of logical data, the G*w.d* and G*w.d*E*e* edit descriptors follow the rules for the L*w* edit descriptor (10.5.2).

10.5.4.3 Generalized Character Editing. When used to specify the input/output of character data, the G*w.d* and G*w.d*E*e* edit descriptors follow the rules for the A*w* edit descriptor (10.5.3).

10.6 Control Edit Descriptors. A control edit descriptor does not cause the transfer of data nor the conversion of data to or from internal representation, but may affect the conversions performed by subsequent data edit descriptors.

10.6.1 Position Editing. The T, TL, TR, and X edit descriptors specify the position at which the next character will be transmitted to or from the record. If any character skipped by a T, TL, TR, or X edit descriptor is of type nondefault character, the result of that position editing is processor dependent.

The position specified by a T edit descriptor may be in either direction from the current position. On input, this allows portions of a record to be processed more than once, possibly with different editing.

The position specified by an X edit descriptor is forward from the current position. On input, a position beyond the last character of the record may be specified if no characters are transmitted from such positions. Note that an *n*X edit descriptor has the same effect as a TR*n* edit descriptor.

On output, a T, TL, TR, or X edit descriptor does not by itself cause characters to be transmitted and therefore does not by itself affect the length of the record. If characters are transmitted to positions at or after the position specified by a T, TL, TR, or X edit descriptor, positions skipped and not previously filled are filled with blanks. The result is as if the entire record were initially filled with blanks.

On output, a character in the record may be replaced. However, a T, TL, TR, or X edit descriptor never directly causes a character already placed in the record to be replaced. Such edit descriptors may result in positioning such that subsequent editing causes a replacement.

10.6.1.1 T, TL, and TR Editing. The left tab limit affects file positioning by the T and TL edit descriptors. Immediately prior to data transfer, the left tab limit becomes defined as the character position of the current record. If, during data transfer, the file is positioned to another record, the left tab limit becomes defined as character position one of that record.

The T*n* edit descriptor indicates that the transmission of the next character to or from a record is to occur at the *n*th character position of the record, relative to the left tab limit.

The TL*n* edit descriptor indicates that the transmission of the next character to or from the record is to occur at the character position *n* characters backward from the current position. However, if *n* is greater than the difference between the current position and the left tab limit, the TL*n* edit descriptor indicates that the transmission of the next character to or from the record is to occur at the left tab limit.

The TR*n* edit descriptor indicates that the transmission of the next character to or from the record is to occur at the character position *n* characters forward from the current position.

Note that *n* must be specified and must be greater than zero.

10.6.1.2 X Editing. The *n*X edit descriptor indicates that the transmission of the next character to or from a record is to occur at the position *n* characters forward from the current position. Note that the *n* must be specified and must be greater than zero.

10.6.2 Slash Editing. The slash edit descriptor indicates the end of data transfer to or from the current record.

On input from a file connected for sequential access, the remaining portion of the current record is skipped and the file is positioned at the beginning of the next record. This record becomes the current record. On output to a file connected for sequential access, a new empty record is created following the current record; this new record then becomes the last and current record of the file and the file is positioned at the beginning of this new record.

For a file connected for direct access, the record number is increased by one and the file is positioned at the beginning of the record that has that record number, if there is such a record, and this record becomes the current record.

Note that a record that contains no characters may be written on output. If the file is an internal file or a file connected for direct access, the record is filled with blank characters. Note also that an entire record may be skipped on input. The repeat specification is optional on the slash edit descriptor. If it is not specified, the default value is one.

10.6.3 Colon Editing. The colon edit descriptor terminates format control if there are no more effective items in the input/output list (9.4.2). The colon edit descriptor has no effect if there are more effective items in the input/output list.

10.6.4 S, SP, and SS Editing. The S, SP, and SS edit descriptors may be used to control optional plus characters in numeric output fields. At the beginning of execution of each formatted output statement, the processor has the option of producing a plus in numeric output fields. If an SP edit descriptor is encountered in a format specification, the processor must produce a plus in any subsequent position that normally contains an optional plus. If an SS edit descriptor is encountered, the processor must not produce a plus in any subsequent position that normally contains an optional plus. If an S edit descriptor is encountered, the option of producing the plus is restored to the processor.

The S, SP, and SS edit descriptors affect only I, F, E, EN, D, and G editing during the execution of an output statement. The S, SP, and SS edit descriptors have no effect during the execution of an input statement.

10.6.5 P Editing. The *k*P edit descriptor sets the value of the scale factor to *k*. The scale factor may affect the editing of numeric quantities.

10.6.5.1 Scale Factor. The value of the scale factor is zero at the beginning of execution of each input/output statement. It applies to all subsequently interpreted F, E, EN, D, and G edit descriptors until a P edit descriptor is encountered, and then a new scale factor is established. Note that reversion of format control (10.3) does not affect the established scale factor.

The scale factor *k* affects the appropriate editing in the following manner:

(1) On input, with F, E, EN, ES, D, and G editing (provided that no exponent exists in the field) and F output editing, the scale factor effect is that the externally represented number equals the internally represented number multiplied by 10^k.

(2) On input, with F, E, EN, ES, D, and G editing, the scale factor has no effect if there is an exponent in the field.

(3) On output, with E and D editing, the significand (4.3.1.2) part of the quantity to be produced is multiplied by 10^k and the exponent is reduced by *k*.

(4) On output, with G editing, the effect of the scale factor is suspended unless the magnitude of the datum to be edited is outside the range that permits the use of F editing. If the use of E editing is required, the scale factor has the same effect as with E output editing.

(5) On output, with EN and ES editing, the scale factor has no effect.

10.6.6 BN and BZ Editing. The BN and BZ edit descriptors may be used to specify the interpretation of blanks, other than leading blanks, in numeric input fields. At the beginning of execution of each formatted input statement, nonleading blank characters from a file connected by an OPEN statement are interpreted as zeros or are ignored, depending on the value of the BLANK= specifier (9.3.4.6) currently in effect for the unit; an internal file is treated as if the file had been opened with BLANK = NULL. If a BN edit descriptor is encountered in a format specification, all nonleading blank characters in succeeding numeric input fields are ignored. The effect of ignoring blanks is to treat the input field as if blanks had been removed, the remaining portion of the field right-justified, and the blanks replaced as leading blanks. However, a field containing only blanks has the value zero. If a BZ edit descriptor is encountered in a format specification, all nonleading blank characters in succeeding numeric input fields are treated as zeros.

The BN and BZ edit descriptors affect only I, B, O, Z, F, E, EN, ES, D, and G editing during execution of an input statement. They have no effect during execution of an output statement.

10.7 Character String Edit Descriptors. A character string edit descriptor must not be used on input.

10.7.1 Character Constant Edit Descriptor. The character constant edit descriptor causes characters to be written from the enclosed characters of the edit descriptor itself, including blanks. Note that a delimiter is either an apostrophe or quote.

For a character constant edit descriptor, the width of the field is the number of characters contained in, but not including, the delimiting characters. Within the field, two consecutive delimiting characters are counted as a single character.

10.7.2 H Editing. The *c*H edit descriptor causes character information to be written from the next *c* characters (including blanks) following the H of the *c*H edit descriptor in the *format-item-list* itself.

10.8 List-Directed Formatting. The characters in one or more list-directed records constitute a sequence of values and value separators. The end of a record has the same effect as a blank character, unless it is within a character constant. Any sequence of two or more consecutive blanks is treated as a single blank, unless it is within a character constant.

Each value is either a null value (9.4.1.10) or one of the forms:

c
r∗*c*
r∗

where *c* is a literal constant or a nondelimited character constant and *r* is an unsigned, nonzero, integer literal constant. The *r*∗*c* form is equivalent to *r* successive appearances of the constant *c*, and the *r*∗ form is equivalent to *r* successive appearances of the null value. Neither of these forms may contain embedded blanks, except where permitted within the constant *c*.

A **value separator** is one of the following:

(1) A comma optionally preceded by one or more contiguous blanks and optionally followed by one or more contiguous blanks,

(2) A slash optionally preceded by one or more contiguous blanks and optionally followed by one or more contiguous blanks, or

(3) One or more contiguous blanks between two nonblank values or following the last nonblank value, where a nonblank value is a constant, an *r*∗*c* form, or an *r*∗ form.

10.8.1 List-Directed Input. Input forms acceptable to edit descriptors for a given type are acceptable for list-directed formatting, except as noted below. The form of the input value must be acceptable for the type of the next effective item in the list. Blanks are never used as zeros, and embedded blanks are not permitted in constants, except within character constants and complex constants as specified below. Note that the end of a record has the effect of a blank, except when it appears within a character constant.

When the next effective item is of type real, the input form is that of a numeric input field. A numeric input field is a field suitable for F editing (10.5.1.2.1) that is assumed to have no fractional digits unless a decimal point appears within the field.

When the next effective item is of type complex, the input form consists of a left parenthesis followed by an ordered pair of numeric input fields separated by a comma, and followed by a right parenthesis. The first numeric input field is the real part of the complex constant and the second is the imaginary part. Each of the numeric input fields may be preceded or followed by blanks. The end of a record may occur between the real part and the comma or between the comma and the imaginary part.

When the next effective item is of type logical, the input form must not include slashes, blanks, or commas among the optional characters permitted for L editing.

When the next effective item is of type character, the input form consists of a character literal constant of the same kind as the effective list item. Character constants may be continued from the end of one record to the beginning of the next record, but the end of record must not occur between a doubled apostrophe in an apostrophe-delimited constant, nor between a doubled quote in a quote-delimited constant. The end of the record does not cause a blank or any other character to become part of the constant. The constant may be continued on as many records as needed. The characters blank, comma, and slash may appear in default character constants.

If the next effective input list item is of type character and:

(1) The character constant does not contain the value separators blank, comma, or slash, and

(2) The character constant does not cross a record boundary, and

(3) The first nonblank character is not a quotation mark or an apostrophe, and

(4) The leading characters are not numeric followed by an asterisk,

the delimiting apostrophes or quotation marks are not required. If the delimiters are omitted, the character constant is terminated by the first blank, comma, slash, or end of record and apostrophes and quotation marks within the datum are not to be doubled.

Let *len* be the length of the next effective item, and let *w* be the length of the character constant. If *len* is less than or equal to *w*, the leftmost *len* characters of the constant are transmitted to the next effective item. If *len* is greater than *w*, the constant is transmitted to the leftmost *w* characters of the next effective item and the remaining $len - w$ characters of the next effective item are filled with blanks. Note that the effect is as though the constant were assigned to the next effective item in a character assignment statement (7.5.1.4).

10.8.1.1 Null Values. A null value is specified by having no characters between successive value separators, no characters preceding the first value separator in the first record read by each execution of a list-directed input statement, or the $r*$ form. Note that the end of a record following any other value separator, with or without separating blanks, does not specify a null value. A null value has no effect on the definition status of the next effective item. A null value must not be used for either the real or imaginary part of a complex constant, but a single null value may represent an entire complex constant.

A slash encountered as a value separator during execution of a list-directed input statement causes termination of execution of that input statement after the assignment of the previous value. Any characters remaining in the current record are ignored. If there are additional items in the input list, the effect is as if null values had been supplied for them. Any DO variable in the input list is defined as though enough null values had been supplied for any remaining input list items.

Note that all blanks in a list-directed input record are considered to be part of some value separator except for the following:

(1) Blanks embedded in a character constant

(2) Embedded blanks surrounding the real or imaginary part of a complex constant

(3) Leading blanks in the first record read by each execution of a list-directed input statement, unless immediately followed by a slash or comma

10.8.1.2 List-Directed Input Example.

```
INTEGER I; REAL X (8); CHARACTER (11) P;
COMPLEX Z; LOGICAL G
  . . .
READ *, I, X, P, Z, G
  . . .
```

The input data records are:

```
12345,12345,,2*1.5,4*
ISN'T_BOB'S,(123,0),.TEXAS$
```

The results are:

Variable	Value
I	12345
X (1)	12345.0
X (2)	unchanged
X (3)	1.5
X (4)	1.5
X (5) – X (8)	unchanged
P	ISN'T_BOB'S
Z	(123.0,0.0)
G	true

10.8.2 List-Directed Output. The form of the values produced is the same as that required for input, except as noted otherwise. With the exception of nondelimited character constants, the values are separated by one or more blanks or by a comma optionally preceded by one or more blanks and optionally followed by one or more blanks.

The processor may begin new records as necessary, but, except for complex constants and character constants, the end of a record must not occur within a constant and blanks must not appear within a constant.

Logical output constants are T for the value true and F for the value false.

For numeric output, reasonable processor-dependent integer values of w, d, and e are used for each of the cases involved.

Integer output constants are produced with the effect of an Iw edit descriptor.

Real constants are produced with the effect of either an F edit descriptor or an E edit descriptor, depending on the magnitude x of the value and a range $10^{d_1} \le x < 10^{d_2}$, where d_1 and d_2 are processor-dependent integers. If the magnitude x is within this range, the constant is produced using 0PF$w.d$; otherwise, 1PE$w.d$Ee is used.

Complex constants are enclosed in parentheses with a comma separating the real and imaginary parts, each produced as defined above for real constants. The end of a record may occur between the comma and the imaginary part only if the entire constant is as long as, or longer than, an entire record. The only embedded blanks permitted within a complex constant are between the comma and the end of a record and one blank at the beginning of the next record.

Character constants produced for an internal file, or for a file opened without a DELIM= specifier (9.3.4.9) or with a DELIM= specifier with a value of NONE:

(1) Are not delimited by apostrophes or quotation marks,

(2) Are not preceded or followed by a value separator,

(3) Have each internal apostrophe or quotation mark represented externally by one apostrophe or quotation mark, and

(4) Have a blank character inserted by the processor for carriage control at the beginning of any record that begins with the continuation of a character constant from the preceding record.

Character constants produced for a file opened with a DELIM= specifier with a value of QUOTE are delimited by quotes, possibly are preceded by a *kind-param* and an underscore, are preceded and followed by a value separator, and have each internal quote represented on the external medium by two contiguous quotes.

Character constants produced for a file opened with a DELIM= specifier with a value of APOSTROPHE are delimited by apostrophes, possibly are preceded by a *kind-param* and an underscore, are preceded and followed by a value separator, and have each internal apostrophe represented on the external medium by two contiguous apostrophes.

If two or more successive values in an output record have identical values, the processor has the option of producing a repeated constant of the form $r*c$ instead of the sequence of identical values.

Slashes, as value separators, and null values are not produced as output by list-directed formatting.

Except for continuation of delimited character constants, each output record begins with a blank character to provide carriage control when the record is printed.

10.9 Namelist Formatting. The characters in one or more namelist records constitute a sequence of **name-value subsequences**, each of which consists of an object name or a subobject designator followed by an equals and followed by one or more values and value separators. The equals may optionally be preceded or followed by one or more contiguous blanks. The end of a record has the same effect as a blank character, unless it is within a character constant. Any sequence of two or more consecutive blanks is treated as a single blank, unless it is within a character constant.

The name may be any name in the *namelist-group-object-list* (5.4).

Each value is either a null value or one of the forms:

c
$r*c$
$r*$

where c is a literal constant and r is an unsigned, nonzero, integer literal constant. The $r*c$ form is equivalent to r successive appearances of the constant c, and the $r*$ form is equivalent to r successive null values. Neither of these forms may contain embedded blanks, except where permitted within the constant c.

A value separator for namelist formatting is the same as for list-directed (10.8).

10.9.1 Namelist Input. Input for a namelist input statement consists of:

(1) Optional blanks,

(2) The character & followed immediately by the *namelist-group-name* specified in the namelist input statement,

(3) One or more blanks,

(4) A sequence of zero or more name-value subsequences separated by value separators, and

(5) A slash to terminate the namelist input statement.

In each name-value subsequence, the name must be the name of a namelist group object list item with an optional qualification and the name with the optional qualification must not be a zero-sized array, a zero-sized array section, or a zero-length character string.

If a processor is capable of representing letters in both upper and lower case, a group name or object name is without regard to case.

10.9.1.1 Namelist Group Object Names. Within the input data, each name must correspond to a specific namelist group object name. Subscripts, strides, and substring range expressions used to qualify group object names must be optionally signed integer literal constants. If a namelist group object is an array, the input record corresponding to it may contain either the array name or the designator of a subobject of that array, using the syntax of subobject designators (R602). If the

namelist group object name is the name of a variable of derived type, the name in the input record may be either the name of the variable or the designator of one of its components, indicated by qualifying the variable name with the appropriate component name. Successive qualifications may be applied as appropriate to the shape and type of the variable represented.

The order of names in the input records need not match the order of the namelist group object items. The input records need not contain all the names of the namelist group object items. The definition status of any names from the *namelist-group-object-list* that do not occur in the input record remains unchanged. The name in the input record may be preceded and followed by one or more optional blanks but must not contain embedded blanks.

10.9.1.2 Namelist Input Values. The datum *c* is any input value acceptable to format specifications for a given type, except for a restriction on the form of input values corresponding to list items of type logical as specified in 10.9.1.3. The form of the input value must be acceptable for the type of the namelist group object list item. The number and forms of the input values that may follow the equals in a name-value subsequence depend on the shape and type of the object represented by the name in the input record. When the name in the input record is that of a scalar variable of an intrinsic type, the equals must not be followed by more than one value. Blanks are never used as zeros, and embedded blanks are not permitted in constants except within character constants and complex constants as specified in 10.9.1.3.

When the name in the input record represents an array variable or a variable of derived type, the effect is as if the variable represented were expanded into a sequence of scalar list items of intrinsic data types, in the same way that formatted input/output list items are expanded (9.4.2). Each input value following the equals must then be acceptable to format specifications for the intrinsic type of the list item in the corresponding position in the expanded sequence, except as noted. The number of values following the equals must not exceed the number of list items in the expanded sequence, but may be less; in the latter case, the effect is as if sufficient null values had been appended to match any remaining list items in the expanded sequence. For example, if the name in the input record is the name of an integer array of size 100, at most 100 values, each of which is either a digit string or a null value, may follow the equals; these values would then be assigned to the elements of the array in array element order.

A slash encountered as a value separator during the execution of a namelist input statement causes termination of execution of that input statement after assignment of the previous value. If there are additional items in the namelist group object being transferred, the effect is as if null values had been supplied for them.

Successive namelist records are read by namelist input until a slash is encountered; the remainder of the record is ignored.

10.9.1.3 Namelist Group Object List Items. When the corresponding namelist group object list item is of type real, the input form of the input value is that of a numeric input field. A numeric input field is a field suitable for F editing (10.5.1.2.1) that is assumed to have no fractional digits unless a decimal point appears within the field.

When the corresponding list item is of type complex, the input form of the input value consists of a left parenthesis followed by an ordered pair of numeric input fields separated by a comma and followed by a right parenthesis. The first numeric input field is the real part of the complex constant and the second part is the imaginary part. Each of the numeric input fields may be preceded or followed by blanks. The end of a record may occur between the real part and the comma or between the comma and the imaginary part.

When the corresponding list item is of type logical, the input form of the input value must not include slashes, blanks, or commas among the optional characters permitted for L editing (10.5.2).

When the corresponding list item is of type character, the input form consists of a character literal constant of the same kind as the corresponding list item. Character constants may be continued from the end of one record to the beginning of the next record, but the end of record must not occur between a doubled apostrophe in an apostrophe-delimited constant, nor between a doubled quote in a quote-delimited constant. The end of the record does not cause a blank or any other

character to become part of the constant. The constant may be continued on as many records as needed. The characters blank, comma, and slash may appear in character constants.

Let *len* be the length of the list item, and let *w* be the length of the character constant. If *len* is less than or equal to *w*, the leftmost *len* characters of the constant are transmitted to the list item. If *len* is greater than *w*, the constant is transmitted to the leftmost *w* characters of the list item and the remaining *len* – *w* characters of the list item are filled with blanks. Note that the effect is as though the constant were assigned to the list item in a character assignment statement (7.5.1.4).

10.9.1.4 Null Values. A null value is specified by:

(1) The *r*∗ form,

(2) Blanks between two consecutive value separators following an equals,

(3) Zero or more blanks preceding the first value separator and following an equals, or

(4) Two consecutive nonblank value separators.

A null value has no effect on the definition status of the corresponding input list item. If the namelist group object list item is defined, it retains its previous value; if it is undefined, it remains undefined. A null value must not be used as either the real or imaginary part of a complex constant, but a single null value may represent an entire complex constant.

Note that the end of a record following a value separator, with or without intervening blanks, does not specify a null value.

10.9.1.5 Blanks. All blanks in a namelist input record are considered to be part of some value separator except for:

(1) Blanks embedded in a character constant,

(2) Embedded blanks surrounding the real or imaginary part of a complex constant,

(3) Leading blanks following the equals unless followed immediately by a slash or comma, and

(4) Blanks between a name and the following equals.

10.9.1.6 Namelist Input Example.

```
INTEGER I; REAL X (8); CHARACTER (11) P; COMPLEX Z;
LOGICAL G
NAMELIST / TODAY / G, I, P, Z, X
READ (*, NML = TODAY)
```

The input data records are:

```
&TODAY I = 12345, X(1) = 12345, X(3:4) = 2*1.5,
P = "ISN'T_BOB'S", Z = (123,0)/
```

The results stored are:

Variable	Value
I	12345
X (1)	12345.0
X (2)	unchanged
X (3)	1.5
X (4)	1.5
X (5) – X (8)	unchanged
P	ISN'T_BOB'S
Z	(123.0,0.0)
G	unchanged

10.9.2 Namelist Output. The form of the output produced is the same as that required for input, except for the forms of real and logical constants. If the processor is capable of representing letters in both upper and lower case, the name in the output is in upper case. With the exception of non-delimited character constants, the values are separated by one or more blanks or by a comma optionally preceded by one or more blanks and optionally followed by one or more blanks.

The processor may begin new records as necessary. However, except for complex constants and character constants, the end of a record must not occur within a constant or a name, and blanks must not appear within a constant or a name.

10.9.2.1 Namelist Output Editing. Logical output constants are T for the value true and F for the value false.

Integer output constants are produced with the effect of an Iw edit descriptor.

Real constants are produced with the effect of either an F edit descriptor or an E edit descriptor, depending on the magnitude x of the value and a range $10^{d_1} \le x < 10^{d_2}$, where d_1 and d_2 are processor-dependent integers. If the magnitude x is within this range, the constant is produced using 0PF*w.d*; otherwise, 1PE*w.d*E*e* is used.

For numeric output, reasonable processor-dependent integer values of *w*, *d*, and *e* are used for each of the cases involved.

Complex constants are enclosed in parentheses with a comma separating the real and imaginary parts, each produced as defined above for real constants. The end of a record may occur between the comma and the imaginary part only if the entire constant is as long as, or longer than, an entire record. The only embedded blanks permitted within a complex constant are between the comma and the end of a record and one blank at the beginning of the next record.

Character constants produced for a file opened without a DELIM= specifier (9.3.4.9) or with a DELIM= specifier with a value of NONE:

(1) Are not delimited by apostrophes or quotation marks,

(2) Are not preceded or followed by a value separator,

(3) Have each internal apostrophe or quotation mark represented externally by one apostrophe or quotation mark, and

(4) Have a blank character inserted by the processor for carriage control at the beginning of any record that begins with the continuation of a character constant from the preceding record.

Character constants produced for a file opened with a DELIM= specifier with a value of QUOTE are delimited by quotes, possibly are preceded by a *kind-param* and an underscore, are preceded and followed by a value separator, and have each internal quote represented on the external medium by two contiguous quotes.

Character constants produced for a file opened with a DELIM= specifier with a value of APOSTROPHE are delimited by apostrophes, possibly are preceded by a *kind-param* and an underscore, are preceded and followed by a value separator, and have each internal apostrophe represented on the external medium by two contiguous apostrophes.

10.9.2.2 Namelist Output Records. If two or more successive values in an array in an output record produced have identical values, the processor has the option of producing a repeated constant of the form *r*∗*c* instead of the sequence of identical values.

The name of each namelist group object list item is placed in the output record followed by an equals and one or more values of the namelist group object list item; however, if the namelist group object list item is a zero-sized array or a zero-length character entity, nothing is placed in the output record.

An ampersand character followed immediately by a *namelist-group-name* will be produced by namelist formatting at the start of the first output record to indicate which specific group of data

objects is being output. A slash is produced by namelist formatting to indicate the end of the namelist formatting.

A null value is not produced by namelist formatting.

Except for continuation of delimited character constants, each output record begins with a blank character to provide carriage control when the record is printed.

11. PROGRAM UNITS

The terms and basic concepts of program units were introduced in 2.2. A program unit is a main program, an external subprogram, a module, or a block data program unit.

This section describes all of these program units except external subprograms, which are described in Section 12.

11.1 Main Program. A main program is a program unit that does not contain a SUBROUTINE, FUNCTION, MODULE, or BLOCK DATA statement as its first statement.

R1101 *main-program* is [*program-stmt*]
[*specification-part*]
[*execution-part*]
[*internal-subprogram-part*]
end-program-stmt

R1102 *program-stmt* is PROGRAM *program-name*

R1103 *end-program-stmt* is END [PROGRAM [*program-name*]]

Constraint: In a *main-program*, the *execution-part* must not contain a RETURN statement or an ENTRY statement.

Constraint: The *program-name* may be included in the *end-program-stmt* only if the optional *program-stmt* is used and, if included, must be identical to the *program-name* specified in the *program-stmt*.

Constraint: An automatic object must not appear in the *specification-part* (R204) of a main program.

The **program name** is global to the executable program, and must not be the same as the name of any other program unit, external procedure, or common block in the executable program, nor the same as any local name in the main program.

An example of a main program is:

```
PROGRAM ANALYSE
   REAL A, B, C (10,10)      !  Specification part
   CALL FIND                 !  Execution part
CONTAINS
   SUBROUTINE FIND           !  Internal procedure
       . . .
   END SUBROUTINE FIND
END PROGRAM ANALYSE
```

11.1.1 Main Program Specifications. The specifications in the scoping unit of the main program must not include an OPTIONAL statement, an INTENT statement, a PUBLIC statement, a PRIVATE statement, or their equivalent attributes (5.1.2). A SAVE statement has no effect in a main program.

11.1.2 Main Program Executable Part. The sequence of *execution-part* statements specifies the actions of the main program during program execution. Execution of an executable program (R201) begins with the first executable construct of the main program.

A main program must not be recursive; that is, a reference to it must not appear in any program unit in the executable program, including itself.

Execution of an executable program ends with execution of the *end-program-stmt* of the main program or with execution of a STOP statement in any program unit of the executable program.

11.1.3 Main Program Internal Procedures. Any definitions of internal procedures in the main program must follow the CONTAINS statement. Internal procedures are described in 11.2.1. The main program is called the **host** of its internal procedures.

11.2 Procedures.

External procedures and module procedures are described in Section 12.

11.2.1 Internal Procedures. Internal procedures may appear in the main program, in an external subprogram, or in a module subprogram. Internal procedures must not appear in other internal procedures. Internal procedures are the same as external procedures except that the name of the internal procedure is not a global entity, an internal procedure must not contain an ENTRY statement, the internal procedure name must not be argument associated with a dummy procedure (12.4.1.2), and the internal procedure has access to host entities by host association.

11.2.2 Host Association. An internal subprogram, a module subprogram, or a derived-type definition has access to the named entities from its host via **host association.** The accessed entities are known by the same name and have the same attributes as in the host and are variables, constants, procedures including interfaces, derived types, type parameters, derived-type components, and namelist groups.

Any declaration or specification of an entity, or any entity accessed through use association, with the same nongeneric name as an accessible entity from the host makes the host entity inaccessible. The appearance of a name as a dummy argument or as a function result is treated as a specification. Entities that are local to a procedure are not accessible to its host.

Note that an interface block does not access the named entities from its host by host association, but it may access entities by use association (11.3.2).

If a procedure gains access to a pointer by host association, the association of the pointer with a target that is current at the time the procedure is invoked remains current within the procedure. This pointer association may be changed within the procedure. When execution of the procedure completes, the pointer association that was current remains current, except where the associated target is a dummy argument or was declared within the procedure and is not saved. In these cases, the completion of the procedure causes the pointer association status of the host associated pointer to become undefined.

11.3 Modules.

A module contains specifications and definitions that are to be accessible to other program units.

R1104 *module* is *module-stmt*
[*specification-part*]
[*module-subprogram-part*]
end-module-stmt

R1105 *module-stmt* is MODULE *module-name*

R1106 *end-module-stmt* is END [MODULE [*module-name*]]

Constraint: If the *module-name* is specified in the *end-module-stmt*, it must be identical to the *module-name* specified in the *module-stmt*.

Constraint: A module *specification-part* must not contain a *stmt-function-stmt* or a *format-stmt*.

Constraint: An automatic object must not appear in the *specification-part* (R204) of a module.

The module name is global to the executable program, and must not be the same as the name of any other program unit, external procedure, or common block in the executable program, nor be the same as any local name in the module.

Note that although statement function definitions and FORMAT statements must not appear in the specification part of a module, they may appear in the specification part of a module subprogram contained in the module.

11.3.1 Module Reference. A USE statement specifying a module name is a **module reference.** At the time a module reference is processed, the public portions of the specified module must be available. A module must not reference itself, either directly or indirectly.

The accessibility, public or private, of specifications and definitions in a module to a scoping unit making reference to the module may be controlled in both the module and the scoping unit making the reference. In the module, the PRIVATE statement, the PUBLIC statement (5.2.3), their equivalent attributes (5.1.2.2), and the PRIVATE statement in a derived-type definition (4.4.1) are used to control the accessibility of module entities outside the module.

In a scoping unit making reference to a module, the ONLY option on the USE statement may be used to further limit the accessibility, in that referencing scoping unit, of the public entities in the module.

11.3.2 The USE Statement. The **USE statement** provides the means by which a scoping unit accesses named data objects, derived types, interface blocks, procedures, and namelist groups in a module. The entities in the scoping unit are said to be **use associated** with the entities in the module. The accessed entities have the attributes specified in the module.

R1107 *use-stmt* **is** USE *module-name* [, *rename-list*]
or USE *module-name* , ONLY : [*only-list*]

R1108 *rename* **is** *local-name* => *use-name*

R1109 *only* **is** *access-id*
or [*local-name* =>] *use-name*

Constraint: Each *access-id* must be a public entity in the module.

Constraint: Each *use-name* must be the name of a public entity in the module.

If a *local-name* appears in a *rename-list* or an *only-list*, it is the local name for the entity specified by *use-name*; otherwise, the local name is the *use-name*.

The USE statement without the ONLY option provides access to all public entities in the specified module.

A USE statement with the ONLY option provides access only to those entities that appear as *access-id*s or *use-name*s in the *only-list*.

More than one USE statement for a given module may appear in a scoping unit. If one of the USE statements is without an ONLY qualifier, all public entities in the module are accessible and the *rename-list*s and *only-list*s are interpreted as a single concatenated *rename-list*. If all the USE statements have ONLY qualifiers, only those entities named in one or more of the *only-list*s are accessible, that is, all the *only-list*s are interpreted as a single concatenated *only-list*.

If two or more generic interfaces with the same name are accessible in a scoping unit, they are interpreted as a single generic interface. Two or more accessible entities, other than generic interfaces, may have the same name only if no entity is referenced by this name in the scoping unit. Except for these cases, the local name of any entity given accessibility by a USE statement must differ from the local names of all other entities accessible to the scoping unit through USE statements and otherwise. Note that an entity may be accessed by more than one local name.

The local name of an entity made accessible by a USE statement may appear in no other specification statement that would cause any attribute (5.1.2) of the entity to be respecified in the scoping unit that contains the USE statement, except that it may appear in a PUBLIC or PRIVATE statement in the scoping unit of a module. Note that this prohibits the local name from appearing in COMMON and EQUIVALENCE specifications, but permits the appearance of local names in namelist group lists. The appearance of such a local name in a PUBLIC statement in a module causes the entity accessible by the USE statement to be a public entity of that module. If the name appears in a PRIVATE statement in a module, the entity is not a public entity of that module. If the local name does not appear in either a PUBLIC or PRIVATE statement, it assumes the default accessibility attribute (5.2.3) of that scoping unit.

Examples:

```
USE STATS_LIB
```

provides access to all public entities in the module STATS_LIB.

```
USE MATH_LIB; USE STATS_LIB, SPROD => PROD
```

makes all public entities in both MATH_LIB and STATS_LIB accessible. If MATH_LIB contains an entity called PROD, it is accessible by its own name while the entity PROD of STATS_LIB is accessible by the name SPROD.

```
USE STATS_LIB, ONLY: YPROD; USE STATS_LIB, ONLY : PROD
```

makes public entities YPROD and PROD in STATS_LIB accessible.

```
USE STATS_LIB, ONLY : YPROD; USE STATS_LIB
```

makes all public entities in STATS_LIB accessible.

11.3.3 Examples of the Use of Modules.

11.3.3.1 Identical Common Blocks. A common block and all its associated specification statements may be placed in a module named, for example, MY_COMMON and accessed by a USE statement of the form

```
USE MY_COMMON
```

that accesses the whole module without any renaming. This ensures that all instances of the common block are identical. Module MY_COMMON could contain more than one common block.

11.3.3.2 Global Data. A module may contain only data objects, for example:

```
MODULE DATA_MODULE
   REAL A (10), B, C (20,20)
   INTEGER :: I=0
   INTEGER, PARAMETER :: J=10
   COMPLEX D (J,J)
END MODULE
```

Note that data objects made global in this manner may have any combination of data types.

Access to some of these may be made by a USE statement with the ONLY option, such as:

```
USE DATA_MODULE, ONLY: A, B, D
```

and access to all of them may be made by the following USE statement:

```
USE DATA_MODULE
```

Access to all of them with some renaming to avoid name conflicts may be made by:

```
USE DATA_MODULE, AMODULE => A, DMODULE => D
```

11.3.3.3 Data Structures. A derived type may be defined in a module and accessed in a number of program units. This is the only way to access the same type definition in more than one program unit. For example:

```
MODULE SPARSE
   TYPE NONZERO
      REAL A
      INTEGER  I, J
   END TYPE
END MODULE
```

defines a type consisting of a real component and two integer components for holding the numerical value of a nonzero matrix element and its row and column indices.

11.3.3.4 Global Allocatable Arrays. Many programs need large global allocatable arrays whose sizes are not known before program execution. A simple form for such a program is:

```
PROGRAM GLOBAL_WORK
   CALL CONFIGURE_ARRAYS       ! Perform the appropriate allocations
   CALL COMPUTE                ! Use the arrays in computations
END PROGRAM GLOBAL_WORK

MODULE WORK_ARRAYS             ! An example set of work arrays
   INTEGER  N
   REAL, ALLOCATABLE, SAVE :: A (:), B (:, :), C (:, :, :)
END MODULE WORK_ARRAYS

SUBROUTINE CONFIGURE_ARRAYS    ! Process to set up work arrays
   USE WORK_ARRAYS
   READ (*, *)  N
   ALLOCATE (A (N), B (N, N), C (N, N, 2 * N))
END SUBROUTINE CONFIGURE_ARRAYS

SUBROUTINE COMPUTE
   USE WORK_ARRAYS
   ...  !  Computations involving arrays A, B, and C
END SUBROUTINE COMPUTE
```

Typically, many subprograms need access to the work arrays, and all such subprograms would contain the statement

```
USE WORK_ARRAYS
```

11.3.3.5 Procedure Libraries. Interfaces to external procedures in a library may be gathered into a module. This permits the use of argument keywords and optional arguments, and allows static checking of the references. Different versions may be constructed for different applications, using keywords in common use in each application. An example is the following library module:

```
MODULE LIBRARY_LLS
   INTERFACE
      SUBROUTINE LLS (X, A, F, FLAG)
         ! The second KIND in the next statement is an intrinsic function
         REAL (KIND = KIND (0.0)) X (:, :)
         REAL (KIND (0.0)), DIMENSION (SIZE (X, 2)) :: A, F
         INTEGER FLAG
      END SUBROUTINE LLS
   END INTERFACE
END MODULE LIBRARY_LLS
```

This module allows the subroutine LLS to be invoked:

```
USE LIBRARY_LLS
   ...
CALL LLS (X = ABC, A = D, F = XX, FLAG = IFLAG)
   ...
```

11.3.3.6 Operator Extensions. In order to extend an intrinsic operator symbol to have an additional meaning, an interface block specifying that operator symbol in the OPERATOR option of the INTERFACE statement may be placed in a module. For example, // may be overloaded to perform concatenation of two derived-type objects serving as varying length character strings and + may be overloaded to specify matrix addition for type MATRIX or interval arithmetic addition for type INTERVAL.

A module might contain several such interface blocks. An operator may be defined by an external function (either in Fortran or some other language) and its procedure interface placed in the

module.

11.3.3.7 Data Abstraction. A module may encapsulate a derived-type definition and all the procedures that represent operations on values of this type. An example is given in C.11.5 for set operations.

11.3.3.8 Host Association and USE Association. A host procedure and an internal procedure may contain the same and differing use-associated entities.

```
MODULE B; REAL BX, Q; INTEGER IX, JX; END MODULE
MODULE C; REAL CX; END MODULE
MODULE D; REAL DX, DY, DZ; END MODULE
MODULE E; REAL EX, EY, EZ; END MODULE
MODULE F; REAL FX; END MODULE
MODULE G; USE F; REAL GX; END MODULE

PROGRAM A
USE B; USE C; USE D
   ...
CONTAINS
   SUBROUTINE INNER_PROC (Q)
      USE C             ! Not needed
      USE B, ONLY: BX   ! Entities accessible are BX, IX, and JX
                        ! If no other IX or JX
                        ! is accessible to INNER_PROC
                        ! Q is local to INNER_PROC
      USE D, X => DX    ! Entities accessible are DX, DY, and DZ
                        ! X is local name for DX in INNER_PROC
                        ! X and DX denote same entity if no other
                        ! entity DX is local to INNER_PROC
      USE E, ONLY: EX   ! EX is accessible in INNER_PROC, not in program A
                        ! EY and EZ are not accessible in INNER_PROC
                        ! or in program A
      USE F             ! FX and GX are accessible in INNER_PROC
      . . .
   END SUBROUTINE INNER_PROC
END PROGRAM A
```

Note: Because program A contains the statement

```
USE B
```

all of the entities in module B, except for Q, are accessible in INNER_PROC, even though INNER_PROC contains the statement

```
USE B, ONLY: BX
```

The USE statement with the ONLY keyword means that this particular statement brings in only the entity named, not that this is the only variable from the module accessible in this scoping unit.

11.3.3.9 Public Entities Renamed. At times it may be necessary to rename entities that are accessed with USE statements. Care must be taken if the modules contain USE statements, too.

The following example illustrates the remaining features of the USE statement.

```
MODULE J; REAL JX, JY, JZ; END MODULE
   MODULE K
   USE J, ONLY : KX => JX, KY => JY
   ! KX and KY are local names to module K
   REAL KZ       ! KZ is local name to module K
   REAL JZ       ! JZ is local name to module K
END MODULE

PROGRAM RENAME
   USE J; USE K
   ! Module J's entity JX is accessible under names JX and KX
   ! Module J's entity JY is accessible under names JY and KY
   ! Module K's entity KZ is accessible under name KZ
   ! Module J's entity JZ and K's entity JZ are different entities
   ! and must not be referenced
   . . .
END PROGRAM RENAME
```

11.4 Block Data Program Units. A block data program unit is used to provide initial values for data objects in named common blocks.

R1110 *block-data* is *block-data-stmt*
[*specification-part*]
end-block-data-stmt

R1111 *block-data-stmt* is BLOCK DATA [*block-data-name*]

R1112 *end-block-data-stmt* is END [BLOCK DATA [*block-data-name*]]

Constraint: The *block-data-name* may be included in the *end-block-data-stmt* only if it was provided in the *block-data-stmt* and, if included, must be identical to the *block-data-name* in the *block-data-stmt*.

Constraint: A *block-data specification-part* may contain only USE statements, type declaration statements, IMPLICIT statements, PARAMETER statements, derived-type definitions, and the following specification statements: COMMON, DATA, DIMENSION, EQUIVALENCE, INTRINSIC, POINTER, SAVE, and TARGET.

Constraint: A type declaration statement in a *block-data specification-part* must not contain the ALLOCATABLE, EXTERNAL, INTENT, OPTIONAL, PRIVATE, or PUBLIC attribute specifiers.

If an object in a named common block is initially defined, all objects having storage units in the common block storage sequence must be specified even if they are not all initially defined. More than one named common block may have objects initially defined in a single block data program unit.

Only a nonpointer object in a named common block may be initially defined in a block data program unit. Note that objects associated with an object in a common block are considered to be in that common block.

The same named common block must not be specified in more than one block data program unit in an executable program.

There must not be more than one unnamed block data program unit in an executable program.

An example of a block data program unit is:

```
BLOCK DATA WORK
   COMMON /WRKCOM/ A, B, C (10, 10)
   DATA A /1.0/, B /2.0/, C /100 * 0.0/
END BLOCK DATA WORK
```

12. PROCEDURES

The concept of a procedure was introduced in 2.2.4. This section contains a complete description of procedures. The actions specified by a procedure are performed when the procedure is invoked by execution of a reference to it. The reference may identify, as actual arguments, entities that are associated during execution of the procedure reference with corresponding dummy arguments in the procedure definition.

12.1 Procedure Classifications. A procedure is classified according to the form of its reference and the way it is defined.

12.1.1 Procedure Classification by Reference. The definition of a procedure specifies it to be a function or a subroutine. A reference to a function either appears explicitly as a primary within an expression, or is implied by a defined operation within an expression. A reference to a subroutine is a CALL statement or a defined assignment statement (7.5.1.3).

A procedure is classified as **elemental** if it may be referenced elementally (12.4.3, 12.4.5).

12.1.2 Procedure Classification by Means of Definition. A procedure is either an intrinsic procedure, an external procedure, a module procedure, an internal procedure, a dummy procedure, or a statement function.

12.1.2.1 Intrinsic Procedures. A procedure that is provided as an inherent part of the processor is an **intrinsic procedure.**

12.1.2.2 External, Internal, and Module Procedures. An **external procedure** is a procedure that is defined by an external subprogram or by a means other than Fortran.

An **internal procedure** is a procedure that is defined by an internal subprogram.

A **module procedure** is a procedure that is defined by a module subprogram.

If a subprogram contains one or more ENTRY statements, it defines a procedure for each ENTRY statement and a procedure for the SUBROUTINE or FUNCTION statement.

An internal subprogram must not contain an ENTRY statement.

12.1.2.3 Dummy Procedures. A dummy argument that is specified as a procedure or appears in a procedure reference is a **dummy procedure.**

12.1.2.4 Statement Functions. A function that is defined by a single statement is a **statement function** (12.5.4).

12.2 Characteristics of Procedures. The **characteristics of a procedure** are the classification of the procedure as a function or subroutine, the characteristics of its arguments, and the characteristics of its result value if it is a function.

12.2.1 Characteristics of Dummy Arguments. Each dummy argument is either a dummy data object, a dummy procedure, or an asterisk (alternate return indicator). A dummy argument other than an asterisk may be specified to have the OPTIONAL attribute. This attribute means that the dummy argument need not be associated with an actual argument for any particular reference to the procedure.

12.2.1.1 Characteristics of Dummy Data Objects. The characteristics of a dummy data object are its type, its type parameters (if any), its shape, its intent (5.1.2.3, 5.2.1), whether it is optional (5.1.2.6, 5.2.2), and whether it is a pointer (5.1.2.7, 5.2.7) or a target (5.1.2.8, 5.2.8). If a type parameter of an object or a bound of an array is an expression that depends on the value or attributes of another object, the exact dependence on other entities is a characteristic. If a shape, size, or character length is assumed, it is a characteristic.

12.2.1.2 Characteristics of Dummy Procedures. The characteristics of a dummy procedure are the explicitness of its interface (12.3.1), its characteristics as a procedure if the interface is explicit, and whether it is optional (5.1.2.6, 5.2.2).

12.2.1.3 Characteristics of Asterisk Dummy Arguments. An asterisk as a dummy argument has no characteristics.

12.2.2 Characteristics of Function Results. The characteristics of a function result are its type, type parameters (if any), rank, and whether it is a pointer. If a function result is an array that is not a pointer, its shape is a characteristic. In certain circumstances (12.5.2.2, 12.5.2.3, 12.5.2.5), the interface of a procedure defined by a subprogram is explicit within that subprogram. Where a type parameter or bound of an array is not a constant expression, the exact dependence on the entities in the expression is a characteristic. If the length of a character data object is assumed, this is a characteristic.

12.3 Procedure Interface.

The interface of a procedure determines the forms of reference through which it may be invoked. The interface consists of the characteristics of the procedure, the name of the procedure, the name and characteristics of each dummy argument, and the procedure's generic identifiers, if any. The characteristics of a procedure are fixed, but the remainder of the interface may differ in different scoping units.

12.3.1 Implicit and Explicit Interfaces. If a procedure is accessible in a scoping unit, its interface is either **explicit** or **implicit** in that scoping unit. The interface of an internal procedure, module procedure, or intrinsic procedure is always explicit in such a scoping unit. The interface of a statement function is always implicit. The interface of an external procedure or dummy procedure is explicit in a scoping unit other than its own if an interface block (12.3.2.1) for the procedure is supplied or accessible, and implicit otherwise. For example, the subroutine LLS of 11.3.3.5 has an explicit interface.

12.3.1.1 Explicit Interface. A procedure must have an explicit interface if any of the following is true:

(1) A reference to the procedure appears:
   (a) With an argument keyword (12.4.1)
   (b) As a defined assignment (subroutines only)
   (c) In an expression as a defined operator (functions only)
   (d) As reference by its generic name (12.3.2.1)

(2) The procedure has:
   (a) An optional dummy argument
   (b) An array-valued result (functions only)
   (c) A dummy argument that is an assumed-shape array, a pointer, or a target
   (d) A result whose type parameter values are neither assumed length nor constant (character functions only)
   (e) A result that is a pointer (functions only)

12.3.2 Specification of the Procedure Interface. The interface for an internal, external, module, or dummy procedure is specified by a FUNCTION, SUBROUTINE, or ENTRY statement and by specification statements for the dummy arguments and the result of a function. These statements may appear in the procedure definition, in an interface block, or in both except that the ENTRY statement must not appear in an interface block.

12.3.2.1 Procedure Interface Block.

R1201 *interface-block* is *interface-stmt*
[*interface-body*] ...
[*module-procedure-stmt*] ...
end-interface-stmt

R1202 *interface-stmt* is INTERFACE [*generic-spec*]

R1203 *end-interface-stmt* is END INTERFACE

R1204 *interface-body* is *function-stmt*
[*specification-part*]
end-function-stmt
or *subroutine-stmt*
[*specification-part*]
end-subroutine-stmt

R1205 *module-procedure-stmt* is MODULE PROCEDURE *procedure-name-list*

R1206 *generic-spec* is *generic-name*
or OPERATOR (*defined-operator*)
or ASSIGNMENT (=)

Constraint: An *interface-body* must not contain an *entry-stmt*, *data-stmt*, *format-stmt*, or *stmt-function-stmt*.

Constraint: The MODULE PROCEDURE specification is allowed only if the *interface-block* has a *generic-spec*.

Constraint: An *interface-block* must not appear in a BLOCK DATA program unit.

Constraint: An *interface-block* in a subprogram must not contain an *interface-body* for a procedure defined by that subprogram.

An external or module subprogram definition specifies a **specific interface** for the procedures defined in that subprogram. Such a specific interface is explicit for module procedures and implicit for external procedures. An **interface body** in an interface block specifies an explicit interface for an existing external procedure or a dummy procedure. If the name on a procedure heading in an interface block is the same as the name of a dummy argument in the subprogram containing the interface block, the interface block declares that dummy argument to be a dummy procedure with the indicated interface; otherwise, the interface block declares the name to be the name of an external procedure with the indicated procedure interface.

An interface body specifies all of the procedure's characteristics and these must be consistent with those specified in the procedure definition. Note that the dummy argument names may be different. An interface block must not contain an ENTRY statement, but an ENTRY interface may be specified by using the entry name as the procedure name in the interface body. A procedure must not have more than one explicit specific interface in a given scoping unit.

An example of an interface block without a generic specification is:

```
INTERFACE

   SUBROUTINE EXT1 (X, Y, Z)
      REAL, DIMENSION (100, 100) :: X, Y, Z
   END SUBROUTINE EXT1

   SUBROUTINE EXT2 (X, Z)
      COMPLEX (KIND = 4) Z (2000)
   END SUBROUTINE EXT2
```

```
      FUNCTION EXT3 (P, Q)
         LOGICAL EXT3
         INTEGER P (1000)
         LOGICAL Q (1000)
      END FUNCTION EXT3

END INTERFACE
```

This interface block specifies explicit interfaces for the three external procedures EXT1, EXT2, and EXT3. Any of these procedures may use keyword calls; for example:

```
EXT3 (Q = P_MASK (N+1 : N+1000), P = ACTUAL_P)
```

An interface block with a generic specification specifies a **generic interface** for each of the procedures in the interface block. The MODULE PROCEDURE specification lists those module procedures, either defined in that module (if the interface block is in a module) or accessible via a USE statement, that have this generic interface. The characteristics of module procedures are not given in interface blocks, but are assumed from the module subprogram definitions. A generic interface is always explicit.

A procedure always may be referenced via its specific interface. It also may be referenced via its generic interface, if it has one.

A generic name **overloads** all of the procedure names in the interface block. A generic name may be the same as any one of the procedure names in that interface block, or the same as any accessible generic name. Any overload is allowed for which any given procedure interface would apply to at most one procedure. The rules on how any two such procedure interfaces must differ are given in 14.1.2.3.

An example of a generic procedure interface is:

```
INTERFACE SWITCH

   SUBROUTINE INT_SWITCH (X, Y)
      INTEGER, INTENT (INOUT) :: X, Y
   END SUBROUTINE INT_SWITCH

   SUBROUTINE REAL_SWITCH (X, Y)
      REAL, INTENT (INOUT) :: X, Y
   END SUBROUTINE REAL_SWITCH

   SUBROUTINE COMPLEX_SWITCH (X, Y)
      COMPLEX, INTENT (INOUT) :: X, Y
   END SUBROUTINE COMPLEX_SWITCH

END INTERFACE
```

Any of these three subroutines (INT_SWITCH, REAL_SWITCH, COMPLEX_SWITCH) may be referenced with the generic name SWITCH, as well as by its original name. For example, a reference to INT_SWITCH could take the form:

```
CALL SWITCH (MAX_VAL, LOC_VAL) ! MAX_VAL and LOC_VAL are of type INTEGER
```

If OPERATOR is specified in a generic specification, all of the procedures specified in the interface block must be functions, that may be referenced as defined operations (12.4). In the case of functions of two arguments, infix binary operator notation is implied. In the case of functions of one argument, prefix operator notation is implied. OPERATOR must not be specified for functions with no arguments or for functions with more than two arguments. If the operator is an *intrinsic-operator* (R310), the number of function arguments must be consistent with the intrinsic uses of that operator. In addition, the dummy arguments must be nonoptional dummy data objects and may be specified with INTENT (IN) but not INTENT (OUT) or INTENT (INOUT); INTENT (IN) is assumed if intent is not specified.

A defined operation is treated as a reference to the function. For a unary defined operation, the operand corresponds to the function's dummy argument; for a binary operation, the left-hand operand corresponds to the first dummy argument of the function and the right-hand operand corresponds to the second argument.

An example of the use of the OPERATOR generic specification is:

```
INTERFACE OPERATOR ( * )

   FUNCTION BOOLEAN_AND (B1, B2)
      LOGICAL, INTENT (IN) :: B1 (:), B2 (SIZE (B1))
      LOGICAL :: BOOLEAN_AND (SIZE (B1))
   END FUNCTION BOOLEAN_AND

END INTERFACE
```

This allows, for example

```
SENSOR (1:N) * ACTION (1:N)
```

as an alternative to the function call

```
BOOLEAN_AND (SENSOR (1:N), ACTION (1:N))    ! SENSOR and ACTION are
                                            ! of type LOGICAL
```

A given defined operator may, as with generic names, apply to more than one function, in which case it is overloaded in exact analogy to overloaded procedure names. For intrinsic operator symbols, the overloads include the intrinsic operations they represent. The procedure characteristic rules for generic name overloading apply without change to operator overloading. Because both forms of each relational operator have the same interpretation (7.3), overloading one form (such as <=) has the effect of defining both forms (<= and .LE.).

If ASSIGNMENT is specified in an INTERFACE statement, all the procedures in the interface block must be subroutines, that may be referenced as defined assignments (7.5.1.3). Each of these subroutines must have exactly two dummy arguments. The first argument may have INTENT (OUT) or INTENT (INOUT) but not INTENT (IN) and the second argument may have INTENT (IN) but not INTENT (OUT) or INTENT (INOUT); for unspecified intent, INTENT (OUT) is assumed for the first argument and INTENT (IN) is assumed for the second argument. A defined assignment is treated as a reference to the subroutine, with the left-hand side as the first argument and the right-hand side enclosed in parentheses as the second argument. The ASSIGNMENT generic specification specifies that the assignment operation is overloaded and, with the inclusion of intrinsic assignment, the procedure characteristics rules for generic name overloading apply to assignment overloading.

An example of the use of the ASSIGNMENT generic specification is

```
INTERFACE ASSIGNMENT ( = )

   SUBROUTINE BIT_TO_NUMERIC (N, B)
      INTEGER, INTENT (OUT) :: N
      LOGICAL, INTENT (IN)  :: B (:)
   END SUBROUTINE BIT_TO_NUMERIC

   SUBROUTINE CHAR_TO_STRING (S, C)
      USE STRING_MODULE
      TYPE (STRING), INTENT (OUT) :: S  ! A variable-length string
      CHARACTER (*), INTENT (IN) ::  C
   END SUBROUTINE CHAR_TO_STRING

END INTERFACE
```

Example assignments are:

```
KOUNT = SENSOR (J:K)    ! CALL BIT_TO_NUMERIC (KOUNT, (SENSOR (J:K)))
NOTE  = '89AB'          ! CALL CHAR_TO_STRING (NOTE, ('89AB'))
```

12.3.2.2 EXTERNAL Statement. An EXTERNAL statement is used to specify a name as representing an external procedure, a dummy procedure, or a block data program unit. Specifying an external procedure name or a dummy procedure name in an EXTERNAL statement permits such a name to be used as an actual argument.

R1207 *external-stmt* is EXTERNAL *external-name-list*

Each *external-name* must be the name of an external procedure, a dummy argument, or a block data program unit.

The appearance of the name of a dummy argument in an EXTERNAL statement specifies that the dummy argument is a dummy procedure.

The appearance in an EXTERNAL statement of a name that is not the name of a dummy argument specifies that the name is the name of an external procedure or block data program unit. If an external procedure name or a dummy procedure name is used as an actual argument, it must appear in an EXTERNAL statement, be given the external attribute in a type declaration statement, or be declared to be a procedure by an interface block in the scoping unit. Appearance of an intrinsic procedure name in an EXTERNAL statement causes that name to become the name of some external subprogram and an intrinsic procedure of the same name is not available in the scoping unit.

Only one appearance of a name in all of the EXTERNAL statements in a scoping unit is permitted.

An example of an EXTERNAL statement is:

```
SUBROUTINE SUB (FOCUS)
   EXTERNAL FOCUS
```

12.3.2.3 INTRINSIC Statement. An INTRINSIC statement specifies a list of names that have the INTRINSIC attribute. A name that has the INTRINSIC attribute represents an intrinsic procedure (Section 13). The INTRINSIC attribute permits a name that represents a specific intrinsic function to be used as an actual argument.

R1208 *intrinsic-stmt* is INTRINSIC *intrinsic-procedure-name-list*

The appearance of a name in an INTRINSIC statement confirms that the name is the name of an intrinsic procedure. The appearance of a generic intrinsic function name (13.10) in an INTRINSIC statement does not cause that name to lose its generic property.

If the specific name (13.12) of an intrinsic function is used as an actual argument, the name must either appear in an INTRINSIC statement or be given the intrinsic attribute in a type declaration statement in the scoping unit.

Only one appearance of a name in all of the INTRINSIC statements in a scoping unit is permitted. Note that a name must not appear in both an EXTERNAL and an INTRINSIC statement in the same scoping unit.

12.3.2.4 Implicit Interface Specification. In a scoping unit where the interface of a function is implicit, the type and type parameters of the function result are specified by implicit or explicit type specification of the function name. The type, type parameters, and shape of dummy arguments of a procedure referenced from a scoping unit where the interface of the procedure is implicit must be such that the actual arguments are consistent with the characteristics of the dummy arguments.

12.4 Procedure Reference.

The form of a procedure reference is dependent on the interface of the procedure, but is independent of the means by which the procedure is defined. The forms of procedure references are:

R1209 *function-reference* is *function-name* ([*actual-arg-spec-list*])

Constraint: The *actual-arg-spec-list* for a function reference must not contain an *alt-return-spec.*

R1210 *call-stmt* is CALL *subroutine-name* [([*actual-arg-spec-list*])]

A function may be referenced also as a defined operation and a subroutine may be referenced also as a defined assignment.

12.4.1 Actual Argument List.

R1211 *actual-arg-spec* is [*keyword* =] *actual-arg*

R1212 *keyword* is *dummy-arg-name*

R1213 *actual-arg* is *expr*
or *variable*
or *procedure-name*
or *alt-return-spec*

R1214 *alt-return-spec* is * *label*

Constraint: The *keyword* = must not appear if the interface of the procedure is implicit in the scoping unit.

Constraint: The *keyword* = may be omitted from an *actual-arg-spec* only if the *keyword* = has been omitted from each preceding *actual-arg-spec* in the argument list.

Constraint: Each *keyword* must be the name of a dummy argument in the explicit interface of the procedure.

Constraint: A *procedure-name actual-arg* must not be the name of an internal procedure and must not be the generic name of a procedure (12.3.2.1, 13.1). If it is the name of an intrinsic function, it must be a specific name for the function (13.12).

Constraint: The *label* used in the *alt-return-spec* must be the statement label of a branch target statement that appears in the same scoping unit as the *call-stmt.*

In either a subroutine reference or a function reference, the actual argument list identifies the correspondence between the actual arguments supplied and the dummy arguments of the procedure. In the absence of a keyword, an actual argument is associated with the dummy argument occupying the corresponding position in the dummy argument list; that is, the first actual argument is associated with the first dummy argument, the second actual argument is associated with the second dummy argument, etc. If a keyword is present, the actual argument is associated with the dummy argument whose name is the same as the keyword (using the dummy argument names from the interface accessible in the scoping unit containing the procedure reference). Exactly one actual argument must be associated with each nonoptional dummy argument. At most one actual argument may be associated with each optional dummy argument. Each actual argument must be associated with a dummy argument. For example, the procedure

```
SUBROUTINE SOLVE (FUNCT, SOLUTION, METHOD, STRATEGY, PRINT)
   INTERFACE
      FUNCTION FUNCT (X)
         REAL FUNCT, X
      END FUNCTION FUNCT
   END INTERFACE
   REAL SOLUTION
   INTEGER, OPTIONAL :: METHOD, STRATEGY, PRINT
   ...
```

may be invoked with

```
CALL SOLVE (FUN, SOL, PRINT = 6)
```

providing its interface is explicit.

12.4.1.1 Arguments Associated with Dummy Data Objects. If a dummy argument is a dummy data object, the associated actual argument must be an expression of the same type or a data object of the same type. The kind type parameter value of the actual argument must agree with that of the dummy argument. If a scalar dummy argument is of type character, the length *len* of the dummy argument must be less than or equal to the length of the actual argument. The dummy argument becomes associated with the leftmost *len* characters of the actual argument. If an array dummy argument is of type character, the restriction on length is for the entire array and not for each array element. The length of an array element in the dummy argument array may be different from the length of an array element in the associated actual argument array, array element, or array element substring, but the dummy argument array must not extend beyond the end of the actual argument array. Except when a procedure reference is elemental (12.4.3, 12.4.5), each element of an array-valued actual argument or of a sequence in a sequence association (12.4.1.4) is associated with the element of the dummy array that has the same position in array element order (6.2.2.2).

If the dummy argument is a pointer, the actual argument must be a pointer and the types, type parameters, and ranks must agree. The dummy argument pointer becomes associated with the target of the actual argument pointer at the invocation of the procedure. This association may be changed during the execution of the procedure, either by allocation or by pointer assignment. When execution of the procedure completes, the association of the actual argument pointer with a target becomes that of the dummy argument, except where the dummy argument target was another dummy argument of the procedure or was declared within the procedure and the target is not saved. In this case, the association status of the actual argument pointer with a target is undefined. Such a pointer may not be used in any way until its association status is reestablished by the execution of an ALLOCATE, pointer assignment, or NULLIFY statement.

If the actual argument is scalar, the corresponding dummy argument must be scalar unless the actual argument is an element of a named array that is explicit-shaped or assumed-size, or a substring of such an element. If the procedure is referenced by a generic name or as a defined operator or defined assignment, the ranks of the actual arguments and corresponding dummy arguments must agree.

If a dummy argument has INTENT (OUT) or INTENT (INOUT), the actual argument must be definable. If a dummy argument has INTENT (OUT), the corresponding actual argument becomes undefined at the time the association is established.

If the actual argument is an array section having a vector subscript, the dummy argument is not definable and must not have INTENT (OUT) or INTENT (INOUT).

If a dummy argument is an assumed-shape array, the actual argument must not be an assumed-size array, an array element designator, an array element substring designator, or a scalar.

A scalar dummy argument may be associated only with a scalar actual argument.

12.4.1.2 Arguments Associated with Dummy Procedures. If a dummy argument is a dummy procedure, the associated actual argument must be the specific name of an external, module, dummy, or intrinsic procedure. The only intrinsic procedures permitted are those listed in 13.12 and not marked with a bullet (•). If the specific name is also a generic name, only the specific procedure is associated with the dummy argument.

If the interface of the dummy procedure is explicit, the characteristics of the associated actual procedure must be the same as the characteristics of the dummy procedure (12.2).

If the interface of the dummy procedure is implicit and either the name of the dummy procedure is explicitly typed or the procedure is referenced as a function, the dummy procedure must not be referenced as a subroutine and the actual argument must be a function or dummy procedure.

If the interface of the dummy procedure is implicit and a reference to the procedure appears as a subroutine reference, the actual argument must be a subroutine or dummy procedure.

12.4.1.3 Arguments Associated with Alternate Return Indicators. If a dummy argument is an asterisk (12.5.2.3), the associated actual argument must be an alternate return specifier. The label in the alternate return specifier must identify an executable construct in the scoping unit containing the procedure reference.

12.4.1.4 Sequence Association. An actual argument represents an **element sequence** if it is an array expression, an array element designator, or an array element substring designator. If the actual argument is an array expression, the element sequence consists of the elements in array element order. If the actual argument is an array element designator, the element sequence consists of that array element and each element that follows it in array element order.

If the actual argument is a character array name, character array section, character array expression, character array element, or character array element substring designator, the element sequence consists of the character storage units beginning with the first storage unit of the actual argument and continuing to the end of the array. The character storage units of an array element substring designator are viewed as array elements consisting of consecutive groups of character storage units having the length of the array element substring. Thus, the first such element is the array element substring itself. Note that some of the elements in the element sequence may consist of storage units from different elements of the original array.

An actual argument that represents an element sequence and corresponds to a dummy argument that is an array-valued data object is sequence associated with the dummy argument if the dummy argument is an explicit-shape or assumed-size array. The rank and shape of the actual argument need not agree with the rank and shape of the dummy argument, but the number of elements in the dummy argument must not exceed the number of elements in the element sequence of the actual argument. If the dummy argument is assumed size, the number of elements in the dummy argument is exactly the number of elements in the element sequence.

12.4.2 Function Reference. A function is invoked during expression evaluation by a function reference or by a defined operation (7.1.3). When it is invoked, all actual argument expressions are evaluated, then the arguments are associated, and then the function is executed. When execution of the function is complete, the value of the function result is available for use in the expression that caused the function to be invoked. The characteristics of the function result (12.2.2) are determined by the interface of the function.

12.4.3 Elemental Intrinsic Function Reference. A reference to an elemental intrinsic function is an **elemental reference** if one or more actual arguments are arrays that have the same shape and the other actual arguments are conformable with them. The result has the same shape as the array arguments and the value of each element in the result is obtained by evaluating the function using the scalar arguments and the corresponding elements of the array arguments. For example, if X and Y are arrays of shape (m, n),

```
MAX (X, 0.0, Y)
```

is an array expression of shape (m, n) whose elements have values

MAX (X (i, j), 0.0, Y (i, j)), $i = 1, 2, ..., m, j = 1, 2, ..., n$

12.4.4 Subroutine Reference. A subroutine is invoked by execution of a CALL statement or defined assignment statement (7.5.1.3). When a subroutine is invoked, all actual argument expressions are evaluated, then the arguments are associated, and then the subroutine is executed. When the actions specified by the subroutine are completed, execution of the CALL statement or defined assignment statement is also completed. If a CALL statement includes one or more alternate return specifiers among its arguments, control may be transferred to one of the statements indicated, depending on the action specified by the subroutine.

12.4.5 Elemental Intrinsic Subroutine Reference. A reference to an elemental intrinsic subroutine is an elemental reference if all INTENT (OUT) actual arguments are arrays that have the same shape and the remaining actual arguments are conformable with them. The values of the elements of the INTENT (OUT) arrays are the same as would be obtained if the subroutine were applied

separately to corresponding elements of each argument.

12.5 Procedure Definition.

12.5.1 Intrinsic Procedure Definition. Intrinsic procedures are defined as an inherent part of the processor. A standard-conforming processor must include the intrinsic procedures described in Section 13, but may include others. However, a standard-conforming program must not make use of intrinsic procedures other than those described in Section 13.

12.5.2 Procedures Defined by Subprograms. When a procedure defined by a subprogram is invoked, an instance (12.5.2.4) of the procedure is created and executed. Execution begins with the first executable construct following the FUNCTION, SUBROUTINE, or ENTRY statement specifying the name of the procedure invoked or with the END statement if there is no such executable construct.

12.5.2.1 Effects of INTENT Attribute on Subprograms. The INTENT attribute of dummy data objects limits the way in which they may be used in a subprogram. A dummy data object having INTENT (IN) must not be defined or redefined by the subprogram. A dummy data object having INTENT (OUT) is initially undefined in the subprogram. A dummy data object with INTENT (INOUT) may be referenced or be defined. A dummy data object whose intent is not specified is subject to the limitations of the data entity that is the associated actual argument. That is, a reference to the dummy data object may occur if the actual argument is defined and the dummy data object may be defined if the actual argument is definable.

12.5.2.2 Function Subprogram. A **function subprogram** is a subprogram that has a FUNCTION statement as its first statement.

R1215 *function-subprogram* **is** *function-stmt*
[*specification-part*]
[*execution-part*]
[*internal-subprogram-part*]
end-function-stmt

R1216 *function-stmt* **is** [*prefix*] FUNCTION *function-name* ■
■ ([*dummy-arg-name-list*]) [RESULT (*result-name*)]

Constraint: The *result-name* must not appear in any specification statement in the scoping unit of the function subprogram.

R1217 *prefix* **is** *type-spec* [RECURSIVE]
or RECURSIVE [*type-spec*]

R1218 *end-function-stmt* **is** END [FUNCTION [*function-name*]]

Constraint: If RESULT is specified, *result-name* must not be the same as *function-name*.

Constraint: FUNCTION must be present on the *end-function-stmt* of an internal or module function.

Constraint: An internal function must not contain an ENTRY statement.

Constraint: An internal function must not contain an *internal-subprogram-part*.

Constraint: If a *function-name* is present on the *end-function-stmt*, it must be identical to the *function-name* specified in the *function-stmt*.

The type and type parameters (if any) of the result of the function defined by a function subprogram may be specified by a type specification in the FUNCTION statement or by the name of the result variable appearing in a type statement in the declaration part of the function subprogram. It must not be specified both ways. If it is not specified either way, it is determined by the implicit typing rules in force within the function subprogram. If the function result is array-valued or a pointer, this must be specified by specifications of the name of the result variable within the

function body. The specifications of the function result attributes, the specification of dummy argument attributes, and the information in the procedure heading collectively define the interface of the function (12.3).

The keyword **RECURSIVE** must be present if the function directly or indirectly invokes itself or a function defined by an ENTRY statement in the same subprogram. Similarly, RECURSIVE must be present if a function defined by an ENTRY statement in the subprogram directly or indirectly invokes itself, another function defined by an ENTRY statement in that subprogram, or the function defined by the FUNCTION statement.

The name of the function is *function-name*.

If RESULT is specified, the name of the result variable of the function is *result-name*, its characteristics (12.2.2) are those of the function result, and all occurrences of the function name in *execution-part* statements in the scoping unit are recursive function references. If RESULT is not specified, the result variable is *function-name* and all occurrences of the function name in *execution-part* statements in the scoping unit are references to the result variable. The value of the result variable at the completion of execution of the function is the value returned by the function. If the function result has been declared to be a pointer, the shape of the value returned by the function is determined by the shape of the result variable when the execution of the function is completed. If the result variable is not a pointer, its value must be defined by the function. If the function result has been declared a pointer, the function must either associate a target with the result variable pointer or cause the association status of this pointer to become defined as disassociated.

If both RECURSIVE and RESULT are specified, the interface of the function being defined is explicit within the function subprogram.

An example of a recursive function is:

```
RECURSIVE FUNCTION CUMM_SUM (ARRAY) RESULT (C_SUM)
   REAL ARRAY (:), CUMM_SUM (SIZE (ARRAY))
   ! The characteristics of C_SUM are those of CUMM_SUM.
   INTENT (IN) ARRAY
   INTEGER N
   N = SIZE (ARRAY)
   IF (N .LE. 1) THEN
      C_SUM = ARRAY
   ELSE
      N = N / 2
      C_SUM (:N) = CUMM_SUM (ARRAY (:N))
      C_SUM (N+1:) = C_SUM (N) + CUMM_SUM (ARRAY (N+1:))
   END IF
END FUNCTION CUMM_SUM
```

12.5.2.3 Subroutine Subprogram. A **subroutine subprogram** is a subprogram that has a SUBROUTINE statement as its first statement.

R1219 *subroutine-subprogram* is *subroutine-stmt*
[*specification-part*]
[*execution-part*]
[*internal-subprogram-part*]
end-subroutine-stmt

R1220 *subroutine-stmt* is [RECURSIVE] SUBROUTINE *subroutine-name* ■
■ [([*dummy-arg-list*])]

R1221 *dummy-arg* is *dummy-arg-name*
or *

R1222 *end-subroutine-stmt* is END [SUBROUTINE [*subroutine-name*]]

Constraint: SUBROUTINE must be present on the *end-subroutine-stmt* of an internal or module subroutine.

Constraint: An internal subroutine must not contain an ENTRY statement.

Constraint: An internal subroutine must not contain an *internal-subprogram-part*.

Constraint: If a *subroutine-name* is present on the *end-subroutine-stmt*, it must be identical to the *subroutine-name* specified in the *subroutine-stmt*.

The keyword RECURSIVE must be present if the subroutine directly or indirectly invokes itself or a subroutine defined by an ENTRY statement in the same subprogram. Similarly, RECURSIVE must be present if a subroutine defined by an ENTRY statement in the subprogram directly or indirectly invokes itself, another subroutine defined by an ENTRY statement in that subprogram, or the subroutine defined by the SUBROUTINE statement.

The name of the subroutine is *subroutine-name*.

If RECURSIVE is specified, the interface of the subroutine being defined is explicit within the subroutine subprogram.

12.5.2.4 Instances of a Subprogram. When a function or subroutine defined by a subprogram is invoked, an instance of that subprogram is created.

Each instance has an independent sequence of execution and an independent set of dummy arguments and local nonsaved data objects. If an internal procedure or statement function contained in the subprogram is invoked directly from an instance of the subprogram, the created instance of that internal procedure or statement function also has access to the entities of that instance of the host subprogram.

All other entities are shared by all instances of the subprogram. For example, the value of a saved data object appearing in one instance may have been defined in a previous instance or by a DATA statement or by initialization in a type statement.

12.5.2.5 ENTRY Statement. An ENTRY statement permits a procedure reference to begin with a particular executable statement within the function or subroutine subprogram in which the ENTRY statement appears.

R1223 *entry-stmt* is ENTRY *entry-name* [([*dummy-arg-list*]) ■
■ [RESULT (*result-name*)]]

Constraint: An *entry-stmt* may appear only in an *external-subprogram* or *module-subprogram*. An *entry-stmt* must not appear within an *executable-construct*.

Constraint: RESULT may be present only if the *entry-stmt* is contained in a function subprogram.

Constraint: Within the subprogram containing the *entry-stmt*, the *entry-name* must not appear as a dummy argument in the FUNCTION or SUBROUTINE statement or in another ENTRY statement and it must not appear in an EXTERNAL statement.

Constraint: A *dummy-arg* may be an alternate return indicator only if the ENTRY statement is contained in a subroutine subprogram.

Constraint: If RESULT is specified, *result-name* must not be the same as *entry-name*.

Optionally, a subprogram may have one or more ENTRY statements.

If the ENTRY statement is contained in a function subprogram, an additional function is defined by that subprogram. The name of the function is *entry-name* and its result variable is *result-name* or *entry-name* if no *result-name* is provided. The characteristics of the function result are specified by specifications of *entry-name*. The dummy arguments of the function are those specified on the ENTRY statement. If the characteristics of the result of the function named on the ENTRY statement are the same as the characteristics of the function named on the FUNCTION statement, their result variables identify the same variable. Otherwise, they are storage associated with the restrictions that they are scalar and that either they all be of type default character and identical length or they all be of one of the types default integer, default real, double precision real, default complex, or default logical.

If RESULT is specified on the ENTRY statement and RECURSIVE is specified on the FUNCTION statement, the interface of the function defined by the ENTRY statement is explicit within the function subprogram.

If the ENTRY statement is contained in a subroutine subprogram, an additional subroutine is defined by that subprogram. The name of the subroutine is *entry-name*. The dummy arguments of the subroutine are those specified on the ENTRY statement.

If RECURSIVE is specified on the SUBROUTINE statement, the interface of the subroutine defined by the ENTRY statement is explicit within the subroutine subprogram.

The order, number, types, kind type parameters, and names of the dummy arguments in an ENTRY statement may differ from the order, number, types, kind type parameters, and names of the dummy arguments in the FUNCTION or SUBROUTINE statement in the containing program.

Because an ENTRY statement defines an additional function or an additional subroutine, it is referenced in the same manner as any other function or subroutine (12.4).

In a subprogram, a name that appears as a dummy argument in an ENTRY statement must not appear in an executable statement preceding that ENTRY statement, unless it also appears in a FUNCTION, SUBROUTINE, or ENTRY statement that precedes the executable statement.

In a subprogram, a name that appears as a dummy argument in an ENTRY statement must not appear in the expression of a statement function unless the name is also a dummy argument of the statement function, appears in a FUNCTION or SUBROUTINE statement, or appears in an ENTRY statement that precedes the statement function statement.

If a dummy argument appears in an executable statement, the execution of the executable statement is permitted during the execution of a reference to the function or subroutine only if the dummy argument appears in the dummy argument list of the procedure name referenced and it is present if it is an OPTIONAL argument (12.5.2.8).

A scoping unit containing a reference to a procedure defined by an ENTRY statement may have access to an interface body for the procedure. The procedure header for the interface body must be a FUNCTION statement for an entry in a function subprogram and must be a SUBROUTINE statement for an entry in a subroutine subprogram.

The keyword RECURSIVE is not used in an ENTRY statement. Instead, the presence or absence of RECURSIVE on the initial SUBROUTINE or FUNCTION statement controls whether the procedure defined by an ENTRY statement is permitted to reference itself.

12.5.2.6 RETURN Statement.

R1224 *return-stmt* is RETURN [*scalar-int-expr*]

Constraint: The *return-stmt* must be contained in the scoping unit of a function or subroutine subprogram.

Constraint: The *scalar-int-expr* is allowed only in the scoping unit of a subroutine subprogram.

Execution of the **RETURN statement** completes execution of the instance of the subprogram in which it appears. If the expression is present and has a value n **between 1 and the number of asterisks in the dummy argument list, the CALL statement that invoked the subroutine transfers control to the statement identified by the nth** alternate return specifier in the actual argument list. If the expression is omitted or has a value outside the required range, there is no transfer of control to an alternate return.

Execution of an *"end-function-stmt* or *"end-subroutine-stmt* is equivalent to executing a RETURN statement with no expression.

12.5.2.7 CONTAINS Statement.

R1225 *contains-stmt* is CONTAINS

The **CONTAINS statement** separates the body of a main program, module, or subprogram from any internal or module subprograms it may contain. The CONTAINS statement is not executable.

12.5.2.8 Restrictions on Dummy Arguments Not Present. A dummy argument is present in an instance of a subprogram if it is associated with an actual argument and the actual argument either is a dummy argument that is present in the invoking procedure or is not a dummy argument of the invoking procedure. A dummy argument that is not optional must be present. An optional dummy argument that is not present is subject to the following restrictions:

(1) If it is a dummy data object, it must not be referenced or be defined.

(2) If it is a dummy procedure, it must not be invoked.

(3) It must not be supplied as an actual argument corresponding to a nonoptional dummy argument other than the argument of the PRESENT intrinsic function.

(4) It may be supplied as an actual argument corresponding to an optional dummy argument. The optional dummy argument is then also considered not to be associated with an actual argument.

12.5.2.9 Restrictions on Entities Associated with Dummy Arguments. While an entity is associated with a dummy argument, the following restrictions hold:

(1) No action may be taken that affects the value or availability of the entity or any part of it, except through the dummy argument. For example, in

```
SUBROUTINE OUTER
   REAL, POINTER :: A (:)
   ...
   ALLOCATE (A (1:N))
   ...
   CALL INNER (A)
   ...
CONTAINS
   SUBROUTINE INNER (B)
   REAL :: B (:)
   ...
   END SUBROUTINE INNER

   SUBROUTINE SET (C, D)
      REAL, INTENT (OUT) :: C
      REAL, INTENT (IN) :: D
      C = D
      END SUBROUTINE SET
END SUBROUTINE OUTER
```

an assignment statement such as

```
A (1) = 1.0
```

would not be permitted during the execution of INNER because this would be changing A without using B, but statements such as

```
B (1) = 1.0
```

or

```
CALL SET (B (1), 1.0)
```

would be allowed. Similarly,

```
DEALLOCATE (A)
```

would not be allowed because this affects the availability of A without using B. In this case,

```
DEALLOCATE (B)
```

also would not be permitted, but would be permitted if B were declared with the

POINTER attribute.

Note that if there is a partial or complete overlap between the actual arguments associated with two different dummy arguments of the same procedure, the overlapped portions must not be defined, redefined, or become undefined during the execution of the procedure. For example, in

```
CALL SUB (A (1:5), A (3:9))
```

A (3:5) must not be defined, redefined, or become undefined through the first dummy argument because it is part of the argument associated with the second dummy argument and must not be defined, redefined, or become undefined through the second dummy argument because it is part of the argument associated with the first dummy argument. A (1:2) remains definable through the first dummy argument and A (6:9) remains definable through the second dummy argument.

This restriction applies equally to pointer targets. For example, in

```
REAL, DIMENSION (10), TARGET :: A
REAL, DIMENSION (:), POINTER :: B, C
B => A (1:5)
C => A (3:9)
CALL SUB (B, C)
```

B (3:5) cannot be defined because it is part of the argument associated with the second dummy argument. C (1:3) cannot be defined because it is part of the argument associated with the first dummy argument. A (1:2) [which is B (1:2)] remains definable through the first dummy argument and A (6:9) [which is C (4:7)] remains definable through the second dummy argument.

Note that since a dummy argument declared with an intent of IN cannot be used to change the associated actual argument, the associated actual argument remains constant throughout the execution of the procedure.

(2) If any part of the entity is defined through the dummy argument, then at any time during the execution of the procedure, either before or after the definition, it may be referenced only through that dummy argument. For example, in

```
MODULE DATA
   REAL :: W, X, Y, Z
END MODULE DATA

PROGRAM MAIN
USE DATA
   ...
CALL INIT (X)
   ...
END PROGRAM MAIN

SUBROUTINE INIT (V)
   USE DATA
      ...
   READ (*, *) V
      ...
END SUBROUTINE INIT
```

variable X must not be directly referenced at any time during the execution of INIT because it is being defined through the dummy argument V. X may be (indirectly) referenced through V. W, Y, and Z may be directly referenced. X may, of course, be directly referenced once execution of INIT is complete.

12.5.3 Definition of Procedures by Means Other Than Fortran. The means other than Fortran by which a procedure may be defined are processor dependent. A reference to such a procedure is made as though it were defined by an external subprogram. The definition of a non-Fortran procedure must not be contained in a Fortran program unit and a Fortran program unit must not be contained in the definition of a non-Fortran procedure. The interface to a non-Fortran procedure may be specified in an interface block.

12.5.4 Statement Function. A statement function is a function defined by a single statement.

R1226 *stmt-function-stmt* is *function-name* ([*dummy-arg-name-list*]) = *scalar-expr*

Constraint: The *scalar-expr* may be composed only of constants (literal and named), references to scalar variables and array elements, references to functions and function dummy procedures, and intrinsic operators. If a reference to another statement function appears in *scalar-expr*, its definition must have been provided earlier in the scoping unit.

Constraint: Named constants in *scalar-expr* must have been declared earlier in the scoping unit. If array elements appear in *scalar-expr*, the parent array must have been declared as an array earlier in the scoping unit. If a scalar variable, array element, function reference, or dummy function reference is typed by the implicit typing rules, its appearance in any subsequent type declaration statement must confirm this implied type and the values of any implied type parameters.

Constraint: The *function-name* and each *dummy-arg-name* must be specified, explicitly or implicitly, to be scalar data objects.

Constraint: A given *dummy-arg-name* may appear only once in any *dummy-arg-name-list*.

Constraint: Each scalar variable reference in *scalar-expr* may be either a reference to a dummy argument of the statement function or a reference to a variable within the same scoping unit as the statement function statement.

The dummy arguments have a scope of the statement function statement. Each dummy argument has the same type and type parameters as the entity of the same name in the scoping unit containing the statement function.

A statement function must not be supplied as a procedure argument.

The value of a statement function reference is obtained by evaluating the expression using the values of the actual arguments for the values of the corresponding dummy arguments and, if necessary, converting the result to the declared type and type attributes of the function.

A function reference in the scalar expression must not cause a dummy argument of the statement function to become defined or undefined.

13. INTRINSIC PROCEDURES

There are four classes of intrinsic procedures: inquiry functions, elemental functions, transformational functions, and subroutines.

13.1 Intrinsic Functions. An **intrinsic function** is an inquiry function, an elemental function, or a transformational function. An **inquiry function** is one whose result depends on the properties of its principal argument other than the value of this argument; in fact, the argument value may be undefined. An **elemental function** is one that is specified for scalar arguments, but may be applied to array arguments as described in 13.2. All other intrinsic functions are **transformational functions**; they almost all have one or more array-valued arguments or an array-valued result.

Generic names of intrinsic functions are listed in 13.10. In most cases, generic functions accept arguments of more than one type and the type of the result is the same as the type of the arguments. **Specific names** of intrinsic functions with corresponding generic names are listed in 13.12.

If an intrinsic function is used as an actual argument to a procedure, its specific name must be used and it may be referenced in the procedure only with scalar arguments. If an intrinsic function does not have a specific name, it must not be used as an actual argument (12.4.1.2).

13.2 Elemental Intrinsic Procedures.

13.2.1 Elemental Intrinsic Function Arguments and Results. If a generic name or a specific name is used to reference an elemental intrinsic function, the shape of the result is the same as the shape of the argument with the greatest rank. If the arguments are all scalar, the result is scalar. For those elemental intrinsic functions that have more than one argument, all arguments must be conformable. In the array-valued case, the values of the elements, if any, of the result are the same as would have been obtained if the scalar-valued function had been applied separately, in any order, to corresponding elements of each argument. Arguments called KIND must always be specified as scalar integer initialization expressions.

13.2.2 Elemental Intrinsic Subroutine Arguments. If a generic name is used to reference an elemental intrinsic subroutine, either all actual arguments must be scalar, or all INTENT (OUT) arguments must be arrays of the same shape and the remaining arguments must be conformable with them. In the case that the INTENT (OUT) arguments are arrays, the values of the elements, if any, of the results are the same as would be obtained if the subroutine with scalar arguments were applied separately, in any order, to corresponding elements of each argument.

13.3 Positional Arguments or Argument Keywords. All intrinsic procedures may be invoked with either positional arguments or argument keywords. The descriptions in 13.13 give the keyword names and positional sequence. A keyword is required for an argument only if a preceding optional argument is omitted.

13.4 Argument Presence Inquiry Function. The inquiry function PRESENT permits an inquiry to be made about the presence of an actual argument associated with a dummy argument that has the OPTIONAL attribute.

13.5 Numeric, Mathematical, Character, and Bit Procedures.

13.5.1 Numeric Functions. The elemental functions INT, REAL, DBLE, and CMPLX perform type conversions. The elemental functions AIMAG, CONJG, AINT, ANINT, NINT, ABS, MOD, SIGN, DIM, DPROD, MODULO, FLOOR, CEILING, MAX, and MIN perform simple numeric operations.

13.5.2 Mathematical Functions. The elemental functions SQRT, EXP, LOG, LOG10, SIN, COS, TAN, ASIN, ACOS, ATAN, ATAN2, SINH, COSH, and TANH evaluate elementary mathematical functions.

13.5.3 Character Functions. The elemental functions ICHAR, CHAR, LGE, LGT, LLE, LLT, IACHAR, ACHAR, INDEX, VERIFY, ADJUSTL, ADJUSTR, SCAN, and LEN_TRIM perform character operations. The transformational function REPEAT returns repeated concatenations of a character string argument. The transformational function TRIM returns the argument with trailing blanks removed.

13.5.4 Character Inquiry Function. The inquiry function LEN returns the length of a character entity. The value of the argument to this function need not be defined. It is not necessary for a processor to evaluate the argument of this function if the value of the function can be determined otherwise.

13.5.5 Kind Functions. The inquiry function KIND returns the kind type parameter value of an integer, real, complex, logical, or character entity. The transformational function SELECTED_REAL_KIND returns the real kind type parameter value that has at least the decimal precision and exponent range specified by its arguments. The transformational function SELECTED_INT_KIND returns the integer kind type parameter value that has at least the decimal exponent range specified by its argument.

13.5.6 Logical Function. The elemental function LOGICAL converts between objects of type logical with different kind type parameter values.

13.5.7 Bit Manipulation and Inquiry Procedures. The bit manipulation procedures consist of a set of ten functions and one subroutine. Logical operations on bits are provided by the functions IOR, IAND, NOT, and IEOR; shift operations are provided by the functions ISHFT and ISHFTC; bit subfields may be referenced by the function IBITS and by the subroutine MVBITS; single-bit processing is provided by the functions BTEST, IBSET, and IBCLR.

For the purposes of these procedures, a bit is defined to be a binary digit w located at position k of a nonnegative integer scalar object based on a model nonnegative integer defined by

$$j = \sum_{k=0}^{s-1} w_k \times 2^k$$

and for which w_k may have the value 0 or 1. An example of a model number compatible with the examples used in 13.7.1 would have $s = 32$, thereby defining a 32-bit integer.

An inquiry function BIT_SIZE is available to determine the parameter s of the model. The value of the argument of this function need not be defined. It is not necessary for a processor to evaluate the argument of this function if the value of the function can be determined otherwise.

Effectively, this model defines an integer object to consist of s bits in sequence numbered from right to left from 0 to $s-1$. This model is valid only in the context of the use of such an object as the argument or result of one of the bit manipulation procedures. In all other contexts, the model defined for an integer in 13.7.1 applies. In particular, whereas the models are identical for $w_{s-1} = 0$, they do not correspond for $w_{s-1} = 1$ and the interpretation of bits in such objects is processor dependent.

13.6 Transfer Function. The function TRANSFER specifies that the physical representation of the first argument is to be treated as if it were one of the type and type parameters of the second argument with no conversion.

13.7 Numeric Manipulation and Inquiry Functions. The numeric manipulation and inquiry functions are described in terms of a model for the representation and behavior of numbers on a processor. The model has parameters which are determined so as to make the model best fit the machine on which the executable program is executed.

13.7.1 Models for Integer and Real Data. The model set for integer i is defined by:

$$i = s \times \sum_{k=1}^{q} w_k \times r^{k-1}$$

where r is an integer exceeding one, q is a positive integer, each w_k is a nonnegative integer less than r, and s is +1 or –1. The model set for real x is defined by:

$$x = \begin{cases} 0 \text{ or} \\ s \times b^e \times \sum_{k=1}^{p} f_k \times b^{-k}, \end{cases}$$

where b and p are integers exceeding one; each f_k is a nonnegative integer less than b, except f_1 which is also nonzero; s is +1 or –1; and e is an integer that lies between some integer maximum e_{max} and some integer minimum e_{min} inclusively. For $x = 0$, its exponent e and digits f_k are defined to be zero. The integer parameters r and q determine the set of model integers and the integer parameters b, p, e_{min}, and e_{max} determine the set of model floating point numbers. The parameters of the integer and real models are available for each integer and real data type implemented by the processor. The parameters characterize the set of available numbers in the definition of the model. The numeric manipulation and inquiry functions provide values related to the parameters and other constants related to them. Examples of these functions in this section use the models:

$$i = s \times \sum_{k=1}^{31} w_k \times 2^{k-1}$$

and

$$x = 0 \text{ or } s \times 2^e \times \left[{}^1/_2 + \sum_{k=2}^{24} f_k \times 2^{-k} \right], \quad -126 \le e \le 127$$

13.7.2 Numeric Inquiry Functions. The inquiry functions RADIX, DIGITS, MINEXPONENT, MAXEXPONENT, PRECISION, RANGE, HUGE, TINY, and EPSILON return scalar values related to the parameters of the model associated with the type and type parameters of the arguments. The value of the arguments to these functions need not be defined, pointer arguments may be disassociated, and array arguments need not be allocated.

13.7.3 Floating Point Manipulation Functions. The elemental functions EXPONENT, SCALE, NEAREST, FRACTION, SET_EXPONENT, SPACING, and RRSPACING return values related to the components of the model values (13.7.1) associated with the actual values of the arguments.

13.8 Array Intrinsic Functions. The array intrinsic functions perform the following operations on arrays: vector and matrix multiplication, numeric or logical computation that reduces the rank, array structure inquiry, array construction, array manipulation, and geometric location.

13.8.1 The Shape of Array Arguments. The transformational array intrinsic functions operate on each array argument as a whole. The shape of the corresponding actual argument must therefore be defined; that is, the actual argument must be an array section, an assumed-shape array, an explicit-shape array, a pointer that is associated with a target, an allocatable array that has been allocated, or an array-valued expression. It must not be an assumed-size array.

Some of the inquiry intrinsic functions accept array arguments for which the shape need not be defined. Assumed-size arrays may be used as arguments to these functions; they include the function LBOUND and certain references to SIZE and UBOUND.

13.8.2 Mask Arguments. Some array intrinsic functions have an optional MASK argument that is used by the function to select the elements of one or more arguments to be operated on by the function. Any element not selected by the mask need not be defined at the time the function is invoked.

The MASK affects only the value of the function, and does not affect the evaluation, prior to invoking the function, of arguments that are array expressions.

A MASK argument must be of type logical.

13.8.3 Vector and Matrix Multiplication Functions. The matrix multiplication function MATMUL operates on two matrices, or on one matrix and one vector, and returns the corresponding matrix-matrix, matrix-vector, or vector-matrix product. The arguments to MATMUL may be numeric (integer, real, or complex) or logical arrays. On logical matrices and vectors, MATMUL performs Boolean matrix multiplication.

The dot product function DOT_PRODUCT operates on two vectors and returns their scalar product. The vectors are of the same type (numeric or logical) as for MATMUL. For logical vectors, DOT_PRODUCT returns the Boolean scalar product.

13.8.4 Array Reduction Functions. The array reduction functions SUM, PRODUCT, MAXVAL, MINVAL, COUNT, ANY, and ALL perform numerical, logical, and counting operations on arrays. They may be applied to the whole array to give a scalar result or they may be applied over a given dimension to yield a result of rank reduced by one. By use of a logical mask that is conformable with the given array, the computation may be confined to any subset of the array (for example, the positive elements).

13.8.5 Array Inquiry Functions. The function ALLOCATED returns a value true if the array argument is currently allocated, and returns false otherwise. The functions SIZE, SHAPE, LBOUND, and UBOUND return, respectively, the size of the array, the shape, and the lower and upper bounds of the subscripts along each dimension. The size, shape, or bounds must be defined.

The values of the array arguments to these functions need not be defined.

13.8.6 Array Construction Functions. The functions MERGE, SPREAD, PACK, and UNPACK construct new arrays from the elements of existing arrays. MERGE combines two conformable arrays into one array by an element-wise choice based on a logical mask. SPREAD constructs an array from several copies of an actual argument (SPREAD does this by adding an extra dimension, as in forming a book from copies of one page). PACK and UNPACK respectively gather and scatter the elements of a one-dimensional array from and to positions in another array where the positions are specified by a logical mask.

13.8.7 Array Reshape Function. RESHAPE produces an array with the same elements and a different shape.

13.8.8 Array Manipulation Functions. The functions TRANSPOSE, EOSHIFT, and CSHIFT manipulate arrays. TRANSPOSE performs the matrix transpose operation on a two-dimensional array. The shift functions leave the shape of an array unaltered but shift the positions of the elements parallel to a specified dimension of the array. These shifts are either circular (CSHIFT), in which case elements shifted off one end reappear at the other end, or end-off (EOSHIFT), in which case specified boundary elements are shifted into the vacated positions.

13.8.9 Array Location Functions. The functions MAXLOC and MINLOC return the location (subscripts) of an element of an array that has maximum and minimum values, respectively. By use of an optional logical mask that is conformable with the given array, the reduction may be confined to any subset of the array.

13.8.10 Pointer Association Status Inquiry Functions. The function ASSOCIATED tests whether a pointer is currently associated with any target, with a particular target, or with the same target as another pointer.

13.9 Intrinsic Subroutines. Intrinsic subroutines are supplied by the processor and have the special definitions given in 13.11 and 13.13. An intrinsic subroutine is referenced by a CALL statement that uses its name explicitly. The name of an intrinsic subroutine must not be used as an actual argument. The effect of a subroutine reference is as specified in 13.13.

13.9.1 Date and Time Subroutines. The subroutines DATE_AND_TIME and SYSTEM_CLOCK return integer data from the date and real-time clock. The time returned is local, but there are facilities for finding out the difference between local time and Coordinated Universal Time.

13.9.2 Pseudorandom Numbers. The subroutine RANDOM returns a pseudorandom number or an array of pseudorandom numbers. The subroutine RANDOM_SEED initializes or restarts the pseudorandom number sequence.

13.9.3 Bit Copy Subroutine. The subroutine MVBITS copies a bit field from a specified position in one integer object to a specified position in another.

13.10 Generic Intrinsic Functions. For all of the intrinsic procedures, the arguments shown are the names that must be used for keywords when using the keyword form for actual arguments. For example, a reference to CMPLX may be written in the form CMPLX (TARGET, SOURCE, M) or in the form CMPLX (Y = SOURCE, KIND = M, X = TARGET).

Many of the argument keywords have names that are indicative of their usage. For example:

KIND	Describes the KIND of the result
STRING, STRING_A	An arbitrary character string
BACK	Indicates a string scan is to be from right to left (backward)
MASK	A mask that may be applied to the arguments
DIM	A selected dimension of an array argument

13.10.1 Argument Presence Inquiry Function.

PRESENT (A)	Argument presence

13.10.2 Numeric Functions.

ABS (A)	Absolute value
AIMAG (Z)	Imaginary part of a complex number
AINT (A, KIND) Optional KIND	Truncation to whole number
ANINT (A, KIND) Optional KIND	Nearest whole number
CEILING (A)	Least integer greater than or equal to number
CMPLX (X, Y, KIND) Optional Y, KIND	Conversion to complex type
CONJG (Z)	Conjugate of a complex number
DBLE (A)	Conversion to double precision real type
DIM (X, Y)	Positive difference

DPROD (X, Y)	Double precision real product
INT (A, KIND)	Conversion to integer type
Optional KIND	
FLOOR (A)	Greatest integer less than or equal to number
MAX (A1, A2, A3,...)	Maximum value
Optional A3,...	
MIN (A1, A2, A3,...)	Minimum value
Optional A3,...	
MOD (A, P)	Remainder function
MODULO (A, P)	Modulo function
NINT (A, KIND)	Nearest integer
Optional KIND	
REAL (A, KIND)	Conversion to real type
Optional KIND	
SIGN (A, B)	Transfer of sign

13.10.3 Mathematical Functions.

ACOS (X)	Arccosine
ASIN (X)	Arcsine
ATAN (X)	Arctangent
ATAN2 (Y, X)	Arctangent
COS (X)	Cosine
COSH (X)	Hyperbolic cosine
EXP (X)	Exponential
LOG (X)	Natural logarithm
LOG10 (X)	Common logarithm (base 10)
SIN (X)	Sine
SINH (X)	Hyperbolic sine
SQRT (X)	Square root
TAN (X)	Tangent
TANH (X)	Hyperbolic tangent

13.10.4 Character Functions.

ACHAR (I)	Character in given position in ASCII collating sequence
ADJUSTL (STRING)	Adjust left
ADJUSTR (STRING)	Adjust right
CHAR (I, KIND)	Character in given position in processor collating sequence
Optional KIND	
IACHAR (C)	Position of a character in ASCII collating sequence
ICHAR (C)	Position of a character in processor collating sequence
INDEX (STRING, SUBSTRING, BACK)	Starting position of a substring
Optional BACK	
LEN_TRIM (STRING)	Length without trailing blank characters
LGE (STRING_A, STRING_B)	Lexically greater than or equal
LGT (STRING_A, STRING_B)	Lexically greater than
LLE (STRING_A, STRING_B)	Lexically less than or equal
LLT (STRING_A, STRING_B)	Lexically less than
REPEAT (STRING, NCOPIES)	Repeated concatenation
SCAN (STRING, SET, BACK)	Scan a string for a character in a set
Optional BACK	
TRIM (STRING)	Remove trailing blank characters
VERIFY (STRING, SET, BACK)	Verify the set of characters in a string
Optional BACK	

13.10.5 Character Inquiry Function.

LEN (STRING)	Length of a character entity

13.10.6 Kind Functions.

KIND (X)	Kind type parameter value
SELECTED_INT_KIND (R)	Integer kind type parameter value, given range
SELECTED_REAL_KIND (P, R)	Real kind type parameter value, given precision and range

13.10.7 Logical Function.

LOGICAL (L, KIND) Optional KIND	Convert between objects of type logical with different kind type parameters

13.10.8 Numeric Inquiry Functions.

DIGITS (X)	Number of significant digits in the model
EPSILON (X)	Number that is almost negligible compared to one
HUGE (X)	Largest number in the model
MAXEXPONENT (X)	Maximum exponent in the model
MINEXPONENT (X)	Minimum exponent in the model
PRECISION (X)	Decimal precision
RADIX (X)	Base of the model
RANGE (X)	Decimal exponent range
TINY (X)	Smallest positive number in the model

13.10.9 Bit Inquiry Function.

BIT_SIZE (I)	Number of bits in the model

13.10.10 Bit Manipulation Functions.

BTEST (I, POS)	Bit testing
IAND (I, J)	Logical AND
IBCLR (I, POS)	Clear bit
IBITS (I, POS, LEN)	Bit extraction
IBSET (I, POS)	Set bit
IEOR (I, J)	Exclusive OR
IOR (I, J)	Inclusive OR
ISHFT (I, SHIFT)	Logical shift
ISHFTC (I, SHIFT, SIZE) Optional SIZE	Circular shift
NOT (I)	Logical complement

13.10.11 Transfer Function.

TRANSFER (SOURCE, MOLD, SIZE) Optional SIZE	Treat first argument as if of type of second argument

13.10.12 Floating-point Manipulation Functions.

EXPONENT (X)	Exponent part of a model number
FRACTION (X)	Fractional part of a number
NEAREST (X, S)	Nearest different processor number in given direction
RRSPACING (X)	Reciprocal of the relative spacing

	of model numbers near given number
SCALE (X, I)	Multiply a real by its base to an integer power
SET_EXPONENT (X, I)	Set exponent part of a number
SPACING (X)	Absolute spacing of model numbers near given number

13.10.13 Vector and Matrix Multiply Functions.

DOT_PRODUCT (VECTOR_A, VECTOR_B)	Dot product of two rank-one arrays
MATMUL (MATRIX_A, MATRIX_B)	Matrix multiplication

13.10.14 Array Reduction Functions.

ALL (MASK, DIM) Optional DIM	True if all values are true
ANY (MASK, DIM) Optional DIM	True if any value is true
COUNT (MASK, DIM) Optional DIM	Number of true elements in an array
MAXVAL (ARRAY, DIM, MASK) Optional DIM, MASK	Maximum value in an array
MINVAL (ARRAY, DIM, MASK) Optional DIM, MASK	Minimum value in an array
PRODUCT (ARRAY, DIM, MASK) Optional DIM, MASK	Product of array elements
SUM (ARRAY, DIM, MASK) Optional DIM, MASK	Sum of array elements

13.10.15 Array Inquiry Functions.

ALLOCATED (ARRAY)	Array allocation status
LBOUND (ARRAY, DIM) Optional DIM	Lower dimension bounds of an array
SHAPE (SOURCE)	Shape of an array or scalar
SIZE (ARRAY, DIM) Optional DIM	Total number of elements in an array
UBOUND (ARRAY, DIM) Optional DIM	Upper dimension bounds of an array

13.10.16 Array Construction Functions.

MERGE (TSOURCE, FSOURCE, MASK)	Merge under mask
PACK (ARRAY, MASK, VECTOR) Optional VECTOR	Pack an array into an array of rank one under a mask
SPREAD (SOURCE, DIM, NCOPIES)	Replicates array by adding a dimension
UNPACK (VECTOR, MASK, FIELD)	Unpack an array of rank one into an array under a mask

13.10.17 Array Reshape Function.

RESHAPE (SOURCE, SHAPE, PAD, ORDER) Optional PAD, ORDER	Reshape an array

13.10.18 Array Manipulation Functions.

CSHIFT (ARRAY, SHIFT, DIM)	Circular shift
EOSHIFT (ARRAY, SHIFT, BOUNDARY, DIM)	End-off shift
Optional BOUNDARY	
TRANSPOSE (MATRIX)	Transpose of an array of rank two

13.10.19 Array Location Functions.

MAXLOC (ARRAY, MASK)	Location of a maximum value in an array
Optional MASK	
MINLOC (ARRAY, MASK)	Location of a minimum value in an array
Optional MASK	

13.10.20 Pointer Association Status Inquiry Function.

ASSOCIATED (POINTER, TARGET)	Association status or comparison
Optional TARGET	

13.11 Intrinsic Subroutines.

DATE_AND_TIME (ALL, COUNT, MSECOND, SECOND, MINUTE, HOUR, DAY, MONTH, YEAR, ZONE)	Obtain date and time
Optional ALL, COUNT, MSECOND, SECOND, MINUTE, HOUR, DAY, MONTH, YEAR, ZONE	
MVBITS (FROM, FROMPOS, LEN, TO, TOPOS)	Copies bits from one integer to another
RANDOM (HARVEST)	Returns pseudorandom number
RANDOM_SEED (SIZE, PUT, GET)	Initializes or restarts the pseudorandom number generator
Optional SIZE, PUT, GET	
SYSTEM_CLOCK (COUNT, COUNT_RATE, COUNT_MAX)	Obtain data from the system clock
Optional COUNT, COUNT_RATE, COUNT_MAX	

13.12 Specific Names for Intrinsic Functions.

	Specific Name	*Generic Name*	*Argument Type*
	ABS (A)	ABS (A)	default real
	ACOS (X)	ACOS (X)	default real
	AIMAG (Z)	AIMAG (Z)	default complex
	AINT (A)	AINT (A)	default real
	ALOG (X)	LOG (X)	default real
	ALOG10 (X)	LOG10 (X)	default real
•	AMAX0 (A1,A2,A3,...) Optional A3,...	REAL (MAX (A1, A2,A3,...)) Optional A3,...	default integer
•	AMAX1 (A1,A2,A3,...) Optional A3,...	MAX (A1, A2,A3,...) Optional A3,...	default real
•	AMIN0 (A1,A2,A3,...) Optional A3,...	REAL (MIN (A1, A2,A3,...)) Optional A3,...	default integer

1	•	AMIN1 (A1,A2,A3,...)	MIN (A1,	default real
2		Optional A3,...	A2,A3,...)	
3			Optional A3,...	
4		AMOD (A,P)	MOD (A,P)	default real
5		ANINT (A)	ANINT (A)	default real
6		ASIN (X)	ASIN (X)	default real
7		ATAN (X)	ATAN (X)	default real
8		ATAN2 (Y,X)	ATAN2 (Y,X)	default real
9		CABS (A)	ABS (A)	default complex
10		CCOS (X)	COS (X)	default complex
11		CEXP (X)	EXP (X)	default complex
12	•	CHAR (I)	CHAR (I)	default integer
13		CLOG (X)	LOG (X)	default complex
14		CONJG (Z)	CONJG (Z)	default complex
15		COS (X)	COS (X)	default real
16		COSH (X)	COSH (X)	default real
17		CSIN (X)	SIN (X)	default complex
18		CSQRT (X)	SQRT (X)	default complex
19		DABS (A)	ABS (A)	double precision real
20		DACOS (X)	ACOS (X)	double precision real
21		DASIN (X)	ASIN (X)	double precision real
22		DATAN (X)	ATAN (X)	double precision real
23		DATAN2 (Y,X)	ATAN2 (Y,X)	double precision real
24		DCOS (X)	COS (X)	double precision real
25		DCOSH (X)	COSH (X)	double precision real
26		DDIM (X,Y)	DIM (X,Y)	double precision real
27		DEXP (X)	EXP (X)	double precision real
28		DIM (X,Y)	DIM (X,Y)	default real
29		DINT (A)	AINT (A)	double precision real
30		DLOG (X)	LOG (X)	double precision real
31		DLOG10 (X)	LOG10 (X)	double precision real
32	•	DMAX1 (A1,A2,A3,...)	MAX (A1,A2,A3,...)	double precision real
33		Optional A3,...	Optional A3,...	
34	•	DMIN1 (A1,A2,A3,...)	MIN (A1,A2,A3,...)	double precision real
35		Optional A3,...	Optional A3,...	
36		DMOD (A,P)	MOD (A,P)	double precision real
37		DNINT (A)	ANINT (A)	double precision real
38		DPROD (X,Y)	DPROD (X,Y)	default real
39		DSIGN (A,B)	SIGN (A,B)	double precision real
40		DSIN (X)	SIN (X)	double precision real
41		DSINH (X)	SINH (X)	double precision real
42		DSQRT (X)	SQRT (X)	double precision real
43		DTAN (X)	TAN (X)	double precision real
44		DTANH (X)	TANH (X)	double precision real
45		EXP (X)	EXP (X)	default real
46	•	FLOAT (A)	REAL (A)	default integer
47		IABS (A)	ABS (A)	default integer
48	•	ICHAR (C)	ICHAR (C)	default character
49		IDIM (X,Y)	DIM (X,Y)	default integer
50	•	IDINT (A)	INT (A)	double precision real
51		IDNINT (A)	NINT (A)	double precision real
52	•	IFIX (A)	INT (A)	default real
53		INDEX (STRING,	INDEX (STRING,	default character
54		SUBSTRING)	SUBSTRING)	
55	•	INT (A)	INT (A)	default real
56		ISIGN (A,B)	SIGN (A,B)	default integer
57		LEN (STRING)	LEN (STRING)	default character

•	LGE (STRING_A, STRING_B)	LGE (STRING_A, STRING_B)	default character
•	LGT (STRING_A, STRING_B)	LGT (STRING_A, STRING_B)	default character
•	LLE (STRING_A, STRING_B)	LLE (STRING_A, STRING_B)	default character
•	LLT (STRING_A, STRING_B)	LLT (STRING_A, STRING_B)	default character
•	MAX0 (A1,A2,A3,...) Optional A3,...	MAX (A1,A2,A3,...) Optional A3,...	default integer
•	MAX1 (A1,A2,A3,...) Optional A3,...	INT (MAX (A1,A2,A3,...)) Optional A3,...	default real
•	MIN0 (A1,A2,A3,...) Optional A3,...	MIN (A1,A2,A3,...) Optional A3,...	default integer
•	MIN1 (A1,A2,A3,...) Optional A3,...	INT (MIN (A1,A2,A3,...)) Optional A3,...	default real
	MOD (A,P)	MOD (A,P)	default integer
	NINT (A)	NINT (A)	default real
•	REAL (A)	REAL (A)	default integer
	SIGN (A,B)	SIGN (A,B)	default real
	SIN (X)	SIN (X)	default real
	SINH (X)	SINH (X)	default real
•	SNGL (A)	REAL (A)	double precision real
	SQRT (X)	SQRT (X)	default real
	TAN (X)	TAN (X)	default real
	TANH (X)	TANH (X)	default real

• These specific intrinsic function names must not be used as an actual argument.

13.13 Specifications of the Intrinsic Procedures.

This section contains detailed specifications of the generic intrinsic procedures in alphabetical order.

13.13.1 ABS (A).

Description. Absolute value.

Class. Elemental function.

Argument. A must be of type integer, real, or complex.

Result Type and Type Parameter. The same as A except that if A is complex, the result is real.

Result Value. If A is of type integer or real, the value of the result is $|A|$; if A is complex with value (x,y), the result is equal to a processor-dependent approximation to $\sqrt{x^2+y^2}$.

Example. ABS ((3.0, 4.0)) has the value 5.0 (approximately).

13.13.2 ACHAR (I).

Description. Returns the character in a specified position of the ASCII collating sequence. It is the inverse of the IACHAR function.

Class. Elemental function.

Argument. I must be of type integer.

Result Type and Type Parameter. Character of length one with kind type parameter value KIND ('A').

Result Value. If I has a value in the range $0 \leq I \leq 127$, the result is the character in position I of the ASCII collating sequence, provided the processor is capable of representing that character; otherwise, the result is processor dependent. If the processor is not capable of representing both upper and lower case letters and I corresponds to a letter in a case that the processor is not capable of representing, the result is the letter in the case that the processor is capable of representing. ACHAR (IACHAR (C)) must have the value C for any character C capable of representation in the processor.

Example. ACHAR (88) has the value 'X'.

13.13.3 ACOS (X).

Description. Arccosine (inverse cosine) function.

Class. Elemental function.

Argument. X must be of type real with a value that satisfies the inequality $|X| \leq 1$.

Result Type and Type Parameter. Same as X.

Result Value. The result has a value equal to a processor-dependent approximation to arccos(X), expressed in radians. It lies in the range $0 \leq \text{ACOS}(X) \leq \pi$.

Example. ACOS (0.54030231) has the value 1.0 (approximately).

13.13.4 ADJUSTL (STRING).

Description. Adjust to the left, removing leading blanks and inserting trailing blanks.

Class. Elemental function.

Argument. STRING must be of type character.

Result Type. Character of the same length and kind type parameter as STRING.

Result Value. The value of the result is the same as STRING except that any leading blanks have been deleted and the same number of trailing blanks have been inserted.

Example. ADJUSTL (' WORD') has the value 'WORD '.

13.13.5 ADJUSTR (STRING).

Description. Adjust to the right, removing trailing blanks and inserting leading blanks.

Class. Elemental function.

Argument. STRING must be of type character.

Result Type. Character of the same length and kind type parameter as STRING.

Result Value. The value of the result is the same as STRING except that any trailing blanks have been deleted and the same number of leading blanks have been inserted.

Example. ADJUSTR ('WORD ') has the value ' WORD'.

13.13.6 AIMAG (Z).

Description. Imaginary part of a complex number.

Class. Elemental function.

Argument. Z must be of type complex.

Result Type and Type Parameter. Real with the same type parameter as Z.

Result Value. If Z has the value (x, y), the result has value y.

Example. AIMAG ((2.0, 3.0)) has the value 3.0.

13.13.7 AINT (A, KIND).

Optional Argument. KIND

Description. Truncation to a whole number.

Class. Elemental function.

Arguments.

A	must be of type real.
KIND (optional)	must be a scalar integer initialization expression.

Result Type and Type Parameter. The result is of type real. If KIND is present, the kind type parameter is that specified by KIND; otherwise, the kind type parameter is that of A.

Result Value. If $|A| < 1$, AINT (A) has the value 0; if $|A| \geq 1$, AINT (A) has a value equal to the largest integer that does not exceed the magnitude of A and whose sign is the same as the sign of A.

Examples. AINT (2.783) has the value 2.0. AINT (–2.783) has the value –2.0.

13.13.8 ALL (MASK, DIM).

Optional Argument. DIM

Description. Determine whether all values are true in MASK along dimension DIM.

Class. Transformational function.

Arguments.

MASK	must be of type logical. It must not be scalar.
DIM (optional)	must be scalar and of type integer with value in the range $1 \leq DIM \leq n$, where n is the rank of MASK.

Result Type, Type Parameter, and Shape. The result is of type logical with the same kind type parameter as MASK. It is scalar if DIM is absent or MASK has rank one; otherwise, the result is an array of rank $n-1$ and of shape $(d_1, d_2, ..., d_{DIM-1}, d_{DIM+1}, ..., d_n)$ where $(d_1, d_2, ..., d_n)$ is the shape of MASK.

Result Value.

Case (i): The result of ALL (MASK) has the value true if all elements of MASK are true or if MASK has size zero, and the result has value false if any element of MASK is false.

Case (ii): If MASK has rank one, ALL (MASK, DIM) has a value equal to that of ALL (MASK). Otherwise, the value of element $(s_1, s_2, ..., s_{DIM-1}, s_{DIM+1}, ..., s_n)$ of ALL (MASK, DIM) is equal to ALL (MASK $(s_1, s_2, ..., s_{DIM-1}, :, s_{DIM+1}, ..., s_n)$).

Examples.

Case (i): The value of ALL ((/ .TRUE., .FALSE., .TRUE. /)) is .FALSE.

Case (ii): If B is the array $\begin{bmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \end{bmatrix}$ and C is the array $\begin{bmatrix} 0 & 3 & 5 \\ 7 & 4 & 8 \end{bmatrix}$ then ALL (B .NE. C, DIM = 1) is (/ .TRUE., .FALSE., .FALSE. /) and ALL (B .NE. C, DIM = 2) is (/ .FALSE., .FALSE. /).

13.13.9 ALLOCATED (ARRAY).

Description. Indicate whether or not an allocatable array is currently allocated.

Class. Inquiry function.

Argument. ARRAY must be an allocatable array.

Result Type, Type Parameter, and Shape. Default logical scalar.

Result Value. The result has the value true if ARRAY is currently allocated and has the value false if ARRAY is not currently allocated. The result is undefined if the allocation status (14.8) of the array is undefined.

13.13.10 ANINT (A, KIND).

Optional Argument. KIND

Description. Nearest whole number.

Class. Elemental function.

Arguments.

A	must be of type real.
KIND (optional)	must be a scalar integer initialization expression.

Result Type and Type Parameter. The result is of type real. If KIND is present, the kind type parameter is that specified by KIND; otherwise, the kind type parameter is that of A.

Result Value. If $A > 0$, ANINT (A) has the value AINT (A + 0.5); if $A \leq 0$, ANINT (A) has the value AINT (A – 0.5).

Examples. ANINT (2.783) has the value 3.0. ANINT (–2.783) has the value –3.0.

13.13.11 ANY (MASK, DIM).

Optional Argument. DIM

Description. Determine whether any value is true in MASK along dimension DIM.

Class. Transformational function.

Arguments.

MASK	must be of type logical. It must not be scalar.
DIM (optional)	must be scalar and of type integer with a value in the range $1 \leq \text{DIM} \leq n$, where n is the rank of MASK.

Result Type, Type Parameter, and Shape. The result is of type logical with the same kind type parameter as MASK. It is scalar if DIM is absent or MASK has rank one; otherwise, the result is an array of rank $n-1$ and of shape $(d_1, d_2, \ldots, d_{\text{DIM}-1}, d_{\text{DIM}+1}, \ldots, d_n)$ where $(d_1, d_2, \ldots, d_n)$ is the shape of MASK.

Result Value.

Case (i): The result of ANY (MASK) has the value true if any element of MASK is true and has the value false if no elements are true or if MASK has size zero.

Case (ii): If MASK has rank one, ANY (MASK, DIM) has a value equal to that of ANY (MASK). Otherwise, the value of element $(s_1, s_2, \ldots, s_{\text{DIM}-1}, s_{\text{DIM}+1}, \ldots, s_n)$ of ANY (MASK, DIM) is equal to ANY (MASK $(s_1, s_2, \ldots, s_{\text{DIM}-1}, :, s_{\text{DIM}+1}, \ldots, s_n)$).

Examples.

Case (i): The value of ANY ((/ .TRUE., .FALSE., .TRUE. /)) is .TRUE.

Case (ii): If B is the array $\begin{bmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \end{bmatrix}$ and C is the array $\begin{bmatrix} 0 & 3 & 5 \\ 7 & 4 & 8 \end{bmatrix}$ ANY (B .NE. C, DIM = 1) is (/ .TRUE., .FALSE., .TRUE. /) and ANY (B .NE. C, DIM = 2) is (/ .TRUE., .TRUE. /).

13.13.12 ASIN (X).

Description. Arcsine (inverse sine) function.

Class. Elemental function.

Argument. X must be of type real. Its value must satisfy the inequality $|X| \leq 1$.

Result Type and Type Parameter. Same as X.

Result Value. The result has a value equal to a processor-dependent approximation to arcsin(X), expressed in radians. It lies in the range $-\pi/2 \leq \text{ASIN}(X) \leq \pi/2$.

Example. ASIN (0.84147098) has the value 1.0 (approximately).

13.13.13 ASSOCIATED (POINTER, TARGET).

Optional Argument. TARGET

Description. Returns the association status of its pointer argument or indicates the pointer is associated with the target.

Class. Inquiry function.

Arguments.

POINTER must be a pointer and may be of any type. Its pointer association status must not be undefined.

TARGET (optional) must be a pointer or target. If it is a pointer, its pointer association status must not be undefined.

Result Type. The result is of type default logical.

Case (i): If TARGET is absent, the result is true if POINTER is currently associated with a target and false if it is not.

Case (ii): If TARGET is present and is a target, the result is true if POINTER is currently associated with TARGET and false if it is not.

Case (iii): If TARGET is present and is a pointer, the result is true if both POINTER and TARGET are currently associated with the same target, and is false otherwise. If either POINTER or TARGET is disassociated, the result is true.

Examples. ASSOCIATED (CURRENT, HEAD) is true if CURRENT points to the target HEAD. After the execution of

```
A_PART => A (:N)
```

ASSOCIATED (A_PART, A) is true if N is equal to UBOUND (A, DIM = 1). After the execution of

```
NULLIFY (CUR); NULLIFY (TOP)
```

ASSOCIATED (CUR, TOP) is false.

13.13.14 ATAN (X).

Description. Arctangent (inverse tangent) function.

Class. Elemental function.

Argument. X must be of type real.

Result Type and Type Parameter. Same as X.

Result Value. The result has a value equal to a processor-dependent approximation to arctan(X), expressed in radians, that lies in the range $-\pi/2 \leq \text{ATAN}(X) \leq \pi/2$.

Example. ATAN (1.5574077) has the value 1.0 (approximately).

13.13.15 ATAN2 (Y, X).

Description. Arctangent (inverse tangent) function. The result is the principal value of the argument of the nonzero complex number (X, Y).

Class. Elemental function.

Arguments.

Y	must be of type real.
X	must be of the same type and kind type parameter as Y. If Y has the value zero, X must not have the value zero.

Result Type and Type Parameter. Same as X.

Result Value. The result has a value equal to a processor-dependent approximation to the principal value of the argument of the complex number (X, Y), expressed in radians. It lies in the range $-\pi < \text{ATAN2}\ (Y, X) \leq \pi$ and is equal to a processor-dependent approximation to a value of arctan(Y/X) if $X \neq 0$. If $Y > 0$, the result is positive. If $Y = 0$, the result is zero if $X > 0$ and the result is π if $X < 0$. If $Y < 0$, the result is negative. If $X = 0$, the absolute value of the result is $\pi/2$.

Examples. ATAN2 (1.5574077, 1.0) has the value 1.0 (approximately). If Y has the value $\begin{bmatrix} 1 & 1 \\ -1 & -1 \end{bmatrix}$ and X has the value $\begin{bmatrix} -1 & 1 \\ -1 & 1 \end{bmatrix}$, the value of ATAN2 (Y, X) is approximately $\begin{bmatrix} \frac{3\pi}{4} & \frac{\pi}{4} \\ \frac{-3\pi}{4} & -\frac{\pi}{4} \end{bmatrix}$.

13.13.16 BIT_SIZE (I).

Description. Returns the number of bits s defined by the model of 13.5.7.

Class. Inquiry function.

Argument. I must be of type integer.

Result Type, Type Parameter, and Shape. Scalar integer with the same kind type parameter as I.

Result Value. The result has the value of the number of bits s in the model integer defined for bit manipulation contexts in 13.5.7.

Example. BIT_SIZE (1) has the value 32 if s in the model is 32.

13.13.17 BTEST (I, POS).

Description. Tests a bit of an integer value.

Class. Elemental function.

Arguments.

I	must be of type integer.
POS	must be of type integer. It must be nonnegative and be less than BIT_SIZE (I).

Result Type. The result is of type default logical.

Result Value. The result has the value true if bit POS of I has the value 1 and has the value false if bit POS of I has the value 0. The model for the interpretation of an integer value as a sequence of bits is in 13.5.7.

Examples. BTEST (8, 3) has the value true. If A has the value $\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$, the value of BTEST (A, 2) is $\begin{bmatrix} \text{false} & \text{false} \\ \text{false} & \text{true} \end{bmatrix}$ and the value of BTEST (2, A) is $\begin{bmatrix} \text{true} & \text{false} \\ \text{false} & \text{false} \end{bmatrix}$

13.13.18 CEILING (A).

Description. Returns the least integer greater than or equal to its argument.

Class. Elemental function.

Argument. A must be of type real.

Result Type and Type Parameter. Default integer.

Result Value. The result has a value equal to the least integer greater than or equal to A. The result is undefined if the processor cannot represent this value in the default integer type.

Example. CEILING (3.7) has the value 4. CEILING (–3.7) has the value –3.

13.13.19 CHAR (I, KIND).

Optional Argument. KIND

Description. Returns the character in a given position of the processor collating sequence associated with the specified kind type parameter. It is the inverse of the function ICHAR.

Class. Elemental function.

Arguments.

I	must be of type integer with a value in the range $0 \le I \le n-1$, where n is the number of characters in the collating sequence.
KIND (optional)	must be a scalar integer initialization expression.

Result Type and Type Parameters. Character of length one. If KIND is present, the kind type parameter is that specified by KIND; otherwise, the kind type parameter is that of default character type.

Result Value. The result is the character in position I of the collating sequence associated with the specified kind type parameter. ICHAR (CHAR (I, KIND (C))) must have the value I for $0 \le I \le n-1$ and CHAR (ICHAR (C), KIND (C)) must have the value C for any character C capable of representation in the processor.

Example. CHAR (88) has the value 'X' on a processor using the ASCII collating sequence.

13.13.20 CMPLX (X, Y, KIND).

Optional Arguments. Y, KIND

Description. Convert to complex type.

Class. Elemental function.

Arguments.

X	must be of type integer, real, or complex.
Y (optional)	must be of type integer or real. It must not be present if X is of type complex.
KIND (optional)	must be a scalar integer initialization expression,

Result Type and Type Parameter. The result is of type complex. If KIND is present, the type parameter is that specified by KIND; otherwise, the type parameter is that of default real

type.

Result Value. If Y is absent and X is not complex, it is as if Y were present with the value zero. If Y is absent and X is complex, it is as if Y were present with the value AIMAG (X). CMPLX (X, Y, KIND) has the complex value whose real part is REAL (X, KIND) and whose imaginary part is REAL (Y, KIND).

Example. CMPLX (–3) has the value (–3.0, 0.0).

13.13.21 CONJG (Z).

Description. Conjugate of a complex number.

Class. Elemental function.

Argument. Z must be of type complex.

Result Type and Type Parameter. Same as Z.

Result Value. If Z has the value (x, y), the result has the value $(x, -y)$.

Example. CONJG ((2.0, 3.0)) has the value (2.0, –3.0).

13.13.22 COS (X).

Description. Cosine function.

Class. Elemental function.

Argument. X must be of type real or complex.

Result Type and Type Parameter. Same as X.

Result Value. The result has a value equal to a processor-dependent approximation to cos(X). If X is of type real, it is regarded as a value in radians. If X is of type complex, its real part is regarded as a value in radians.

Example. COS (1.0) has the value 0.54030231 (approximately).

13.13.23 COSH (X).

Description. Hyperbolic cosine function.

Class. Elemental function.

Argument. X must be of type real.

Result Type and Type Parameter. Same as X.

Result Value. The result has a value equal to a processor-dependent approximation to cosh(X).

Example. COSH (1.0) has the value 1.5430806 (approximately).

13.13.24 COUNT (MASK, DIM).

Optional Argument. DIM

Description. Count the number of true elements of MASK along dimension DIM.

Class. Transformational function.

Arguments.

MASK	must be of type logical. It must not be scalar.
DIM (optional)	must be scalar and of type integer with a value in the range $1 \le \text{DIM} \le n$, where n is the rank of MASK.

Result Type, Type Parameter, and Shape. The result is of type default integer. It is scalar if DIM is absent or MASK has rank one; otherwise, the result is an array of rank $n-1$ and of shape $(d_1, d_2, ..., d_{DIM-1}, d_{DIM+1}, ..., d_n)$ where $(d_1, d_2, ..., d_n)$ is the shape of MASK.

Result Value.

Case (i): The result of COUNT (MASK) has a value equal to the number of true elements of MASK or has the value zero if MASK has size zero.

Case (ii): If MASK has rank one, COUNT (MASK, DIM) has a value equal to that of COUNT (MASK). Otherwise, the value of element $(s_1, s_2, ..., s_{DIM-1}, s_{DIM+1}, ..., s_n)$ of COUNT (MASK, DIM) is equal to COUNT (MASK $(s_1, s_2, ..., s_{DIM-1}, :, s_{DIM+1}, ..., s_n)$).

Examples.

Case (i): The value of COUNT ((/ .TRUE., .FALSE., .TRUE. /)) is 2.

Case (ii): If B is the array $\begin{bmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \end{bmatrix}$ and C is the array $\begin{bmatrix} 0 & 3 & 5 \\ 7 & 4 & 8 \end{bmatrix}$, COUNT (B .NE. C, DIM = 1) is (/ 2, 0, 1 /) and COUNT (B .NE. C, DIM = 2) is (/ 1, 2 /).

13.13.25 CSHIFT (ARRAY, SHIFT, DIM).

Optional Argument. DIM

Description. Perform a circular shift on an array expression of rank one or perform circular shifts on all the complete rank one sections along a given dimension of an array expression of rank two or greater. Elements shifted out at one end of a section are shifted in at the other end. Different sections may be shifted by different amounts and in different directions.

Class. Transformational function.

Arguments.

ARRAY	may be of any type. It must not be scalar.
SHIFT	must be of type integer and must be scalar if ARRAY has rank one; otherwise, it must be scalar or of rank $n-1$ and of shape $(d_1, d_2, ..., d_{DIM-1}, d_{DIM+1}, ..., d_n)$ where $(d_1, d_2, ..., d_n)$ is the shape of ARRAY.
DIM (optional)	must be a scalar and of type integer with a value in the range $1 \le DIM \le n$, where n is the rank of ARRAY. If DIM is omitted, it is as if it were present with the value 1.

Result Type, Type Parameter, and Shape. The result is of the type and type parameters of ARRAY, and has the shape of ARRAY.

Result Value.

Case (i): If ARRAY has rank one, the result is obtained by applying |SHIFT| circular shifts to ARRAY in the direction indicated by the sign of SHIFT. If SHIFT has the value 1, element i of the result is ARRAY $(i+1)$ for $i = 1, 2, ..., m-1$ and element m of the result is ARRAY (1) where m is the size of ARRAY. If SHIFT is positive, the result is equivalent to SHIFT applications of CSHIFT with SHIFT=1. If SHIFT has the value –1, element i of the result is ARRAY $(i-1)$ for $i = 2, 3, ..., m$ and element 1 of the result is ARRAY (m). If SHIFT is negative, the result is equivalent to –SHIFT applications of CSHIFT with SHIFT=–1.

Case (ii): If ARRAY has rank greater than one, section $(s_1, s_2, ..., s_{DIM-1}, :, s_{DIM+1}, ..., s_n)$ of the result has a value equal to CSHIFT (ARRAY $(s_1, s_2, ..., s_{DIM-1}, :, s_{DIM+1}, ..., s_n)$, 1, *sh*), where *sh* is SHIFT or SHIFT $(s_1, s_2, ..., s_{DIM-1}, s_{DIM+1}, ..., s_n)$.

Examples.

Case (i): If V is the array (/ 1, 2, 3, 4, 5, 6 /), the effect of shifting V circularly to the left by two positions is achieved by CSHIFT (V, SHIFT = 2, DIM = 1) which has the value (/ 3, 4, 5, 6, 1, 2 /); CSHIFT (V, SHIFT = –2, DIM = 1) achieves a circular shift to the right by two positions and has the value (/ 5, 6, 1, 2, 3, 4 /).

Case (ii): The rows of an array of rank two may all be shifted by the same amount or by different amounts. If M is the array $\begin{bmatrix} A & B & C \\ D & E & F \\ G & H & I \end{bmatrix}$, the value of CSHIFT (M, SHIFT = –1, DIM = 2) is $\begin{bmatrix} C & A & B \\ F & D & E \\ I & G & H \end{bmatrix}$, and the value of CSHIFT (M, SHIFT = (/ –1, 1, 0 /), DIM = 2) is $\begin{bmatrix} C & A & B \\ E & F & D \\ G & H & I \end{bmatrix}$.

13.13.26 DATE_AND_TIME (ALL, COUNT, MSECOND, SECOND, MINUTE, HOUR, DAY, MONTH, YEAR, ZONE).

Optional Arguments. ALL, COUNT, MSECOND, SECOND, MINUTE, HOUR, DAY, MONTH, YEAR, ZONE

Description. Returns integer data from the date and real-time clock available to the processor. All values returned must refer to the same instant in time.

Class. Subroutine.

Arguments.

ALL (optional) must be of type default integer and rank one. It is an INTENT (OUT) argument. Its size must be at least 9. The values returned in ALL are as for the remaining 9 arguments, taken in order.

COUNT (optional) must be scalar and of type default integer. It is an INTENT (OUT) argument. It is set to a processor-dependent value based on the current value of the basic clock or to –HUGE (0) if there is no clock. The processor-dependent value is incremented by one for each clock count until the value COUNT_MAX (as returned by subroutine SYSTEM_CLOCK) is reached and is reset to zero at the next count. It lies in the range 0 to COUNT_MAX if there is a clock.

MSECOND (optional) must be scalar and of type default integer. It is an INTENT (OUT) argument. It is set to the millisecond part of the local time, or to –HUGE (0) if there is no clock. It lies in the range 0 to 999 if there is a clock.

SECOND (optional) must be scalar and of type default integer. It is an INTENT (OUT) argument. It is set to the second part of the local time, or to –HUGE (0) if there is no clock. It lies in the range 0 to 60 if there is a clock. The value normally lies in the range 0 to 59; the value 60 is intended to be used only to accommodate leap seconds.

MINUTE (optional) must be scalar and of type default integer. It is an INTENT (OUT) argument. It is set to the minute part of the local time, or to –HUGE (0) if there is no clock. It lies in the range 0 to 59 if there is a clock.

HOUR (optional) must be scalar and of type default integer. It is an INTENT (OUT) argument. It is set to the hour part of the local time, or to –HUGE (0) if there is no clock. It lies in the range 0 to 23 if there is a clock.

DAY (optional) must be scalar and of type default integer. It is an INTENT (OUT) argument. It is set to the day of the month, or to –HUGE (0) if there is no

date available. It lies in the range 1 to 31 if there is a date available.

MONTH (optional) must be scalar and of type default integer. It is an INTENT (OUT) argument. It is set to the month of the year, or to –HUGE (0) if there is no date available. It lies in the range 1 to 12 if there is a date available.

YEAR (optional) must be scalar and of type default integer. It is an INTENT (OUT) argument. It is set to the year according to the Gregorian calendar (e.g. 1988), or to –HUGE (0) if there is no date available.

ZONE (optional) must be scalar and of type default integer. It is an INTENT (OUT) argument. It is set to the number of minutes that local time is in advance of Coordinated Universal Time, or to –HUGE (0) if this information is not available.

Example.

```
CALL DATE_AND_TIME (ZONE = HERE)
```

will assign the value –300 to the variable HERE if the local time is 5 hours behind Coordinated Universal Time (UTC) as defined by CCIR Recommendation 460-2 (also known as Greenwich Mean Time).

13.13.27 DBLE (A).

Description. Convert to double precision real type.

Class. Elemental function.

Argument. A must be of type integer, real, or complex.

Result Type and Type Parameter. Double precision real.

Result Value.

Case (i): If A is of type double precision real, DBLE (A) = A.

Case (ii): If A is of type integer or real, the result is as much precision of the significant part of A as a double precision real datum can contain.

Case (iii): If A is of type complex, the result is as much precision of the significant part of the real part of A as a double precision real datum can contain.

Example. DBLE (–3) has the value –3.0D0.

13.13.28 DIGITS (X).

Description. Returns the number of significant digits in the model representing numbers of the same type and type parameter as the argument.

Class. Inquiry function.

Argument. X must be of type integer or real. It may be scalar or array valued.

Result Type, Type Parameter, and Shape. Default integer scalar.

Result Value. The result has the value q if X is of type integer and p if X is of type real, where q and p are as defined in 13.7.1 for the model representing numbers of the same type and type parameter as X.

Example. DIGITS (X) has the value 24 for real X whose model is as at the end of 13.7.1.

13.13.29 DIM (X, Y).

Description. The difference X–Y if it is positive; otherwise zero.

Class. Elemental function.

Arguments.

X must be of type integer or real.

Y must be of the same type and kind type parameter as X.

Result Type and Type Parameter. Same as X.

Result Value. The value of the result is X–Y if X > Y and zero otherwise.

Example. DIM (–3.0, 2.0) has the value 0.0.

13.13.30 DOT_PRODUCT (VECTOR_A, VECTOR_B).

Description. Performs dot-product multiplication of numeric or logical vectors.

Class. Transformational function.

Arguments.

VECTOR_A must be of numeric type (integer, real, or complex) or of logical type. It must be array valued and of rank one.

VECTOR_B must be of numeric type if VECTOR_A is of numeric type or of type logical if VECTOR_A is of type logical. It must be array valued and of rank one. It must be of the same size as VECTOR_A.

Result Type, Type Parameter, and Shape. If the arguments are of numeric type, the type and type parameter of the result are those of the expression VECTOR_A * VECTOR_B determined by the types of the arguments according to 7.1.4. If the arguments are of type logical, the result is of type logical with the type parameter of the expression VECTOR_A .AND. VECTOR_B according to 7.1.4. The result is scalar.

Result Value.

Case (i): If VECTOR_A is of type integer or real, the result has the value SUM (VECTOR_A*VECTOR_B). If the vectors have size zero, the result has the value zero.

Case (ii): If VECTOR_A is of type complex, the result has the value SUM (CONJG (VECTOR_A)*VECTOR_B). If the vectors have size zero, the result has the value zero.

Case (iii): If VECTOR_A is of type logical, the result has the value ANY (VECTOR_A .AND. VECTOR_B). If the vectors have size zero, the result has the value false.

Example. DOT_PRODUCT ((/ 1, 2, 3 /), (/ 2, 3, 4 /)) has the value 20.

13.13.31 DPROD (X, Y).

Description. Double precision real product.

Class. Elemental function.

Arguments.

X must be of type default real.

Y must be of type default real.

Result Type and Type Parameters. Double precision real.

Result Value. The result has a value equal to a processor-dependent approximation to the product of X and Y.

Example. DPROD (–3.0, 2.0) has the value –6.0D0.

13.13.32 EOSHIFT (ARRAY, SHIFT, BOUNDARY, DIM).

Optional Arguments. BOUNDARY, DIM

Description. Perform an end-off shift on an array expression of rank one or perform end-off shifts on all the complete rank-one sections along a given dimension of an array expression of rank two or greater. Elements are shifted off at one end of a section and copies of a boundary value are shifted in at the other end. Different sections may have different boundary values and may be shifted by different amounts and in different directions.

Class. Transformational function.

Arguments.

ARRAY — may be of any type. It must not be scalar.

SHIFT — must be of type integer and must be scalar if ARRAY has rank one; otherwise, it must be scalar or of rank $n-1$ and of shape $(d_1, d_2, ..., d_{DIM-1}, d_{DIM+1}, ..., d_n)$ where $(d_1, d_2, ..., d_n)$ is the shape of ARRAY.

BOUNDARY (optional) — must be of the same type and type parameters as ARRAY and must be scalar if ARRAY has rank one; otherwise, it must be either scalar or of rank $n-1$ and of shape $(d_1, d_2, ..., d_{DIM-1}, d_{DIM+1}, ..., d_n)$. BOUNDARY may be omitted for the data types in the following table and, in this case, it is as if it were present with the scalar value shown.

Type of ARRAY	Value of BOUNDARY
Integer	0
Real	0.0
Complex	(0.0, 0.0)
Logical	false
Character (*len*)	*len* blanks

DIM (optional) — must be scalar and of type integer with a value in the range $1 \le DIM \le n$, where n is the rank of ARRAY. If DIM is omitted, it is as if it were present with the value 1.

Result Type, Type Parameter, and Shape. The result has the type, type parameters, and shape of ARRAY.

Result Value. Element $(s_1, s_2, ..., s_n)$ of the result has the value ARRAY $(s_1, s_2, ..., s_{DIM-1}, s_{DIM}+sh, s_{DIM+1}, ..., s_n)$ where sh is SHIFT or SHIFT $(s_1, s_2, ..., s_{DIM-1}, s_{DIM+1}, ..., s_n)$ provided the inequality LBOUND (ARRAY, DIM) $\le s_{DIM} + sh \le$ UBOUND (ARRAY, DIM) holds and is otherwise BOUNDARY or BOUNDARY $(s_1, s_2, ..., s_{DIM-1}, s_{DIM+1}, ..., s_n)$.

Examples.

Case (i): If V is the array (/ 1, 2, 3, 4, 5, 6 /), the effect of shifting V end-off to the left by 3 positions is achieved by EOSHIFT (V, SHIFT = 3, DIM = 1) which has the value (/ 4, 5, 6, 0, 0, 0 /); EOSHIFT (V, SHIFT = –2, BOUNDARY = 99, DIM = 1) achieves an end-off shift to the right by 2 positions with the boundary value of 99 and has the value (/ 99, 99, 1, 2, 3, 4 /).

Case (ii): The rows of an array of rank two may all be shifted by the same amount or by different amounts and the boundary elements can be the same or different. If M is the array $\begin{bmatrix} A & B & C \\ D & E & F \\ G & H & I \end{bmatrix}$, then the value of EOSHIFT (M, SHIFT = –1, BOUNDARY = '*', DIM = 2) is $\begin{bmatrix} * & A & B \\ * & D & E \\ * & G & H \end{bmatrix}$, and the value of EOSHIFT (M,

SHIFT = (/ –1, 1, 0 /), BOUNDARY = (/ '*', '/', '?' /), DIM = 2) is $\begin{bmatrix} * & A & B \\ E & F & / \\ G & H & I \end{bmatrix}$.

13.13.33 EPSILON (X).

Description. Returns a positive model number that is almost negligible compared to unity in the model representing numbers of the same type and type parameter as the argument.

Class. Inquiry function.

Argument. X must be of type real. It may be scalar or array valued.

Result Type, Type Parameter, and Shape. Scalar of the same type and type parameter as X.

Result Value. The result has the value b^{1-p} where b and p are as defined in 13.7.1 for the model representing numbers of the same type and type parameter as X.

Example. EPSILON (X) has the value 2^{-23} for real X whose model is as at the end of 13.7.1.

13.13.34 EXP (X).

Description. Exponential.

Class. Elemental function.

Argument. X must be of type real or complex.

Result Type and Type Parameter. Same as X.

Result Value. The result has a value equal to a processor-dependent approximation to e^X. If X is of type complex, its imaginary part is regarded as a value in radians.

Example. EXP (1.0) has the value 2.7182818 (approximately).

13.13.35 EXPONENT (X).

Description. Returns the exponent part of the argument when represented as a model number.

Class. Elemental function.

Argument. X must be of type real.

Result Type. Default integer.

Result Type and Type Parameters. The result has a value equal to the exponent e of the model representation (13.7.1) for the value of X, provided X is nonzero and e is within the range for integers. EXPONENT (X) has the value zero if X is zero.

Examples. EXPONENT (1.0) has the value 1 and EXPONENT (4.1) has the value 3 for reals whose model is as at the end of 13.7.1.

13.13.36 FLOOR (A).

Description. Returns the greatest integer less than or equal to its argument.

Class. Elemental function.

Argument. A must be of type real.

Result Type and Type Parameter. Default integer.

Result Value. The result has value equal to the greatest integer less than or equal to A. The result is undefined if the processor cannot represent this value in the default integer type.

Example. FLOOR (3.7) has the value 3. FLOOR (–3.7) has the value –4.

13.13.37 FRACTION (X).

Description. Returns the fractional part of the model representation of the argument value.

Class. Elemental function.

Argument. X must be of type real.

Result Type and Type Parameter. Same as X.

Result Value. The result has the value $X \times b^{-e}$, where b and e are as defined in 13.7.1 for the model representation of X. If X has the value zero, the result has the value zero.

Example. FRACTION (3.0) has the value 0.75 for reals whose model is as at the end of 13.7.1.

13.13.38 HUGE (X).

Description. Returns the largest number in the model representing numbers of the same type and type parameter as the argument.

Class. Inquiry function.

Argument. X must be of type integer or real. It may be scalar or array valued.

Result Type, Type Parameter, and Shape. Scalar of the same type and type parameter as X.

Result Value. The result has the value r^q-1 if X is of type integer and $(1-b^{-p})b^{e_{max}}$ if X is of type real, where r, q, b, p, and e_{max} are as defined in 13.7.1 for the model representing numbers of the same type and type parameter as X.

Example. HUGE (X) has the value $(1-2^{-24})\times 2^{127}$ for real X whose model is as at the end of 13.7.1.

13.13.39 IACHAR (C).

Description. Returns the position of a character in the ASCII collating sequence.

Class. Elemental function.

Argument. C must be of type default character and of length one.

Result Type and Type Parameter. Default integer.

Result Value. If C is in the collating sequence defined by the codes specified in ANSI X3.4-1986 (ASCII), the result is the position of C in that sequence and satisfies the inequality ($0 \le$ IACHAR (C) ≤ 127). A processor-dependent value is returned if C is not in the ASCII collating sequence. The results must be consistent with the LGE, LGT, LLE, and LLT lexical comparison functions. For example, if LLE (C, D) is true, IACHAR (C) .LE. IACHAR (D) is true where C and D are any two characters representable by the processor.

Example. IACHAR ('X') has the value 88.

13.13.40 IAND (I, J).

Description. Performs a logical AND.

Class. Elemental function.

Arguments.

I must be of type integer.

J must be of type integer with the same kind parameter as I.

Result Type and Type Parameter. Same as I.

Result Value. The result has the value obtained by combining I and J bit-by-bit according to the following truth table:

I	J	IAND (I, J)
1	1	1
1	0	0
0	1	0
0	0	0

The model for the interpretation of an integer value as a sequence of bits is in 13.5.7.

Example. IAND (1, 3) has the value 1.

13.13.41 IBCLR (I, POS).

Description. Clears one bit to zero.

Class. Elemental function.

Arguments.

I	must be of type integer.
POS	must be of type integer. It must be nonnegative and less than BIT_SIZE (I).

Result Type and Type Parameter. Same as I.

Result Value. The result has the value of the sequence of bits of I, except that bit POS of I is set to zero. The model for the interpretation of an integer value as a sequence of bits is in 13.5.7.

Examples. IBCLR (14, 1) has the result 12. If V has the value (/ 1, 2, 3, 4 /), the value of IBCLR (POS = V, I = 31) is (/ 29, 27, 23, 15 /).

13.13.42 IBITS (I, POS, LEN).

Description. Extracts a sequence of bits.

Class. Elemental function.

Arguments.

I	must be of type integer.
POS	must be of type integer. It must be nonnegative and POS + LEN must be less than or equal to BIT_SIZE (I).
LEN	must be of type integer and positive.

Result Type and Type Parameter. Same as I.

Result Value. The result has the value of the sequence of LEN bits in I beginning at bit POS right-adjusted and with all other bits zero. The model for the interpretation of an integer value as a sequence of bits is in 13.5.7.

Example. IBITS (14, 1, 3) has the value 7.

13.13.43 IBSET (I, POS).

Description. Sets one bit to one.

Class. Elemental function.

Arguments.

I	must be of type integer.
POS	must be of type integer. It must be nonnegative and less than BIT_SIZE (I).

Result Type and Type Parameter. Same as I.

Result Value. The result has the value of the sequence of bits of I, except that bit POS of I is set to one. The model for the interpretation of an integer value as a sequence of bits is in 13.5.7.

Examples. IBSET (12, 1) has the value 14. If V has the value (/ 1, 2, 3, 4 /), the value of IBSET (POS = V, I = 0) is (/ 2, 4, 8, 16 /).

13.13.44 ICHAR (C).

Description. Returns the position of a character in the processor collating sequence associated with the kind type parameter of the character.

Class. Elemental function.

Argument. C must be of type character and of length one. Its value must be that of a character capable of representation in the processor.

Result Type and Type Parameter. Default integer.

Result Value. The result is the position of C in the processor collating sequence associated with the kind type parameter of C and is in the range $0 \leq$ ICHAR (C) $\leq n-1$, where n is the number of characters in the collating sequence. For any characters C and D capable of representation in the processor, C .LE. D is true if and only if ICHAR (C) .LE. ICHAR (D) is true and C .EQ. D is true if and only if ICHAR (C). EQ. ICHAR (D) is true.

Example. ICHAR ('X') has the value 88 on a processor using the ASCII collating sequence for the default character type.

13.13.45 IEOR (I, J).

Description. Performs an exclusive OR.

Class. Elemental function.

Arguments.

I must be of type integer.

J must be of type integer with the same kind type parameter as I.

Result Type and Type Parameter. Same as I.

Result Value. The result has the value obtained by combining I and J bit-by-bit according to the following truth table:

I	J	IEOR (I, J)
1	1	0
1	0	1
0	1	1
0	0	0

The model for the interpretation of an integer value as a sequence of bits is in 13.5.7.

Example. IEOR (1, 3) has the value 2.

13.13.46 INDEX (STRING, SUBSTRING, BACK).

Optional Argument. BACK

Description. Returns the starting position of a substring within a string.

Class. Elemental function.

Arguments.

STRING	must be of type character.
SUBSTRING	must be of type character with the same kind type parameter as STRING.
BACK (optional)	must be of type logical.

Result Type and Type Parameter. Default integer.

Result Value.

Case (i): If BACK is absent or present with the value false, the result is the minimum value of I such that STRING (I : I + LEN (SUBSTRING) – 1) == SUBSTRING or zero if there is no such value. Zero is returned if LEN (STRING) < LEN (SUBSTRING) and one is returned if LEN (SUBSTRING) = 0.

Case (ii): If BACK is present with the value true, the result is the maximum value of I such that STRING (I : I + LEN (SUBSTRING) – 1) == SUBSTRING or zero if there is no such value. Zero is returned if LEN (STRING) < LEN (SUBSTRING) and LEN (STRING) + 1 is returned if LEN (SUBSTRING) = 0.

Examples. INDEX ('FORTRAN', 'R') has the value 3.
INDEX ('FORTRAN', 'R', BACK = .TRUE.) has the value 5.

13.13.47 INT (A, KIND).

Optional Argument. KIND

Description. Convert to integer type.

Class. Elemental function.

Arguments.

A	must be of type integer, real, or complex.
KIND (optional)	must be a scalar integer initialization expression.

Result Type and Type Parameter. Integer. If KIND is present, the kind type parameter is that specified by KIND; otherwise, the kind type parameter is that of default integer type.

Result Value.

Case (i): If A is of type integer, INT (A) = A.

Case (ii): If A is of type real, there are two cases: if $|A| < 1$, INT (A) has the value 0; if $|A| \geq 1$, INT (A) is the integer whose magnitude is the largest integer that does not exceed the magnitude of A and whose sign is the same as the sign of A.

Case (iii): If A is of type complex, INT (A) is the value obtained by applying the case (ii) rule to the real part of A.

Example. INT (–3.7) has the value –3.

13.13.48 IOR (I, J).

Description. Performs an inclusive OR.

Class. Elemental function.

Arguments.

I	must be of type integer.
J	must be of type integer with the same kind type parameter as I.

Result Type and Type Parameter. Same as I.

Result Value. The result has the value obtained by combining I and J bit-by-bit according to the following truth table:

I	J	IOR (I, J)
1	1	1
1	0	1
0	1	1
0	0	0

The model for the interpretation of an integer value as a sequence of bits is in 13.5.7.

Example. IOR (1, 3) has the value 3.

13.13.49 ISHFT (I, SHIFT).

Description. Performs a logical shift.

Class. Elemental function.

Arguments.

I	must be of type integer.
SHIFT	must be of type integer. The absolute value of SHIFT must be less than or equal to BIT_SIZE (I).

Result Type and Type Parameter. Same as I.

Result Value. The result has the value obtained by shifting the bits of I by SHIFT positions. If SHIFT is positive, the shift is to the left; if SHIFT is negative, the shift is to the right; and if SHIFT is zero, no shift is performed. Bits shifted out from the left or from the right, as appropriate, are lost. Zeros are shifted in from the opposite end. The model for the interpretation of an integer value as a sequence of bits is in 13.5.7.

Example. ISHFT (3, 1) has the result 6.

13.13.50 ISHFTC (I, SHIFT, SIZE).

Optional Argument. SIZE

Description. Performs a circular shift of the rightmost bits.

Class. Elemental function.

Arguments.

I	must be of type integer.
SHIFT	must be of type integer. The absolute value of SHIFT must be less than or equal to SIZE.
SIZE (optional)	must be of type integer. The value of SIZE must be positive and must not exceed BIT_SIZE (I). If SIZE is absent, it is as if it were present with the value of BIT_SIZE (I).

Result Type and Type Parameter. Same as I.

Result Value. The result has the value obtained by shifting the SIZE rightmost bits of I circularly by SHIFT positions. If SHIFT is positive, the shift is to the left; if SHIFT is negative, the shift is to the right; and if SHIFT is zero, no shift is performed. No bits are lost. The unshifted bits are unaltered. The model for the interpretation of an integer value as a sequence of bits is in 13.5.7.

Example. ISHFTC (3, 2, 3) has the value 5.

13.13.51 KIND (X).

Description. Returns the value of the kind type parameter of X.

Class. Inquiry function.

Argument. X may be of any intrinsic type.

Result Type, Type Parameter, and Shape. Default integer scalar.

Result Value. The result has a value equal to the kind type parameter value of X.

Example. KIND (0.0) has the kind type parameter value of default real.

13.13.52 LBOUND (ARRAY, DIM).

Optional Argument. DIM

Description. Returns all the lower bounds or a specified lower bound of an array.

Class. Inquiry function.

Arguments.

ARRAY — may be of any type. It must not be scalar. It must not be a pointer that is disassociated or an allocatable array that is not allocated.

DIM (optional) — must be scalar and of type integer with a value in the range $1 \leq \text{DIM} \leq n$, where n is the rank of ARRAY.

Result Type, Type Parameter, and Shape. The result is of type default integer. It is scalar if DIM is present; otherwise, the result is an array of rank one and size n, where n is the rank of ARRAY.

Result Value.

Case (i): LBOUND (ARRAY, DIM) has a value equal to the lower bound for subscript DIM of ARRAY if dimension DIM of ARRAY does not have size zero and has the value 1 if dimension DIM has size zero. For an array section or an array expression, it has the value 1.

Case (ii): LBOUND (ARRAY) has a value whose ith component is equal to LBOUND (ARRAY, i), for $i = 1, 2, ..., n$, where n is the rank of ARRAY.

Example. If A is declared by the statement

```
REAL A (2:3, 7:10)
```

then LBOUND (A) is (/ 2, 7 /) and LBOUND (A, DIM=2) is 7.

13.13.53 LEN (STRING).

Description. Returns the length of a character entity.

Class. Inquiry function.

Argument. STRING must be of type character. It may be scalar or array valued.

Result Type, Type Parameter, and Shape. Default integer scalar.

Result Value. The result has a value equal to the number of characters in STRING if it is scalar or in an element of STRING if it is array valued.

Example. If C is declared by the statement

```
CHARACTER (11) C (100)
```

LEN (C) has the value 11.

13.13.54 LEN_TRIM (STRING).

Description. Returns the length of the character argument without counting trailing blank characters.

Class. Elemental function.

Argument. STRING must be of type character.

Result Type and Type Parameter. Default integer.

Result Value. The result has a value equal to the number of characters after any trailing blanks in STRING are removed. If the argument contains no nonblank characters, the result is zero.

Examples. LEN_TRIM (' A B ') has the value 4 and LEN_TRIM (' ') has the value 0.

13.13.55 LGE (STRING_A, STRING_B).

Description. Test whether a string is lexically greater than or equal to another string, based on the ASCII collating sequence.

Class. Elemental function.

Arguments.

STRING_A must be of type default character.

STRING_B must be of type default character.

Result Type and Type Parameters. Default logical.

Result Value. If the strings are of unequal length, the comparison is made as if the shorter string were extended on the right with blanks to the length of the longer string. If either string contains a character not in the ASCII character set, the result is processor dependent. The result is true if the strings are equal or if STRING_A follows STRING_B in the ASCII collating sequence; otherwise, the result is false.

Example. LGE ('ONE', 'TWO') has the value false.

13.13.56 LGT (STRING_A, STRING_B).

Description. Test whether a string is lexically greater than another string, based on the ASCII collating sequence.

Class. Elemental function.

Arguments.

STRING_A must be of type default character.

STRING_B must be of type default character.

Result Type and Type Parameters. Default logical.

Result Value. If the strings are of unequal length, the comparison is made as if the shorter string were extended on the right with blanks to the length of the longer string. If either string contains a character not in the ASCII character set, the result is processor dependent. The result is true if STRING_A follows STRING_B in the ASCII collating sequence; otherwise, the result is false. The result is false if both STRING_A and STRING_B are zero length.

Example. LGT ('ONE', 'TWO') has the value false.

13.13.57 LLE (STRING_A, STRING_B).

Description. Test whether a string is lexically less than or equal to another string, based on the ASCII collating sequence.

Class. Elemental function.

Arguments.

STRING_A must be of type default character.

STRING_B must be of type default character.

Result Type and Type Parameters. Default logical.

Result Value. If the strings are of unequal length, the comparison is made as if the shorter string were extended on the right with blanks to the length of the longer string. If either string contains a character not in the ASCII character set, the result is processor dependent. The result is true if the strings are equal or if STRING_A precedes STRING_B in the ASCII collating sequence; otherwise, the result is false.

Example. LLE ('ONE', 'TWO') has the value true.

13.13.58 LLT (STRING_A, STRING_B).

Description. Test whether a string is lexically less than another string, based on the ASCII collating sequence.

Class. Elemental function.

Arguments.

STRING_A must be of type default character.

STRING_B must be of type default character.

Result Type and Type Parameters. Default logical.

Result Value. If the strings are of unequal length, the comparison is made as if the shorter string were extended on the right with blanks to the length of the longer string. If either string contains a character not in the ASCII character set, the result is processor dependent. The result is true if STRING_A precedes STRING_B in the ASCII collating sequence; otherwise, the result is false. The result is false if both STRING_A and STRING_B are of zero length.

Example. LLT ('ONE', 'TWO') has the value true.

13.13.59 LOG (X).

Description. Natural logarithm.

Class. Elemental function.

Argument. X must be of type real or complex. If X is real, its value must be greater than zero. If X is complex, its value must not be zero.

Result Type and Type Parameter. Same as X.

Result Value. The result has a value equal to a processor-dependent approximation to $\log_e X$. A result of type complex is the principal value with imaginary part ω in the range $-\pi < \omega \leq \pi$. The imaginary part of the result is π only when the real part of the argument is less than zero and the imaginary part of the argument is zero.

Example. LOG (10.0) has the value 2.3025851 (approximately).

13.13.60 LOG10 (X).

Description. Common logarithm.

Class. Elemental function.

Argument. X must be of type real. The value of X must be greater than zero.

Result Type and Type Parameter. Same as X.

Result Value. The result has a value equal to a processor-dependent approximation to $\log_{10}X$.

Example. LOG10 (10.0) has the value 1.0 (approximately).

13.13.61 LOGICAL (L, KIND).

Optional Argument. KIND

Description. Converts between kinds of logical.

Class. Elemental function.

Arguments.

L	must be of type logical.
KIND (optional)	must be a scalar integer initialization expression.

Result Type and Type Parameter. Logical. If KIND is present, the kind type parameter is that specified by KIND; otherwise, the kind type parameter is that of default logical.

Result Value. The value is that of L.

Example. LOGICAL (L .OR. .NOT. L) has the value true and is of type default logical, regardless of the kind type parameter of the logical variable L.

13.13.62 MATMUL (MATRIX_A, MATRIX_B).

Description. Performs matrix multiplication of numeric or logical matrices.

Class. Transformational function.

Arguments.

MATRIX_A	must be of numeric type (integer, real, or complex) or of logical type. It must be array valued and of rank one or two.
MATRIX_B	must be of numeric type if MATRIX_A is of numeric type and of logical type if MATRIX_A is of logical type. It must be array valued and of rank one or two. If MATRIX_A has rank one, MATRIX_B must have rank two. If MATRIX_B has rank one, MATRIX_A must have rank two. The size of the first (or only) dimension of MATRIX_B must equal the size of the last (or only) dimension of MATRIX_A.

Result Type, Type Parameter, and Shape. If the arguments are of numeric type, the type and type parameter of the result are determined by the types of the arguments according to 7.1.4. If the arguments are of type logical, the result is of type logical with the type parameters of the expression MATRIX_A .AND. MATRIX_B according to 7.1.4. The shape of the result depends on the shapes of the arguments as follows:

Case (i): If MATRIX_A has shape (n, m) and MATRIX_B has shape (m, k), the result has shape (n, k).

Case (ii): If MATRIX_A has shape (m) and MATRIX_B has shape (m, k), the result has shape (k).

Case (iii): If MATRIX_A has shape (n, m) and MATRIX_B has shape (m), the result has shape (n).

Result Value.

Case (i): Element (i, j) of the result has the value SUM (MATRIX_A (i, :) * MATRIX_B (:, j)) if the arguments are of numeric type and has the value ANY (MATRIX_A (i, :) .AND. MATRIX_B (:, j)) if the arguments are of logical type.

Case (ii): Element (*j*) of the result has the value SUM (MATRIX_A (:) * MATRIX_B (:, *j*)) if the arguments are of numeric type and has the value ANY (MATRIX_A (:) .AND. MATRIX_B (:, *j*)) if the arguments are of logical type.

Case (iii): Element (*i*) of the result has the value SUM (MATRIX_A (*i*, :) * MATRIX_B (:)) if the arguments are of numeric type and has the value ANY (MATRIX_A (*i*, :) .AND. MATRIX_B (:)) if the arguments are of logical type.

Examples. Let A and B be the matrices $\begin{bmatrix} 1 & 2 & 3 \\ 2 & 3 & 4 \end{bmatrix}$ and $\begin{bmatrix} 1 & 2 \\ 2 & 3 \\ 3 & 4 \end{bmatrix}$; let X and Y be the vectors (/ 1, 2 /) and (/ 1, 2, 3 /).

Case (i): The result of MATMUL (A, B) is the matrix-matrix product AB with the value $\begin{bmatrix} 14 & 20 \\ 20 & 29 \end{bmatrix}$.

Case (ii): The result of MATMUL (X, A) is the vector-matrix product XA with the value (/ 5, 8, 11 /).

Case (iii): The result of MATMUL (A, Y) is the matrix-vector product AY with the value (/ 14, 20 /).

13.13.63 MAX (A1, A2, A3, ...).

Optional Arguments. A3, ...

Description. Maximum value.

Class. Elemental function.

Arguments. The arguments must all have the same type which must be integer or real and they must all have the same type parameter.

Result Type and Type Parameter. Same as the arguments.

Result Value. The value of the result is that of the largest argument.

Example. MAX (–9.0, 7.0, 2.0) has the value 7.0.

13.13.64 MAXEXPONENT (X).

Description. Returns the maximum exponent in the model representing numbers of the same type and type parameter as the argument.

Class. Inquiry function.

Argument. X must be of type real. It may be scalar or array valued.

Result Type, Type Parameter, and Shape. Default integer scalar.

Result Value. The result has the value e_{max}, as defined in 13.7.1 for the model representing numbers of the same type and type parameter as X.

Example. MAXEXPONENT (X) has the value 127 for real X whose model is as at the end of 13.7.1.

13.13.65 MAXLOC (ARRAY, MASK).

Optional Argument. MASK

Description. Determine the location of the first element of ARRAY having the maximum value of the elements identified by MASK.

Class. Transformational function.

Arguments.

ARRAY	must be of type integer or real. It must not be scalar.
MASK (optional)	must be of type logical and must be conformable with ARRAY.

Result Type, Type Parameter, and Shape. The result is of type default integer; it is an array of rank one and of size equal to the rank of ARRAY.

Result Value.

Case (i): If MASK is absent, the result is a rank-one array whose element values are the values of the subscripts of an element of ARRAY whose value equals the maximum value of all of the elements of ARRAY. The ith subscript returned lies in the range 1 to e_i, where e_i is the extent of the ith dimension of ARRAY. If more than one element has the maximum value, the element whose subscripts are returned is the first such element, taken in array order. If ARRAY has size zero, the value of the result is processor dependent.

Case (ii): If MASK is present, the result is a rank-one array whose element values are the values of the subscripts of an element of ARRAY, corresponding to a true element of MASK, whose value equals the maximum value of all such elements of ARRAY. The ith subscript returned lies in the range 1 to e_i, where e_i is the extent of the ith dimension of ARRAY. If more than one such element has the maximum value, the element whose subscripts are returned is processor dependent. If there are no such elements (that is, if ARRAY has size zero or every element of MASK has the value false), the value of the result is processor dependent.

Examples.

Case (i): The value of MAXLOC ((/ 2, 4, 6 /)) is (/ 3 /).

Case (ii): If A has the value $\begin{bmatrix} 0 & -5 & 8 & -3 \\ 3 & 4 & -1 & 2 \\ 1 & 5 & 6 & -4 \end{bmatrix}$, MAXLOC (A, MASK = A .LT. 6) has the value (/ 3, 2 /). Note that this is true even if A has a declared lower bound other than 1.

13.13.66 MAXVAL (ARRAY, DIM, MASK).

Optional Arguments. DIM, MASK

Description. Maximum value of the elements of ARRAY along dimension DIM corresponding to the true elements of MASK.

Class. Transformational function.

Arguments.

ARRAY	must be of type integer or real. It must not be scalar.
DIM (optional)	must be scalar and of type integer with a value in the range $1 \le \text{DIM} \le n$, where n is the rank of ARRAY.
MASK (optional)	must be of type logical and must be conformable with ARRAY.

Result Type, Type Parameter, and Shape. The result is of the same type and type parameter as ARRAY. It is scalar if DIM is absent or ARRAY has rank one; otherwise, the result is an array of rank $n-1$ and of shape $(d_1, d_2, \ldots, d_{\text{DIM}-1}, d_{\text{DIM}+1}, \ldots, d_n)$ where $(d_1, d_2, \ldots, d_n)$ is the shape of ARRAY.

Result Value.

Case (i): The result of MAXVAL (ARRAY) has a value equal to the maximum value of all the elements of ARRAY or has the value of the negative number of the largest magnitude supported by the processor for numbers of the type and type

parameter of ARRAY if ARRAY has size zero.

Case (ii): The result of MAXVAL (ARRAY, MASK = MASK) has a value equal to the maximum value of the elements of ARRAY corresponding to true elements of MASK or has the value of the negative number of the largest magnitude supported by the processor for numbers of the type and type parameter of ARRAY if there are no true elements.

Case (iii): If ARRAY has rank one, MAXVAL (ARRAY, DIM [,MASK]) has a value equal to that of MAXVAL (ARRAY [,MASK = MASK]). Otherwise, the value of element $(s_1, s_2, ..., s_{DIM-1}, s_{DIM+1}, ..., s_n)$ of MAXVAL (ARRAY, DIM [,MASK]) is equal to MAXVAL (ARRAY $(s_1, s_2, ..., s_{DIM-1}, :, s_{DIM+1}, ..., s_n)$, [, MASK = MASK $(s_1, s_2, ..., s_{DIM-1}, :, s_{DIM+1}, ..., s_n)$]).

Examples.

Case (i): The value of MAXVAL ((/ 1, 2, 3 /)) is 3.

Case (ii): MAXVAL (C, MASK = C .LT. 0.0) finds the maximum of the negative elements of C.

Case (iii): If B is the array $\begin{bmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \end{bmatrix}$, MAXVAL (B, DIM = 1) is (/ 2, 4, 6 /) and MAXVAL (B, DIM = 2) is (/ 5, 6 /).

13.13.67 MERGE (TSOURCE, FSOURCE, MASK).

Description. Choose alternative value according to the value of a mask.

Class. Elemental function.

Arguments.

TSOURCE	may be of any type.
FSOURCE	must be of the same type and type parameters as TSOURCE.
MASK	must be of type logical.

Result Type and Type Parameters. Same as TSOURCE.

Result Value. The result is TSOURCE if MASK is true and FSOURCE otherwise.

Example. If TSOURCE is the array $\begin{bmatrix} 1 & 6 & 5 \\ 2 & 4 & 6 \end{bmatrix}$, FSOURCE is the array $\begin{bmatrix} 0 & 3 & 2 \\ 7 & 4 & 8 \end{bmatrix}$ and MASK is the array $\begin{bmatrix} T & . & T \\ . & . & T \end{bmatrix}$, where "T" represents true and "." represents false, then MERGE (TSOURCE, FSOURCE, MASK) is $\begin{bmatrix} 1 & 3 & 5 \\ 7 & 4 & 6 \end{bmatrix}$. The value of MERGE (1.0, 0.0, K > 0) is 1.0 for K = 5 and 0.0 for K = –2.

13.13.68 MIN (A1, A2, A3, ...).

Optional Arguments. A3, ...

Description. Minimum value.

Class. Elemental function.

Arguments. The arguments must all be of the same type which must be integer or real and they must all have the same type parameter.

Result Type and Type Parameter. Same as the arguments.

Result Value. The value of the result is that of the smallest argument.

Example. MIN (–9.0, 7.0, 2.0) has the value –9.0.

13.13.69 MINEXPONENT (X).

Description. Returns the minimum (most negative) exponent in the model representing numbers of the same type and type parameter as the argument.

Class. Inquiry function.

Argument. X must be of type real. It may be scalar or array valued.

Result Type, Type Parameter, and Shape. Default integer scalar.

Result Value. The result has the value e_{min}, as defined in 13.7.1 for the model representing numbers of the same type and type parameter as X.

Example. MINEXPONENT (X) has the value –126 for real X whose model is as at the end of 13.7.1.

13.13.70 MINLOC (ARRAY, MASK).

Optional Argument. MASK

Description. Determine the location of the first element of ARRAY having the minimum value of the elements identified by MASK.

Class. Transformational function.

Arguments.

ARRAY	must be of type integer or real. It must not be scalar.
MASK (optional)	must be of type logical and must be conformable with ARRAY.

Result Type, Type Parameter, and Shape. The result is of type default integer; it is an array of rank one and of size equal to the rank of ARRAY.

Result Value.

Case (i): If MASK is absent, the result is a rank-one array whose element values are the values of the subscripts of an element of ARRAY whose value equals the minimum value of all the elements of ARRAY. The ith subscript returned lies in the range 1 to e_i, where e_i is the extent of the ith dimension of ARRAY. If more than one element has the minimum value, the element whose subscripts are returned is the first such element, taken in array element order. If ARRAY has size zero, the value of the result is processor dependent.

Case (ii): If MASK is present, the result is a rank-one array whose element values are the values of the subscripts of an element of ARRAY, corresponding to a true element of MASK, whose value equals the minimum value of all such elements of ARRAY. The ith subscript returned lies in the range 1 to e_i, where e_i is the extent of the ith dimension of ARRAY. If more than one such element has the minimum value, the element whose subscripts are returned is processor dependent. If ARRAY has size zero or every element of MASK has the value false, the value of the result is processor dependent.

Examples.

Case (i): The value of MINLOC ((/ 2, 4, 6 /)) is (/ 1 /).

Case (ii): If A has the value $\begin{bmatrix} 0 & -5 & 8 & -3 \\ 3 & 4 & -1 & 2 \\ 1 & 5 & 6 & -4 \end{bmatrix}$, MINLOC (A, MASK = A .GT. –4) has the value (/ 1, 4 /). Note that this is true even if A has a declared lower bound other

than 1.

13.13.71 MINVAL (ARRAY, DIM, MASK).

Optional Arguments. DIM, MASK

Description. Minimum value of all the elements of ARRAY along dimension DIM corresponding to true elements of MASK.

Class. Transformational function.

Arguments.

ARRAY	must be of type integer or real. It must not be scalar.
DIM (optional)	must be scalar and of type integer with a value in the range $1 \le DIM \le n$, where n is the rank of ARRAY.
MASK (optional)	must be of type logical and must be conformable with ARRAY.

Result Type, Type Parameter, and Shape. The result is of the same type and type parameter as ARRAY. It is scalar if DIM is absent or ARRAY has rank one; otherwise, the result is an array of rank $n-1$ and of shape $(d_1, d_2, ..., d_{DIM-1}, d_{DIM+1}, ..., d_n)$ where $(d_1, d_2, ..., d_n)$ is the shape of ARRAY.

Result Value.

Case (i): The result of MINVAL (ARRAY) has a value equal to the minimum value of all the elements of ARRAY or has the value of the positive number of the largest magnitude supported by the processor for numbers of the type and type parameters of ARRAY if ARRAY has size zero.

Case (ii): The result of MINVAL (ARRAY, MASK = MASK) has a value equal to the minimum value of the elements of ARRAY corresponding to true elements of MASK or has the value of the positive number of the largest magnitude supported by the processor for numbers of the type and type parameters of ARRAY if there are no true elements.

Case (iii): If ARRAY has rank one, MINVAL (ARRAY, DIM [,MASK]) has a value equal to that of MINVAL (ARRAY [,MASK = MASK]). Otherwise, the value of element $(s_1, s_2, ..., s_{DIM-1}, s_{DIM+1}, ..., s_n)$ of MINVAL (ARRAY, DIM [,MASK]) is equal to MINVAL (ARRAY $(s_1, s_2, ..., s_{DIM-1}, :, s_{DIM+1}, ..., s_n)$ [, MASK= MASK $(s_1, s_2, ..., s_{DIM-1}, :, s_{DIM+1}, ..., s_n)$]).

Examples.

Case (i): The value of MINVAL ((/ 1, 2, 3 /)) is 1.

Case (ii): MINVAL (C, MASK = C .GT. 0.0) forms the minimum of the positive elements of C.

Case (iii): If B is the array $\begin{bmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \end{bmatrix}$, MINVAL (B, DIM = 1) is (/ 1, 3, 5 /) and MINVAL (B, DIM = 2) is (/ 1, 2 /).

13.13.72 MOD (A, P).

Description. Remainder function.

Class. Elemental function.

Arguments.

A	must be of type integer or real.
P	must be of the same type and kind type parameter as A.

Result Type and Type Parameter. Same as A.

Result Value. If P≠0, the value of the result is A–INT (A/P) * P. If P = 0, the result is processor defined.

Examples. MOD (3.0, 2.0) has the value 1.0. MOD (8, 5) has the value 3. MOD (–8, 5) has the value –3. MOD (8, –5) has the value –3. MOD (–8, –5) has the value –3.

13.13.73 MODULO (A, P).

Description. Modulo function.

Class. Elemental function.

Arguments.

A	must be of type integer or real.
P	must be of the same type and kind type parameter as A.

Result Type and Type Parameter. Same as A.

Result Value.

Case (i): A is of type integer. If P ≠ 0, the value of the result is A - FLOOR (REAL (A) / REAL (P)) * P. If P = 0, the result is processor defined.

Case (ii): A is of type real. If P ≠ 0, the value of the result is A - FLOOR (A / P) * P. If P = 0, the result is processor defined.

Examples. MODULO (8, 5) has the value 3. MODULO (–8, 5) has the value 2. MODULO (8, –5) has the value –2. MODULO (–8, –5) has the value –3.

13.13.74 MVBITS (FROM, FROMPOS, LEN, TO, TOPOS).

Description. Copies a sequence of bits from one data object to another.

Class. Elemental subroutine.

Arguments.

FROM	must be of type integer. It is an INTENT (IN) argument.
FROMPOS	must be of type integer and nonnegative. It is an INTENT (IN) argument. FROMPOS + LEN must be less than or equal to BIT_SIZE (FROM). The model for the interpretation of an integer value as a sequence of bits is in 13.5.7.
LEN	must be of type integer and positive. It is an INTENT (IN) argument. It must be conformable with TO.
TO	must be a variable of type integer with the same kind type parameter value as FROM and may be the same variable as FROM. It is an INTENT (OUT) argument. TO is set by copying the sequence of bits of length LEN, starting at positions FROMPOS of FROM to positions TOPOS of TO. No other bits of TO are altered. On return, the LEN bits of TO starting at TOPOS are equal to the value that the LEN bits of FROM starting at FROMPOS had on entry. The model for the interpretation of an integer value as a sequence of bits is in 13.5.7.
TOPOS	must be of type integer and nonnegative. It is an INTENT (IN) argument. If TO is a scalar, TOPOS + LEN must be less than or equal to BIT_SIZE (TO).

Example. If TO has the initial value 6, the value of TO after the statement CALL MVBITS (7, 2, 2, TO, 0) is 5.

13.13.75 NEAREST (X, S).

Description. Returns the nearest different machine representable number in a given direction.

Class. Elemental function.

Arguments.

X	must be of type real.
S	must be of type real and not equal to zero.

Result Type and Type Parameter. Same as X.

Result Value. The result has a value equal to the machine representable number distinct from X and nearest to it in the direction of the infinity with the same sign as S.

Example. NEAREST (3.0, 2.0) has the value $3+2^{-22}$ on a machine whose representation is that of the model at the end of 13.7.1.

13.13.76 NINT (A, KIND).

Optional Argument. KIND

Description. Nearest integer.

Class. Elemental function.

Arguments.

A	must be of type real.
KIND (optional)	must be a scalar integer initialization expression.

Result Type and Type Parameter. Integer. If KIND is present, the kind type parameter is that specified by KIND; otherwise, the kind type parameter is that of default integer type.

Result Value. If A > 0, NINT (A) has the value INT (A+0.5); if A ≤ 0, NINT (A) has the value INT (A–0.5).

Example. NINT (2.783) has the value 3.

13.13.77 NOT (I).

Description. Performs a logical complement.

Class. Elemental function.

Argument. I must be of type integer.

Result Type and Type Parameter. Same as I.

Result Value. The result has the value obtained by complementing I bit-by-bit according to the following truth table:

I	NOT (I)
1	0
0	1

The model for the interpretation of an integer value as a sequence of bits is in 13.5.7.

Example. If I is represented by the string of bits 01010101, NOT (I) has the binary value 10101010.

13.13.78 PACK (ARRAY, MASK, VECTOR).

Optional Argument. VECTOR

Description. Pack an array into an array of rank one under the control of a mask.

Class. Transformational function.

Arguments.

ARRAY	may be of any type. It must not be scalar.
MASK	must be of type logical and must be conformable with ARRAY.
VECTOR (optional)	must be of the same type and type parameters as ARRAY and must have rank one. VECTOR must have at least as many elements as there are true elements in MASK. If MASK is scalar with the value true, VECTOR must have at least as many elements as there are in ARRAY.

Result Type, Type Parameter, and Shape. The result is an array of rank one with the same type and type parameters as ARRAY. If VECTOR is present, the result size is that of VECTOR; otherwise, the result size is the number t of true elements in MASK unless MASK is scalar with the value true, in which case the result size is the size of ARRAY.

Result Value. Element i of the result is the element of ARRAY that corresponds to the ith true element of MASK, taking elements in array element order, for $i = 1, 2, ..., t$. If VECTOR is present and has size $n > t$, element i of the result has the value VECTOR (i), for $i = t+1, ..., n$.

Example. The nonzero elements of an array M with the value $\begin{bmatrix} 0 & 0 & 0 \\ 9 & 0 & 0 \\ 0 & 0 & 7 \end{bmatrix}$ may be "gathered" by the function PACK. The result of PACK (M, MASK = M .NE. 0) is (/ 9, 7 /) and the result of PACK (M, M .NE. 0, VECTOR = (/ 2, 4, 6, 8, 10, 12 /)) is (/ 9, 7, 6, 8, 10, 12 /).

13.13.79 PRECISION (X).

Description. Returns the decimal precision in the model representing real numbers with the same kind type parameter as the argument.

Class. Inquiry function.

Argument. X must be of type real or complex. It may be scalar or array valued.

Result Type, Type Parameter, and Shape. Default integer scalar.

Result Value. The result has the value INT ((*p*–1) * LOG10 (*b*)) + *k*, where *b* and *p* are as defined in 13.7.1 for the model representing real numbers with the same value for the kind type parameter as X, and where *k* is 1 if *b* is an integral power of 10 and 0 otherwise.

Example. PRECISION (X) has the value INT (23 * LOG10 (2.)) = INT (6.92...) = 6 for real X whose model is as at the end of 13.7.1.

13.13.80 PRESENT (A).

Description. Determine whether an optional argument is present.

Class. Inquiry function.

Argument. A must be an optional argument of the procedure in which the PRESENT function reference appears.

Result Type and Type Parameters. Default logical scalar.

Result Value. The result has the value true if A is present (12.5.2.8) and otherwise has the value false.

13.13.81 PRODUCT (ARRAY, DIM, MASK).

Optional Arguments. DIM, MASK

Description. Product of all the elements of ARRAY along dimension DIM corresponding to the true elements of MASK.

Class. Transformational function.

Arguments.

ARRAY	must be of type integer, real, or complex. It must not be scalar.
DIM (optional)	must be scalar and of type integer with a value in the range $1 \le \text{DIM} \le n$, where n is the rank of ARRAY.
MASK (optional)	must be of type logical and must be conformable with ARRAY.

Result Type, Type Parameter, and Shape. The result is of the same type and type parameters as ARRAY. It is scalar if DIM is absent or ARRAY has rank one; otherwise, the result is an array of rank $n-1$ and of shape $(d_1, d_2, ..., d_{\text{DIM}-1}, d_{\text{DIM}+1}, ..., d_n)$ where $(d_1, d_2, ..., d_n)$ is the shape of ARRAY.

Result Value.

Case (i): The result of PRODUCT (ARRAY) has a value equal to a processor-dependent approximation to the product of all the elements of ARRAY or has the value one if ARRAY has size zero.

Case (ii): The result of PRODUCT (ARRAY, MASK = MASK) has a value equal to a processor-dependent approximation to the product of the elements of ARRAY corresponding to the true elements of MASK or has the value one if there are no true elements.

Case (iii): If ARRAY has rank one, PRODUCT (ARRAY, DIM [,MASK]) has a value equal to that of PRODUCT (ARRAY [,MASK = MASK]). Otherwise, the value of element $(s_1, s_2, ..., s_{\text{DIM}-1}, s_{\text{DIM}+1}, ..., s_n)$ of PRODUCT (ARRAY, DIM [,MASK]) is equal to PRODUCT (ARRAY $(s_1, s_2, ..., s_{\text{DIM}-1}, :, s_{\text{DIM}+1}, ..., s_n)$ [, MASK = MASK $(s_1, s_2, ..., s_{\text{DIM}-1}, :, s_{\text{DIM}+1}, ..., s_n)$]).

Examples.

Case (i): The value of PRODUCT ((/ 1, 2, 3 /)) is 6.

Case (ii): PRODUCT (C, MASK = C .GT. 0.0) forms the product of the positive elements of C.

Case (iii): If B is the array $\begin{bmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \end{bmatrix}$, PRODUCT (B, DIM = 1) is (/ 2, 12, 30 /) and PRODUCT (B, DIM = 2) is (/ 15, 48 /).

13.13.82 RADIX (X).

Description. Returns the base of the model representing numbers of the same type and type parameter as the argument.

Class. Inquiry function.

Argument. X must be of type integer or real. It may be scalar or array valued.

Result Type, Type Parameter, and Shape. Default integer scalar.

Result Value. The result has the value r if X is of type integer and the value b if X is of type real, where r and b are as defined in 13.7.1 for the model representing numbers of the same type and type parameter as X.

Example. RADIX (X) has the value 2 for real X whose model is as at the end of 13.7.1.

13.13.83 RANDOM (HARVEST).

Description. Returns one pseudorandom number or an array of pseudorandom numbers from the uniform distribution over the range $0 \le x < 1$.

Class. Subroutine.

Argument. HARVEST must be of type real. It is an INTENT (OUT) argument. It may be a scalar or an array variable. It is set to contain pseudorandom numbers from the uniform distribution in the interval $0 \le x < 1$.

Examples.

```
REAL X, Y (10, 10)
CALL RANDOM (HARVEST = X)  ! INITIALIZES X WITH A PSEUDORANDOM NUMBER
CALL RANDOM (Y)
! X AND Y CONTAIN UNIFORMLY DISTRIBUTED RANDOM NUMBERS
```

13.13.84 RANDOM_SEED (SIZE, PUT, GET).

Optional Arguments. SIZE, PUT, GET

Description. Restarts or queries the pseudorandom number generator used by RANDOM.

Class. Subroutine.

Arguments. There must either be exactly one or no arguments present.

SIZE (optional) must be scalar and of type default integer. It is an INTENT (OUT) argument. It is set to the number N of integers that the processor uses to hold the value of the seed.

PUT (optional) must be a default integer array of rank one and size $\ge N$. It is an INTENT (IN) argument. It is used by the processor to set the seed value.

GET (optional) must be a default integer array of rank one and size $\ge N$. It is an INTENT (OUT) argument. It is set by the processor to the current value of the seed.

If no argument is present, the processor sets the seed to a processor-dependent value.

Examples.

```
CALL RANDOM_SEED  ! PROCESSOR INITIALIZATION
CALL RANDOM_SEED (SIZE = K)  ! SETS K = N
CALL RANDOM_SEED (PUT = SEED (1 : K))  ! SET USER SEED
CALL RANDOM_SEED (GET = OLD (1 : K))  ! READ CURRENT SEED
```

13.13.85 RANGE (X).

Description. Returns the decimal exponent range in the model representing integer or real numbers with the same kind type parameter as the argument.

Class. Inquiry function.

Argument. X must be of type integer, real, or complex. It may be scalar or array valued.

Result Type, Type Parameter, and Shape. Default integer scalar.

Result Value.

Case (i): For an integer argument, the result has the value INT (LOG10 (*huge*)), where *huge* is the largest positive integer in the model representing integer numbers with same kind type parameter as X (13.7.1).

Case (ii): For a real or complex argument, the result has the value INT (MIN (LOG10 (*huge*), –LOG10 (*tiny*))), where *huge* and *tiny* are the largest and smallest positive

numbers in the model representing real numbers with the same value for the kind type parameter as X (13.7.1).

Example. RANGE (X) has the value 38 for real X whose model is as at the end of 13.7.1, since in this case *huge* = $(1-2^{-24}) \times 2^{127}$ and *tiny* = 2^{-127}.

13.13.86 REAL (A, KIND).

Optional Argument. KIND

Description. Convert to real type.

Class. Elemental function.

Arguments.

A	must be of type integer, real, or complex.
KIND (optional)	must be a scalar integer initialization expression.

Result Type and Type Parameter. Real.

Case (i): If A is of type integer or real and KIND is present, the type parameter is that specified by KIND. If A is of type integer or real and KIND is not present, the type parameter is the processor-dependent type parameter for the default real type.

Case (ii): If A is of type complex and KIND is present, the type parameter is that specified by KIND. If A is of type complex and KIND is not present, the type parameter is the type parameter of A.

Result Value.

Case (i): If A is of type integer or real, the result is equal to a processor-dependent approximation to A.

Case (ii): If A is of type complex, the result is equal to a processor-dependent approximation to the real part of A.

Examples. REAL (–3) has the value –3.0. REAL (Z) has the same kind type parameter and the same value as the real part of the complex variable **Z.**

13.13.87 REPEAT (STRING, NCOPIES).

Description. Concatenate several copies of a string.

Class. Transformational function.

Arguments.

STRING	must be scalar and of type character.
NCOPIES	must be scalar and of type integer. Its value must not be negative.

Result Type, Type Parameter, and Shape. Character scalar of length NCOPIES times that of STRING, with the same kind type parameter as STRING.

Result Value. The value of the result is the concatenation of NCOPIES copies of STRING.

Examples. REPEAT ('H', 2) has the value HH. REPEAT ('XYZ', 0) has the value of a zero-length string.

13.13.88 RESHAPE (SOURCE, SHAPE, PAD, ORDER).

Optional Arguments. PAD, ORDER

Description. Change the shape of an array.

Class. Transformational function.

Arguments.

SOURCE	may be of any type. It must be array valued. If PAD is absent or of size zero, the size of SOURCE must be ≥ PRODUCT (SHAPE). The size of the result is the product of the values of the elements of SHAPE.
SHAPE	must be of type integer, rank one, and constant size. Its size must be positive and less than 8. It must not have an element whose value is negative.
PAD (optional)	must be of the same type and type parameters as SOURCE. PAD must be array valued.
ORDER (optional)	must be of type integer, must have the same shape as SHAPE, and its value must be a permutation of (1, 2, ..., *n*), where *n* is the size of SHAPE. If absent, it is as if it were present with value (1, 2, ..., *n*).

Result Type, Type Parameter, and Shape. The result is an array of shape SHAPE (that is, SHAPE (RESHAPE (SOURCE, SHAPE, PAD, ORDER)) is equal to SHAPE) with the same type and type parameters as SOURCE.

Result Value. The elements of the result, taken in permuted subscript order ORDER (1), ..., ORDER (*n*), are those of SOURCE in normal array element order followed if necessary by those of PAD in array element order, followed if necessary by additional copies of PAD in array element order.

Examples. RESHAPE ((/ 1, 2, 3, 4, 5, 6 /), (/ 2, 3 /)) has the value $\begin{bmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \end{bmatrix}$. RESHAPE ((/ 1, 2, 3, 4, 5, 6 /), (/ 2, 4 /), (/ 0, 0 /), (/ 2, 1 /)) has the value $\begin{bmatrix} 1 & 2 & 3 & 4 \\ 5 & 6 & 0 & 0 \end{bmatrix}$.

13.13.89 RRSPACING (X).

Description. Returns the reciprocal of the relative spacing of model numbers near the argument value.

Class. Elemental function.

Argument. X must be of type real.

Result Type and Type Parameter. Same as X.

Result Value. The result has the value $|X \times b^{-e}| \times b^{p}$, where b, e, and p are as defined in 13.7.1 for the model representation of X.

Example. RRSPACING (–3.0) has the value 0.75×2^{24} for reals whose model is as at the end of 13.7.1.

13.13.90 SCALE (X, I).

Description. Returns $X \times b^{I}$ where b is the base in the model representation of X.

Class. Elemental function.

Arguments.

X	must be of type real.
I	must be of type integer.

Result Type and Type Parameter. Same as X.

Result Value. The result has the value $X \times b^{I}$, where b is defined in 13.7.1 for model numbers representing values of X, provided this result is within range.

Example. SCALE (3.0, 2) has the value 12.0 for reals whose model is as at the end of 13.7.1.

13.13.91 SCAN (STRING, SET, BACK).

Optional Argument. BACK

Description. Scan a string for any one of the characters in a set of characters.

Class. Elemental function.

Arguments.

STRING	must be of type character.
SET	must be of type character with the same kind type parameter as STRING.
BACK (optional)	must be of type logical.

Result Type and Type Parameter. Default integer.

Result Value.

Case (i): If BACK is absent or is present with the value false and if STRING contains at least one character found in SET, the value of the result is the position of the leftmost character of STRING that is in SET.

Case (ii): If BACK is present with the value true and if STRING contains at least one character found in SET, the value of the result is the position of the rightmost character of STRING that is in SET.

Case (iii): The value of the result is zero if no character of STRING is in SET or if the length of STRING or SET is zero.

Examples.

Case (i): SCAN ('FORTRAN', 'TR') has the value 3.

Case (ii): SCAN ('FORTRAN', 'TR', BACK = .TRUE.) has the value 5.

Case (iii): SCAN ('FORTRAN', 'BCD') has the value 0.

13.13.92 SELECTED_INT_KIND (R).

Description. Returns the smallest value of the kind type parameter of an integer data type that represents all integer values n with $-10^R < n < 10^R$.

Class. Transformational function.

Arguments.

R	must be scalar and of type integer.

Result Type, Type Parameter, and Shape. Default integer scalar.

Result Value. The result has a value equal to the smallest value of the kind type parameter of an integer data type that represents all values n in the range of values n with $-10^R < n < 10^R$, or if no such kind type parameter is available on the processor, the result is –1.

Example. SELECTED_INT_KIND (6) has the value KIND (0) on a machine that supports default integer representation method with $r = 2$ and $q = 31$.

13.13.93 SELECTED_REAL_KIND (P, R).

Optional Arguments. P, R

Description. Returns the smallest value of the kind type parameter of a real data type with decimal precision of at least P digits and a decimal exponent range of at least R.

Class. Transformational function.

Arguments. At least one argument must be present.

P (optional)	must be scalar and of type integer.
R (optional)	must be scalar and of type integer.

Result Type, Type Parameter, and Shape. Default integer scalar.

Result Value. The result has a value equal to the smallest value of the kind type parameter of a real data type with decimal precision, as returned by the function PRECISION, of at least P digits and a decimal exponent range, as returned by the function RANGE, of at least R, or if no such kind type parameter is available on the processor, the result is –1 if the precision is not available, –2 if the exponent range is not available, and –3 if neither is available.

Example. SELECTED_REAL_KIND (6, 70) has the value KIND (0.0) on a machine that supports default real approximation method with $b = 16$, $p = 6$, $e_{min} = -64$, and $e_{max} = 63$.

13.13.94 SET_EXPONENT (X, I).

Description. Returns the model number whose fractional part is the fractional part of the model representation of X and whose exponent part is I.

Class. Elemental function.

Arguments.

X	must be of type real.
I	must be of type integer.

Result Type and Type Parameter. Same as X.

Result Value. The result has the value $X \times b^{I-e}$, where b and e are as defined in 13.7.1 for the model representation of X, provided this result is within range. If X has value zero, the result has value zero.

Example. SET_EXPONENT (3.0, 1) has the value 1.5 for reals whose model is as at the end of 13.7.1.

13.13.95 SHAPE (SOURCE).

Description. Returns the shape of an array or a scalar.

Class. Inquiry function.

Argument. SOURCE may be of any type. It may be array valued or scalar. It must not be a pointer that is disassociated or an allocatable array that is not allocated. It must not be an assumed-size array.

Result Type, Type Parameter, and Shape. The result is a default integer array of rank one whose size is equal to the rank of SOURCE.

Result Value. The value of the result is the shape of SOURCE.

Examples. The value of SHAPE (A (2:5, –1:1)) is (/ 4, 3 /). The value of SHAPE (3) is the rank-one array of size zero.

13.13.96 SIGN (A, B).

Description. Absolute value of A times the sign of B.

Class. Elemental function.

Arguments.

A	must be of type integer or real.

B must be of the same type and kind type parameter as A.

Result Type and Type Parameter. Same as A.

Result Value. The value of the result is $|A|$ if $B \geq 0$ and $-|A|$ if $B < 0$.

Example. SIGN (–3.0, 2.0) has the value 3.0.

13.13.97 SIN (X).

Description. Sine function.

Class. Elemental function.

Argument. X must be of type real or complex.

Result Type and Type Parameter. Same as X.

Result Value. The result has a value equal to a processor-dependent approximation to sin(X). If X is of type real, it is regarded as a value in radians. If X is of type complex, its real part is regarded as a value in radians.

Example. SIN (1.0) has the value 0.84147098 (approximately).

13.13.98 SINH (X).

Description. Hyperbolic sine function.

Class. Elemental function.

Argument. X must be of type real.

Result Type and Type Parameter. Same as X.

Result Value. The result has a value equal to a processor-dependent approximation to sinh(X).

Example. SINH (1.0) has the value 1.1752012 (approximately).

13.13.99 SIZE (ARRAY, DIM).

Optional Argument. DIM

Description. Returns the extent of an array along a specified dimension or the total number of elements in the array.

Class. Inquiry function.

Arguments.

ARRAY may be of any type. It must not be scalar. It must not be a pointer that is disassociated or an allocatable array that is not allocated. If ARRAY is an assumed-size array, DIM must be present with a value less than the rank of ARRAY.

DIM (optional) must be scalar and of type integer with a value in the range $1 \leq \text{DIM} \leq n$, where n is the rank of ARRAY.

Result Type, Type Parameter, and Shape. Default integer scalar.

Result Value. The result has a value equal to the extent of dimension DIM of ARRAY or, if DIM is absent, the total number of elements of ARRAY.

Examples. The value of SIZE (A (2:5, –1:1), DIM=2) is 3. The value of SIZE (A (2:5, –1:1)) is 12.

13.13.100 SPACING (X).

Description. Returns the absolute spacing of model numbers near the argument value.

Class. Elemental function.

Argument. X must be of type real.

Result Type and Type Parameter. Same as X.

Result Value. The result has the value b^{e-p}, where b, e, and p are as defined in 13.7.1 for the model representation of X, provided this result is within range; otherwise, the result is the same as that of TINY (X).

Example. SPACING (3.0) has the value 2^{-22} for reals whose model is as at the end of 13.7.1.

13.13.101 SPREAD (SOURCE, DIM, NCOPIES).

Description. Replicates an array by adding a dimension. Broadcasts several copies of SOURCE along a specified dimension (as in forming a book from copies of a single page) and thus forms an array of rank one greater.

Class. Transformational function.

Arguments.

SOURCE	may be of any type. It may be scalar or array valued. The rank of SOURCE must be less than 7.
DIM	must be scalar and of type integer with value in the range $1 \le \text{DIM} \le n+1$, where n is the rank of SOURCE.
NCOPIES	must be scalar and of type integer.

Result Type, Type Parameter, and Shape. The result is an array of the same type and type parameters as SOURCE and of rank $n+1$, where n is the rank of SOURCE.

Case (i): If SOURCE is scalar, the shape of the result is (MAX (NCOPIES, 0)).

Case (ii): If SOURCE is array valued with shape $(d_1, d_2, ..., d_n)$, the shape of the result is $(d_1, d_2, ..., d_{\text{DIM}-1}, \text{MAX (NCOPIES, 0)}, d_{\text{DIM}}, ..., d_n)$.

Result Value.

Case (i): If SOURCE is scalar, each element of the result has a value equal to SOURCE.

Case (ii): If SOURCE is array valued, the element of the result with subscripts $(r_1, r_2, ..., r_{n+1})$ has the value SOURCE $(r_1, r_2, ..., r_{\text{DIM}-1}, r_{\text{DIM}+1}, ..., r_{n+1})$.

Example. If A is the array (/ 2, 3, 4 /), SPREAD (A, DIM=1, NCOPIES=NC) is the array $\begin{bmatrix} 2 & 3 & 4 \\ 2 & 3 & 4 \\ 2 & 3 & 4 \end{bmatrix}$ if NC has the value 3 and is a zero-sized array if NC has the value 0.

13.13.102 SQRT (X).

Description. Square root.

Class. Elemental function.

Argument. X must be of type real or complex. Unless X is complex, its value must be greater than or equal to zero.

Result Type and Type Parameter. Same as X.

Result Value. The result has a value equal to a processor-dependent approximation to the square root of X. A result of type complex is the principal value with the real part greater than or equal to zero. When the real part of the result is zero, the imaginary part is greater

than or equal to zero.

Example. SQRT (4.0) has the value 2.0 (approximately).

13.13.103 SUM (ARRAY, DIM, MASK).

Optional Arguments. DIM, MASK

Description. Sum all the elements of ARRAY along dimension DIM with mask MASK.

Class. Transformational function.

Arguments.

ARRAY	must be of type integer, real, or complex. It must not be scalar.
DIM (optional)	must be scalar and of type integer with a value in the range $1 \le DIM \le n$, where n is the rank of ARRAY.
MASK (optional)	must be of type logical and must be conformable with ARRAY.

Result Type, Type Parameter, and Shape. The result is of the same type and type parameter as ARRAY. It is scalar if DIM is absent or ARRAY has rank one; otherwise, the result is an array of rank $n-1$ and of shape $(d_1, d_2, ..., d_{DIM-1}, d_{DIM+1}, ..., d_n)$ where $(d_1, d_2, ..., d_n)$ is the shape of ARRAY.

Result Value.

Case (i): The result of SUM (ARRAY) has a value equal to a processor-dependent approximation to the sum of all the elements of ARRAY or has the value zero if ARRAY has size zero.

Case (ii): The result of SUM (ARRAY, MASK = MASK) has a value equal to a processor-dependent approximation to the sum of the elements of ARRAY corresponding to the true elements of MASK or has the value zero if there are no true elements.

Case (iii): If ARRAY has rank one, SUM (ARRAY, DIM [,MASK]) has a value equal to that of SUM (ARRAY [,MASK = MASK]). Otherwise, the value of element $(s_1, s_2, ..., s_{DIM-1}, s_{DIM+1}, ..., s_n)$ of SUM (ARRAY, DIM [,MASK]) is equal to SUM (ARRAY $(s_1, s_2, ..., s_{DIM-1}, :, s_{DIM+1}, ..., s_n)$ [, MASK= MASK $(s_1, s_2, ..., s_{DIM-1}, :, s_{DIM+1}, ..., s_n)$]).

Examples.

Case (i): The value of SUM ((/ 1, 2, 3 /)) is 6.

Case (ii): SUM (C, MASK= C .GT. 0.0) forms the arithmetic sum of the positive elements of C.

Case (iii): If B is the array $\begin{bmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \end{bmatrix}$, SUM (B, DIM = 1) is (/ 3, 7, 11 /) and SUM (B, DIM = 2) is (/ 9, 12 /).

13.13.104 SYSTEM_CLOCK (COUNT, COUNT_RATE, COUNT_MAX).

Optional Arguments. COUNT, COUNT_RATE, COUNT_MAX

Description. Returns integer data from a real-time clock.

Class. Subroutine.

Arguments.

COUNT (optional)	must be scalar and of type default integer. It is an INTENT (OUT) argument. It is set to a processor-dependent value based on the current value of the basic clock or to –HUGE (0) if there is no clock. The processor-dependent value is incremented by one for each clock count

until the value COUNT_MAX is reached and is reset to zero at the next count. It lies in the range 0 to COUNT_MAX if there is a clock.

COUNT_RATE (optional)
must be scalar and of type default integer. It is an INTENT (OUT) argument. It is set to the number of basic clock counts per second, or to zero if there is no clock.

COUNT_MAX (optional)
must be scalar and of type default integer. It is an INTENT (OUT) argument. It is set to the maximum value that COUNT can have, or to zero if there is no clock.

Example. If the basic system clock is a 24-hour clock that registers time in 1-second intervals, at 11:30 A.M. the reference

```
CALL SYSTEM_CLOCK (COUNT = C, COUNT_RATE = R, COUNT_MAX = M)
```

sets $C = 11 \times 3600 + 30 \times 60 = 41400$, $R = 1$, and $M = 24 \times 3600 - 1 = 86399$.

13.13.105 TAN (X).

Description. Tangent function.

Class. Elemental function.

Argument. X must be of type real.

Result Type and Type Parameter. Same as X.

Result Value. The result has a value equal to a processor-dependent approximation to tan(X), with X regarded as a value in radians.

Example. TAN (1.0) has the value 1.5574077 (approximately).

13.13.106 TANH (X).

Description. Hyperbolic tangent function.

Class. Elemental function.

Argument. X must be of type real.

Result Type and Type Parameter. Same as X.

Result Value. The result has a value equal to a processor-dependent approximation to tanh(X).

Example. TANH (1.0) has the value 0.76159416 (approximately).

13.13.107 TINY (X).

Description. Returns the smallest positive number in the model representing numbers of the same type and type parameter as the argument.

Class. Inquiry function.

Argument. X must be of type real. It may be scalar or array valued.

Result Type, Type Parameter, and Shape. Scalar with the same type and type parameter as X.

Result Value. The result has the value $b^{e_{min}-1}$ where b and e_{min} are as defined in 13.7.1 for the model representing numbers of the same type and type parameters as X.

Example. TINY (X) has the value 2^{-127} for real X whose model is as at the end of 13.7.1.

13.13.108 TRANSFER (SOURCE, MOLD, SIZE).

Optional Argument. SIZE

Description. Returns a result with a physical representation identical to that of SOURCE but interpreted with the type and type parameters of MOLD.

Class. Transformational function.

Arguments.

SOURCE	may be of any type and may be scalar or array valued.
MOLD	may be of any type and may be scalar or array valued.
SIZE (optional)	must be scalar and of type integer.

Result Type, Type Parameter, and Shape. The result is of the same type and type parameters as MOLD.

Case (i): If MOLD is a scalar and SIZE is absent, the result is a scalar.

Case (ii): If MOLD is array valued and SIZE is absent, the result is array valued and of rank one. Its size is as small as possible such that its physical representation is not shorter than that of SOURCE.

Case (iii): If SIZE is present, the result is array valued of rank one and size SIZE.

Result Value. If the physical representation of the result has the same length as that of SOURCE, the physical representation of the result is that of SOURCE. If the physical representation of the result is longer than that of SOURCE, the physical representation of the leading part is that of SOURCE and the remainder is undefined. If the physical representation of the result is shorter than that of SOURCE, the physical representation of the result is the leading part of SOURCE. If D and E are scalar variables such that the physical representation of D is as long as or longer than that of E, the value of TRANSFER (TRANSFER (E, D), E) must be the value of E. IF D is an array and E is an array of rank one, the value of TRANSFER (TRANSFER (E, D), E, SIZE (E)) must be the value of E.

Examples.

Case (i): TRANSFER (1082130432, 0.0) has the value 4.0 on a processor that represents the values 4.0 and 1082130432 as the string of binary digits 0100 0000 1000 0000 0000 0000 0000 0000.

Case (ii): TRANSFER ((/ 1.1, 2.2, 3.3 /), (/ (0.0, 0.0) /)) is a complex rank-one array of length two whose first element has the value (1.1, 2.2) and whose second element has a real part with the value 3.3. The imaginary part of the second element is undefined.

Case (iii): TRANSFER ((/ 1.1, 2.2, 3.3 /), (/ (0.0, 0.0) /), 1) has the value (/ (1.1, 2.2) /).

13.13.109 TRANSPOSE (MATRIX).

Description. Transpose an array of rank two.

Class. Transformational function.

Argument. MATRIX may be of any type and must have rank two.

Result Type, Type Parameters, and Shape. The result is an array of the same type and type parameters as MATRIX and with rank two and shape (n, m) where (m, n) is the shape of MATRIX.

Result Value. Element (i, j) of the result has the value MATRIX (j, i), $i = 1, 2, ..., n$; $j = 1, 2, ..., m$.

Example. If A is the array $\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$, then TRANSPOSE (A) has the value $\begin{bmatrix} 1 & 4 & 7 \\ 2 & 5 & 8 \\ 3 & 6 & 9 \end{bmatrix}$.

13.13.110 TRIM (STRING).

Description. Returns the argument with trailing blank characters removed.

Class. Transformational function.

Argument. STRING must be of type character and must be a scalar.

Result Type and Type Parameters. Character with the same kind type parameter value of STRING and with a length that is the length of STRING less the number of trailing blanks in STRING.

Result Value. The value of the result is the same as STRING except any trailing blanks are removed. If STRING contains no nonblank characters, the result has zero length.

Example. TRIM (' A B ') has the value ' A B'.

13.13.111 UBOUND (ARRAY, DIM).

Optional Argument. DIM

Description. Returns all the upper bounds of an array or a specified upper bound.

Class. Inquiry function.

Arguments.

ARRAY	may be of any type. It must not be scalar. It must not be a pointer that is disassociated or an allocatable array that is not allocated. If ARRAY is an assumed-size array, DIM must be present with a value less than the rank of ARRAY.
DIM (optional)	must be scalar and of type integer with a value in the range $1 \leq \text{DIM} \leq n$, where n is the rank of ARRAY.

Result Type, Type Parameter, and Shape. The result is of type default integer. It is scalar if DIM is present; otherwise, the result is an array of rank one and size n, where n is the rank of ARRAY.

Result Value.

Case (i): UBOUND (ARRAY, DIM) has a value equal to the upper bound for subscript DIM of ARRAY if dimension DIM of ARRAY does not have size zero and has the value zero if dimension DIM has size zero. For an array section or an array expression, its value is the number of elements in the corresponding dimension.

Case (ii): UBOUND (ARRAY) has a value whose ith component is equal to UBOUND (ARRAY, i), for $i = 1, 2, ..., n$, where n is the rank of ARRAY.

Example. If A is declared by the statement

```
REAL A (2:3, 7:10)
```

then UBOUND (A) is (/ 3, 10 /) and UBOUND (A, DIM=2) is 10.

13.13.112 UNPACK (VECTOR, MASK, FIELD).

Description. Unpack an array of rank one into an array under the control of a mask.

Class. Transformational function.

Arguments.

VECTOR	may be of any type. It must have rank one. Its size must be at least t where t is the number of true elements in MASK.
MASK	must be array valued and of type logical.
FIELD	must be of the same type and type parameters as VECTOR and must be conformable with MASK.

Result Type, Type Parameter, and Shape. The result is an array of the same type and type parameters as VECTOR and the same shape as MASK.

Result Value. The element of the result that corresponds to the ith true element of MASK, in array element order, has the value VECTOR (i) for $i = 1, 2, ..., t$, where t is the number of true values in MASK. Each other element has a value equal to FIELD if FIELD is scalar or to the corresponding element of FIELD if it is an array.

Example. Specific values may be "scattered" to specific positions in an array by using UNPACK. If M is the array $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$, V is the array (/ 1, 2, 3 /), and Q is the logical mask $\begin{bmatrix} . & T & . \\ T & . & . \\ . & . & T \end{bmatrix}$, where "T" represents true and "." represents false, then the result of UNPACK (V, MASK = Q, FIELD = M) has the value $\begin{bmatrix} 1 & 2 & 0 \\ 1 & 1 & 0 \\ 0 & 0 & 3 \end{bmatrix}$ and the result of UNPACK (V, MASK = Q, FIELD = 0) has the value $\begin{bmatrix} 0 & 2 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 3 \end{bmatrix}$.

13.13.113 VERIFY (STRING, SET, BACK).

Optional Argument. BACK

Description. Verify that a set of characters contains all the characters in a string.

Class. Elemental function.

Arguments.

STRING	must be of type character.
SET	must be of type character with the same kind type parameter as STRING.
BACK (optional)	must be of type logical.

Result Type and Type Parameter. Default integer.

Result Value.

Case (i): If BACK is absent or present with the value false and if STRING contains at least one character found in SET, the value of the result is the position of the leftmost character of STRING that is not in SET.

Case (ii): If BACK is present with the value true and if STRING contains at least one character found in SET, the value of the result is the position of the rightmost character of STRING that is not in SET.

Case (iii): The value of the result is zero if each character in STRING is in SET or if STRING has zero length.

Examples.

Case (i): VERIFY ('ABBA', 'A') has the value 2.

Case (ii): VERIFY ('ABBA', 'A', BACK = .TRUE.) has the value 3.

Case (iii): VERIFY ('ABBA', 'AB') has the value 0.

14. SCOPE, ASSOCIATION, AND DEFINITION

Entities are identified by lexical tokens within a **scope** that is an executable program, a scoping unit, a single statement, or part of a statement. If the scope is an executable program, the entity is called a **global entity**. If the scope is a scoping unit, the entity is called a **local entity**. If the scope is a statement or part of a statement, the entity is called a **statement entity**.

An entity may be identified by

(1) A name (14.1),

(2) A label (14.2),

(3) An external input/output unit number (14.3),

(4) An operator symbol (14.4), or

(5) An assignment symbol (14.5).

By means of association, an entity may be referred to by the same identifier or a different identifier in a different scoping unit, or by a different identifier in the same scoping unit.

A program unit consists of a set of nonoverlapping scoping units. A **scoping unit** is

(1) A derived-type definition (4.4.1),

(2) A procedure interface body, excluding any derived-type definitions and procedure interface bodies contained within it (12.3.2.1), or

(3) A program unit or subprogram, excluding derived-type definitions, procedure interface bodies, and subprograms contained within it.

A scoping unit that immediately surrounds another scoping unit is called the **host scoping unit**.

14.1 Scope of Names.

Named entities are global, local, or statement entities.

14.1.1 Global Entities.

Program units, common blocks, and external procedures are global entities of an executable program. A name that identifies a global entity must not be used to identify any other global entity in the same executable program.

14.1.2 Local Entities.

Within a scoping unit, entities in the following classes:

(1) Named variables that are not statement entities, named constants, named constructs, statement functions, internal procedures, module procedures, dummy procedures, intrinsic procedures, user-defined generic procedures, derived types, and namelist group names,

(2) Type components, in a separate class for each type, and

(3) Argument keywords, in a separate class for each procedure with an explicit interface

are local entities of that scoping unit.

A name that identifies a global entity in a scoping unit must not be used to identify a local entity of class (1) in that scoping unit, except for a common block name (14.1.2.1) or an external function name (14.1.2.2).

Within a scoping unit, a name that identifies a local entity of one class must not be used to identify another local entity of the same class, except in the case of generic procedures (14.1.2.3). A name that identifies a local entity of one class may be used to identify a local entity of another class.

An intrinsic procedure is inaccessible in a scoping unit containing another local entity of the same class and having the same name.

The name of a local entity identifies that entity in a scoping unit and may be used to identify any local or global entity in another scoping unit.

14.1.2.1 Common Blocks. A common block name in a scoping unit also may be the name of any local entity other than a named constant, intrinsic procedure, or a local variable that is also an external function in a function subprogram. If a name is used for both a common block and a local entity, the appearance of that name in any context other than as a common block name in a COMMON or SAVE statement identifies only the local entity. Note that an intrinsic procedure name may be a common block name in a scoping unit that does not reference the intrinsic procedure.

14.1.2.2 Function Results. If a FUNCTION statement or ENTRY statement in a function subprogram does not have a RESULT clause, there is a local variable, called the **result variable**, with the same name as the function being defined; otherwise, there is a local variable with the name specified in the RESULT clause.

14.1.2.3 Unambiguous Generic Procedure References. This subsection contains the rules that must be satisfied by every pair of specific procedures that have the same generic name, have the same generic operator, or both define assignment. They ensure that a generic reference is unambiguous. When an intrinsic procedure, operator, or assignment is extended, the rules apply as if the intrinsic consisted of a collection of specific procedures, one for each allowed combination of type, kind type parameter, and rank for each argument or operand. When a generic is accessed from a module, the rules apply to all the specific versions even if some of them are inaccessible by their specific names.

Two procedures that have the same name in a scoping unit must both have explicit interfaces, must both be subroutines, or both be functions, and at least one of them must have a nonoptional dummy argument that

(1) Corresponds by position in the argument list to a dummy argument not present in the other, present with a different type, present with a different kind type parameter, or present with a different rank when both are pointers or assumed-shape arrays; and

(2) Corresponds by argument keyword to a dummy argument not present in the other, present with a different type, present with a different kind type parameter, or present with a different rank when both are pointers or assumed-shape arrays.

For example, the procedures with interface bodies given by the interface block

```
INTERFACE A
   SUBROUTINE AR (X)
      REAL X
   END SUBROUTINE AR

   SUBROUTINE AI (J)
      INTEGER J
   END SUBROUTINE AI
END INTERFACE
```

satisfy rules (1) and (2). However, if J were declared REAL, rule (1) would not be satisfied while rule (2) remains satisfied; in this case, the reference to A in the statement

```
CALL A (0.0)
```

would be ambiguous.

Within a scoping unit, two procedures that have the same generic operator or both define assignment must have a dummy argument that corresponds by position in the argument list to a dummy argument of the other that has a different type, different kind type parameter, or different rank.

14.1.2.4 Components. A component name has the same scope as the type of which it is a component. It may appear only within a designator of a component of a structure of that type. If the type is accessible in another scoping unit by use association or host association (14.6.1.2) and the definition of the type does not contain the PRIVATE statement (4.4.1), the component name is accessible for names of components of structures of that type in that scoping unit.

14.1.2.5 Argument Keywords. A dummy argument name in an internal procedure, module procedure, or a procedure interface block has a scope as an argument keyword of the scoping unit of its host. As an argument keyword, it may appear only in a procedure reference for the procedure of which it is a dummy argument. If the procedure or procedure interface block is accessible in another scoping unit by use association or host association (14.6.1.2), the argument keyword is accessible for procedure references for that procedure in that scoping unit.

14.1.3 Statement Entities. The name of a variable that appears as a dummy argument in a statement function statement has a scope of the statement in which it appears. It has the type and type parameters that it would have if it were the name of a variable in the scoping unit that includes the statement function.

The name of a variable that appears as the DO variable of an implied-DO in a DATA statement or an array constructor has a scope of the implied-DO list. It has the type and type parameters that it would have if it were the name of a variable in the scoping unit that includes the DATA statement or array constructor and this type must be integer.

The name of a statement entity also may be the name of a global or local entity in the same scoping unit; in this case, the name is interpreted within the statement as that of the statement entity.

14.2 Scope of Labels. A label is a local entity. No two statements in the same scoping unit may have the same label.

14.3 Scope of External Input/Output Units. An external input/output unit is a global entity.

14.4 Scope of Operators. The intrinsic operators have a scope of an executable program. A defined operator has a scope of a scoping unit. Within a scoping unit, two operations may be identified by the same operator provided they have at least one corresponding operand with different type, different type parameters where neither is an asterisk, or different rank.

14.5 Scope of the Assignment Symbol. Intrinsic assignment has a scope of an executable program. A defined assignment has a scope of a scoping unit. Within a scoping unit, two assignments may be identified by the assignment symbol provided they have at least one corresponding operand with different type, different type parameters where neither is an asterisk, or different rank.

14.6 Association. Two entities may become associated by name association, pointer association, or storage association.

14.6.1 Name Association. There are three forms of **name association**: argument association, use association, and host association. Argument, use, and host association provide mechanisms by which entities known in one scoping unit may be accessed in another scoping unit.

14.6.1.1 Argument Association. The rules governing argument association are given in Section 12. As explained in 12.4, execution of a procedure reference establishes an association between an actual argument and its corresponding dummy argument. Argument association may be sequence association (12.4.1.4).

The name of the dummy argument may be different from the name, if any, of its associated actual argument. (Note that an actual argument may be a nameless data entity, such as an expression that is not simply a variable or constant.) The dummy argument name is the name by which the associated actual argument is known, and by which it may be accessed, in the referenced procedure.

Upon termination of execution of a procedure reference, all argument associations established by that reference are terminated. A dummy argument of that procedure may be associated with an entirely different actual argument in a subsequent execution of the procedure.

14.6.1.2 Use Association and Host Association. Use association is the association of names in different scoping units specified by a USE statement. The rules for use association are given in 11.3.2. They allow for the renaming of the entities being accessed.

The rules for host association are given in 11.2.2.

Use association or host association allows access in one scoping unit to entities defined in another scoping unit and remains in effect throughout the execution of the executable program.

Within a scoping unit, an entity accessed by use association or host association has the type and type parameters of the associated entity and must not appear in a type declaration statement. The accessibility attribute may be specified in a module, but all other attributes are those of the associated entity and must not be specified again. If the entity is renamed in a USE statement in a scoping unit, the original name is not associated with it in this scoping unit and may be used for other purposes. The new local name may be used in exactly the same way as the original name could have been used if there had been no renaming and no conflict with another local name.

Table 14.1 Summary Comparison of Use and Host Associations

Characteristic	Use Associations	Host Associations
Scope	Single scoping unit, plus using scoping units if in a module	Single scoping unit plus scoping units of internal or module subprograms
Duration	Entire program execution	Entire program execution
May change?	No	No
How established?	Appearance in USE statement	Internal or module subprogram or derived-type definition
How terminated?	Termination of execution of the executable program	Termination of execution of the executable program
Appearance in USE statement	Normal (only) way to establish	Not allowed
Allowed with unallocated parent	Yes	Yes
May appear in ALLOCATE statement	Yes	Yes
May appear in NULLIFY or DEALLOCATE statement	Yes	Yes

14.6.2 Pointer Association. Pointer association between a pointer and a target allows the target to be referenced or defined by a reference to the pointer. At different times during the execution of the program, a pointer may be associated with different targets or be disassociated.

The initial association status of a pointer is undefined. The association status of a pointer becomes defined as associated when the pointer is allocated (6.3.1) or pointer assigned to a target (7.5.2). The association status of a pointer becomes defined as disassociated when the pointer is nullified (6.3.2), pointer assigned to a disassociated pointer, or deallocated (6.3.3). Only the target of a previously allocated pointer may be deallocated.

The pointer association status of a pointer becomes undefined if the associated target is deallocated other than through the pointer or the target becoming undefined through execution of a RETURN

or END statement (item (4) of 14.7.6).

A pointer that is associated with a definable target may be defined or undefined according to the rules for a variable (14.7).

14.6.3 Storage Association. Storage sequences are used to describe relationships that exist among variables, common blocks, and function result variables. **Storage association** is the association of two or more data objects that occurs when two or more storage sequences share or are aligned with one or more storage units.

14.6.3.1 Storage Sequence. A **storage sequence** is a sequence of storage units. The **size of a storage sequence** is the number of storage units in the storage sequence. A **storage unit** is a character storage unit, a numeric storage unit, or an unspecified storage unit.

In a storage association context:

(1) A nonpointer scalar object of type default integer, default real, or default logical occupies a single **numeric storage unit**.

(2) A nonpointer scalar object of type double precision real or default complex occupies two contiguous numeric storage units.

(3) A nonpointer scalar object of type default character and character length one occupies one **character storage unit**.

(4) A nonpointer scalar object of type default character and character length *len* occupies *len* contiguous character storage units.

(5) A nonpointer scalar object of type nondefault integer, real other than default or double precision, nondefault logical, nondefault complex, nondefault character of any length, or nonsequence type occupies a single **unspecified storage unit** that is different for each case.

(6) A nonpointer array occupies a sequence of contiguous storage units, one for each array element, in array element order (6.2.2.2).

(7) A nonpointer scalar object of sequence type occupies a sequence of storage units corresponding to the sequence of its ultimate components.

(8) A pointer occupies a single unspecified storage unit that is different from that of any nonpointer object and is different for each combination of type, type parameters, and rank.

A sequence of storage sequences forms a storage sequence. The order of the storage units in such a composite storage sequence is that of the individual storage units in each of the constituent storage sequences taken in succession, ignoring any zero-sized constituent sequences.

Each common block has a storage sequence (5.5.2.1).

14.6.3.2 Association of Storage Sequences. Two nonzero-sized storage sequences s_1 and s_2 are **storage associated** if the ith storage unit of s_1 is the same as the jth storage unit of s_2. This causes the $(i+k)$th storage unit of s_1 to be the same as the $(j+k)$th storage unit of s_2, for each integer k such that $1 \le i+k \le$ *size of* s_1 and $1 \le j+k \le$ *size of* s_2.

Storage association also is defined between two zero-sized storage sequences, and between a zero-sized storage sequence and a storage unit. A zero-sized storage sequence in a sequence of storage sequences is storage associated with its successor, if any. If the successor is another zero-sized storage sequence, the two sequences are storage associated. If the successor is a nonzero-sized storage sequence, the zero-sized sequence is storage associated with the first storage unit of the successor. Two storage units that are each storage associated with the same zero-sized storage sequence are the same storage unit.

14.6.3.3 Association of Scalar Data Objects. Two scalar data objects are storage associated if their storage sequences are storage associated. Two scalar entities are **totally associated** if they have the same storage sequence. Two scalar entities are **partially associated** if they are storage associated without being totally associated.

The definition status and value of a data object affects the definition status and value of any storage associated entity. An EQUIVALENCE statement, a COMMON statement, an ENTRY statement, or a procedure reference may cause storage association of storage sequences.

An EQUIVALENCE statement causes storage association of data objects only within one scoping unit, unless one of the equivalenced entities is also in a common block (5.5.1.1 and 5.5.2.1).

COMMON statements cause data objects in one scoping unit to become storage associated with data objects in another scoping unit.

A named common block is permitted to contain a sequence of differing storage units provided each scoping unit that accesses the common block specifies an identical sequence of storage units. The same rule applies to blank common blocks. If the sizes of the two blank common blocks differ, the sequence of storage units of the shorter block must be identical to the initial sequence of the storage units of the longer block.

An ENTRY statement in a function also may cause association (12.5.2.5).

For character objects, partial association may exist only between two default character objects, two character sequence structures, or a default character object and a character sequence structure. Otherwise, partial association may exist only between an object of default complex, double precision real, or numeric sequence type and an object of default integer, default real, default logical, double precision real, default complex, or numeric sequence type.

Except for character entities, partial association may occur only through the use of COMMON, EQUIVALENCE, or ENTRY statements. Partial association must not occur through argument association, except for arguments of type default character.

In the example:

```
REAL A (4), B
COMPLEX C (2)
DOUBLE PRECISION D
EQUIVALENCE (C (2), A (2), B), (A, D)
```

the third storage unit of C, the second storage unit of A, the storage unit of B, and the second storage unit of D are specified as the same. The storage sequences may be illustrated as:

```
Storage unit        1      2      3      4      5
                 ----C(1)----|---C(2)----
                       A(1)   A(2)   A(3)   A(4)
                              --B--
                      ------D------
```

A (2) and B are totally associated. The following are partially associated: A (1) and C (1), A (2) and C (2), A (3) and C (2), B and C (2), A (1) and D, A (2) and D, B and D, C (1) and D, and C (2) and D. Note that although C (1) and C (2) are each storage associated with D, C (1) and C (2) are not storage associated with each other.

Partial association of character entities occurs when some, but not all, of the storage units of the entities are the same. In the example:

```
CHARACTER A*4, B*4, C*3
EQUIVALENCE (A (2:3), B, C)
```

A, B, and C are partially associated.

14.7 Definition and Undefinition of Variables. A variable may be defined or may be undefined and its definition status may change during execution of an executable program. An action that causes a variable to become undefined does not imply that the variable was previously defined. An action that causes a variable to become defined does not imply that the variable was previously undefined.

14.7.1 Definition of Objects and Subobjects. Arrays, including sections, and variables of derived, character, or complex type are objects that consist of zero or more subobjects. Associations may be established between variables and subobjects and between subobjects of different variables. These subobjects may become defined or undefined.

(1) An object is defined if and only if all of its subobjects are defined.

(2) If an object is undefined, at least one (but not necessarily all) of its subobjects are undefined.

14.7.2 Variables That Are Always Defined. Zero-sized arrays and zero-length strings are always defined.

14.7.3 Variables That Are Initially Defined. The following variables are initially defined:

(1) Variables specified to have initial values by DATA statements,

(2) Variables specified to have initial values by type declaration statements, and

(3) Variables that are always defined.

14.7.4 Variables That Are Initially Undefined. All other variables are initially undefined.

14.7.5 Events That Cause Variables to Become Defined. Variables become defined as follows:

(1) Execution of an intrinsic assignment statement other than a masked array assignment statement causes the variable that precedes the equals to become defined. Execution of a defined assignment statement may cause all or part of the variable that precedes the equals to become defined.

(2) Execution of a masked array assignment statement may cause some or all of the array elements in the assignment statement to become defined (7.5.3).

(3) As execution of an input statement proceeds, each variable that is assigned a value from the input file becomes defined at the time that data is transferred to it. (See (5) in 14.7.6.) Execution of a WRITE statement whose unit specifier identifies an internal file causes each record that is written to become defined.

(4) Execution of a DO statement causes the DO variable, if any, to become defined.

(5) Beginning of execution of the action specified by an implied-DO list in an input/output statement causes the implied-DO variable to become defined.

(6) Execution of an ASSIGN statement causes the variable in the statement to become defined with a statement label value.

(7) A reference to a procedure causes the entire dummy argument data object to become defined if the entire corresponding actual argument is defined with a value that is not a statement label.

A reference to a procedure causes a subobject of a dummy argument to become defined if the corresponding subobject of the corresponding actual argument is defined.

(8) Execution of an input/output statement containing an input/output IOSTAT= specifier causes the specified integer variable to become defined.

(9) Execution of a READ statement containing a SIZE= specifier causes the specified integer variable to become defined.

(10) Execution of an INQUIRE statement causes any variable that is assigned a value during the execution of the statement to become defined if no error condition exists.

(11) When a character storage unit becomes defined, all associated character storage units become defined.

When a numeric storage unit becomes defined, all associated numeric storage units of the same type become defined, except that variables associated with the variable in an ASSIGN statement become undefined when the ASSIGN statement is executed. When an entity of double precision real type becomes defined, all totally associated entities of double precision real type become defined.

When an unspecified storage unit becomes defined, all associated unspecified storage units become defined.

(12) When a default complex entity becomes defined, all partially associated default real entities become defined.

(13) When both parts of a default complex entity become defined as a result of partially associated default real or default complex entities becoming defined, the default complex entity becomes defined.

(14) When all components of a numeric sequence structure or character sequence structure become defined as a result of partially associated objects becoming defined, the structure becomes defined.

(15) Execution of an ALLOCATE or DEALLOCATE statement with a STAT= specifier causes the variable specified by the STAT= specifier to become defined.

(16) Allocation of a zero-sized array causes the array to become defined.

(17) Invocation of a procedure causes any automatic object of zero size in that procedure to become defined.

(18) Execution of a pointer assignment statement that associates a pointer with a target that is defined causes the pointer to become defined.

14.7.6 Events That Cause Variables to Become Undefined. Variables become undefined as follows:

(1) When a variable of a given type becomes defined, all associated variables of different type become undefined. However, when a variable of type default real is partially associated with a variable of type default complex, the complex variable does not become undefined when the real variable becomes defined and the real variable does not become undefined when the complex variable becomes defined. When a variable of type default complex is partially associated with another variable of type default complex, definition of one does not cause the other to become undefined.

(2) Execution of an ASSIGN statement causes the variable in the statement to become undefined as an integer. Variables that are associated with the variable also become undefined.

(3) If the evaluation of a function may cause an argument of the function or a variable in a module or in a common block to become defined and if a reference to the function appears in an expression in which the value of the function is not needed to determine the value of the expression, the argument or variable becomes undefined when the expression is evaluated.

(4) The execution of a RETURN statement or an END statement within a subprogram causes all variables local to its scoping unit or local to the current instance of its scoping unit for a recursive invocation to become undefined except for the following:

(a) Variables with the SAVE attribute.

(b) Variables in blank common.

(c) Variables in a named common block that appears in the subprogram and appears in at least one other scoping unit that is making either a direct or indirect reference to the subprogram.

(d) Variables accessed from the host scoping unit.

(e) Variables accessed from a module that also is accessed in at least one other scoping unit that is making either a direct or indirect reference to the module.

(f) Variables in a named common block that are initially defined (14.7.3) and that have not been subsequently defined or redefined.

(5) When an error condition or end-of-file condition occurs during execution of an input statement, all of the variables specified by the input list or *namelist-group* of the statement become undefined.

(6) When an error or end-of-file condition occurs during execution of an input/output statement, some or all of the implied-DO variables may become undefined (9.4.3).

(7) Execution of a defined assignment statement may leave all or part of the variable that precedes the equals undefined.

(8) Execution of a direct access input statement that specifies a record that has not been written previously causes all of the variables specified by the input list of the statement to become undefined.

(9) Execution of an INQUIRE statement may cause the NAME=, RECL=, and NEXTREC= variables to become undefined (9.6).

(10) When a character storage unit becomes undefined, all associated character storage units become undefined.

When a numeric storage unit becomes undefined, all associated numeric storage units become undefined unless the undefinition is a result of defining an associated numeric storage unit of different type (see (1) above).

When an entity of double precision real type becomes undefined, all totally associated entities of double precision real type become undefined.

When an unspecified storage unit becomes undefined, all associated unspecified storage units become undefined.

(11) A reference to a procedure causes part of a dummy argument to become undefined if the corresponding part of the actual argument is defined with a value that is a statement label value.

(12) When an allocatable array is deallocated, it becomes undefined. Successful execution of an ALLOCATE statement causes the allocated array to become undefined.

(13) Execution of an INQUIRE statement causes all inquiry specifier variables to become undefined if an error condition exists, except for the variable in the IOSTAT= specifier, if any.

(14) When a procedure is invoked:

(a) An optional dummy argument that is not associated with an actual argument is undefined.

(b) A dummy argument with INTENT (OUT) is undefined.

(c) An actual argument associated with a dummy argument with INTENT (OUT) becomes undefined.

(d) A subobject of a dummy argument is undefined if the corresponding subobject of the actual argument is undefined.

(e) The result variable of a function is undefined.

(15) When the association status of a pointer becomes undefined or disassociated (6.3), the pointer becomes undefined.

14.8 Allocation Status. The allocation status of an allocatable array is one of the following at any time during the execution of an executable program:

(1) Not currently allocated, which means that the array has never been allocated or that the last operation on it was a deallocation.

(2) Currently allocated, which means that the array has been allocated by an ALLOCATE statement and has not been subsequently deallocated.

(3) Undefined, which means that the array does not have the SAVE attribute and was currently allocated when execution of a RETURN or END statement resulted in no executing scoping units having access to it.

If the allocation status of an allocatable array is currently allocated, the array may be referenced and defined. An allocatable array that is not currently allocated must not be referenced or defined. If the allocation status of an allocatable array is undefined, the array must not be referenced, defined, allocated, or deallocated.

APPENDIX A. GLOSSARY OF TECHNICAL TERMS

The following is a list of the principal technical terms used in the standard and their definitions. A reference in parentheses immediately after a term is to the section where the term is defined or explained. The wording of a definition here is not necessarily the same as in the standard. Where the definition uses a term that is itself defined in this glossary, the first occurrence of the term is printed in italics.

action statement. A single *statement* specifying a computational action (R216).

actual argument (12.4.1). An *expression*, a *variable*, a *procedure*, or an alternate return specifier that is specified in a procedure *reference*.

allocatable array (5.1.2.4.3). A *named array* whose *type*, *type parameters*, and *rank* are specified in a *type declaration statement* containing an ALLOCATABLE *attribute*. Only when it has space allocated for it does it have a *shape* and may it be *referenced* or *defined*.

argument (12). An *actual argument* or a *dummy argument*.

argument association (14.6.1.1). The relationship between an *actual argument* and a *dummy argument* during the execution of a *procedure reference*.

argument keyword (2.5.2). A *dummy argument name*. It may be used in a *procedure reference* ahead of the equals symbol (R1211) provided the procedure has an *explicit interface*.

array (2.4.7). A set of scalar data, all of the same *type* and *type parameters*, whose individual elements are arranged in a rectangular pattern. It may be a *named* array, the *target* of an *array pointer*, an *array section*, a *structure component*, a *function* value, or an *expression*. Its *rank* is at least one. Note that in FORTRAN 77, arrays were always named and always variables.

array element (2.4.7, 6.2.2.1). One of the *scalar data* that make up an *array*.

array pointer (5.1.2.4.3). A *pointer* to an *array*.

array section (6.2.2.3). A *subobject* of an *array* consisting of a set of *array elements* or *substrings* of array elements. The set is specified by *subscripts*, *subscript triplets*, and *vector subscripts*.

array-valued. Having the property of being an *array*.

assignment statement (7.5.1.1). A *statement* of the form '*variable* = *expression*'.

association (14.6). *Name association*, *pointer association*, or *storage association*.

assumed-size array (5.1.2.4.4). A *dummy array* whose *size* is assumed from the associated *actual argument*. Its last upper bound is specified by an asterisk.

attribute (5). A property of a *data object* that may be specified in a *type declaration statement* (R501).

automatic data object (5.1). A *data object* that is a *local entity* of a *subprogram*, that is not a *dummy argument*, and that has a nonconstant character length or array bound.

belong (8.1.4.4.3, 8.1.4.4.4). If an EXIT or a CYCLE *statement* contains a *construct name*, the statement **belongs** to the DO construct using that name. Otherwise, it **belongs** to the innermost DO construct in which it appears.

block (8.1). A sequence of *executable constructs* embedded in another executable construct, bounded by *statements* that are particular to the construct, and treated as an integral unit.

block data program unit (11.4). A *program unit* that provides initial values for *data objects* in *named common blocks*.

bounds (5.1.2.4.1). For a *named array*, the limits within which the values of the *subscripts* of its *array elements* must lie.

character. A letter, digit, or other symbol.

characteristics (12.2)

(1) Of a *procedure*, its classification as a *function* or *subroutine*, the characteristics of its *dummy arguments*, and the characteristics of its *function result* if it is a function.

(2) Of a *dummy argument*, whether it is a *data object*, is a *procedure*, or has the OPTIONAL *attribute*.

(3) Of a *data object*, its *type*, *type parameters*, *shape*, the exact dependence of an array bound or the character length on other entities, *intent*, whether it is optional, whether it is a *pointer* or a *target*, and whether the shape, *size*, or *character length* is assumed.

(4) Of a *dummy procedure*, whether the interface is explicit, the characteristics of the procedure if the interface is explicit, and whether it is optional.

(5) Of a *function result*, its type, type parameters, whether it is a pointer, rank if it is a pointer, shape if it is not a pointer, the exact dependence of an array bound or the character length on other entities, and whether the character length is assumed.

character string (4.3.2.1). A sequence of *characters* numbered from left to right 1, 2, 3, . . .

character storage unit (14.6.3.1). The unit of storage for holding a *datum* of *type* character.

collating sequence. An ordering of all the different *characters* of a particular *kind type parameter*.

common block (5.5.2). A block of physical storage that may be accessed by any of the *scoping units* in an *executable program*.

component (4.4). A constituent of a *derived type*.

conformable (2.4.7). Two *arrays* are said to be **conformable** if they have the same *shape*. A *scalar* is **conformable** with any array.

conformance (1.4). An *executable program* conforms to the standard if it uses only those forms and relationships described therein and if the executable program has an interpretation according to the standard. A *program unit* conforms to the standard if it can be included in an executable program in a manner that allows the executable program to be standard conforming. A *processor* conforms to the standard if it executes standard-conforming programs in a manner that fulfills the interpretations prescribed in the standard.

connected (9.3.2).

(1) For an *external unit*, the property of referring to an *external file*.

(2) For an *external file*, the property of having an *external unit* that refers to it.

constant (2.4.4). A *data object* whose value must not change during execution of an *executable program*. It may be a *named constant* or a *literal constant*. Note that in FORTRAN 77, constants were always literal constants.

constant expression (7.1.6.1). An *expression* satisfying rules that ensure that its value does not vary during program execution.

construct (8). A sequence of *statements* starting with a CASE, DO, IF, or WHERE statement and ending with the corresponding terminal statement.

data. Plural of *datum*.

data entity (2.4.3, 4.2). An *entity* that has or may have a data value. It may be a *constant*, a *variable*, an *expression*, or a *function result*.

data object (2.4.3.1). A *datum* of *intrinsic* or *derived type* or an *array* of such *data*. It may be *named*, it may be a *subobject*, or it may be a *literal constant*.

data type (2.4.1). A *named* category of *data* that is characterized by a set of values, together with a way to denote these values and a collection of *operations* that interpret and manipulate the values. For an *intrinsic* type, the set of data values depends on the values of the *type parameters*.

datum. A single quantity that may have any of the set of values specified for its *data type*.

definable (2.5.4). A *variable* is **definable** if its value may be changed by the appearance of its *name* or *designator* on the left of an *assignment statement*. An *allocatable array* that has not been allocated is an example of a *data object* that is not definable. An example of a *subobject* that is not definable is C

(I) when C is an *array* that is a *constant* and I is an integer variable.

defined (2.5.4). For a *data object*, the property of having or being given a valid value.

defined assignment statement (7.5.1.3). An *assignment statement* that is not an *intrinsic* assignment statement and is defined by a *subroutine* that is associated with a *generic identifier*.

defined operation (7.1.3). An *operation* that is not an *intrinsic* operation and is defined by a *function* that is associated with a *generic identifier*.

deleted feature (1.6). A feature in FORTRAN 77 that is considered to have been redundant and largely unused. No features in FORTRAN 77 have been deleted from the standard. Note that a feature designated as an *obsolescent feature* in the standard may become a deleted feature in the next revision.

derived type (2.4.1.2, 4.4). A *type* whose *data* have *components*, each of which is either of intrinsic type or of another derived type.

designator. See *subobject designator*.

disassociated (2.4.8). A *pointer* is **disassociated** following execution of a DEALLOCATE or NULLIFY *statement*.

dummy argument (12.5.2.2, 12.5.2.3, 12.5.2.5, 12.5.4). An entity whose *name* appears in the parenthesized list following the *procedure* name in a FUNCTION *statement*, a SUBROUTINE *statement*, an ENTRY statement, or a *statement function* statement.

dummy array. A *dummy argument* that is an *array*.

dummy pointer. A *dummy argument* that is a *pointer*.

dummy procedure (12.1.2.3). A *dummy argument* that is specified or *referenced* as a *procedure*.

elemental (12.4.3, 12.4.5). An adjective applied to an *intrinsic operation*, *procedure*, or *assignment statement* that is applied independently to elements of an *array* or corresponding elements of a set of *conformable* arrays and *scalars*.

entity. The term used for any of the following: a *program unit*, a *procedure*, an *operator*, an *interface block*, a *common block*, an *external unit*, a *statement function*, a *type*, a *named variable*, an *expression*, a *component* of a *structure*, a *named constant*, a *statement label*, a *construct*, or a namelist group.

executable construct (2.1). A CASE, DO, IF, or WHERE *construct* or an *action statement* (R216).

executable program (2.2.2). A set of *program units* that includes exactly one *main program*.

executable statement (2.3.1). An instruction to perform or control one or more computational actions.

explicit interface (12.3.1). For a *procedure referenced* in a *scoping unit*, the property of being an *internal procedure*, a *module procedure*, an *intrinsic procedure*, an *external procedure* that has an *interface block*, or a *dummy procedure* that has an interface block.

explicit-shape array (5.1.2.4.1). A *named array* that is declared with explicit *bounds*.

expression (7.1). A sequence of *operands*, *operators*, and parentheses (R723). It may be a *variable*, a *constant*, a *function reference*, or may represent a computation.

extent (2.4.7). The size of one dimension of an *array*.

external file (9.2.1). A sequence of *records* that exists in a medium external to the *executable program*.

external procedure (2.2.4.1). A *procedure* that is defined by an *external subprogram* or by a means other than Fortran.

external subprogram (2.2). A *subprogram* that is not contained in a *main program*, *module*, or another subprogram. Note that a module is not called a subprogram. Note that in FORTRAN 77, a *block data program unit* is called a subprogram.

external unit (9.3). A mechanism that is used to refer to an *external file*. It is identified by a non-negative integer.

file (9.2). An *internal file* or an *external file*.

function (2.2.4). A *procedure* that is invoked in an *expression*.

function result (12.5.2.2). The *data object* that returns the value of a *function*.

function subprogram (12.5.2.2). A sequence of *statements* beginning with a FUNCTION statement that is not in an *interface block* and ending with the corresponding END statement.

generic identifier. A *lexical token* that appears in an INTERFACE *statement* and is associated with all the *procedures* in the *interface block*.

global entity (14.1.1). An *entity* identified by a *lexical token* whose *scope* is an *executable program*. It may be a *program unit*, a *common block*, or an *external procedure*.

host (2.2.4.3). A *main program* or *subprogram* that contains an *internal procedure* is called the **host** of the internal procedure. A *module* that contains a *module procedure* is called the **host** of the module procedure.

host association (11.2.2). The process by which an *internal subprogram, module subprogram,* or *derived type* definition accesses *entities* of its *host*.

implicit interface (12.3.1). A *procedure referenced* in a *scoping unit* is said to have an **implicit interface** if the procedure is an *external procedure* that does not have an *interface block*, a *dummy procedure* that does not have an interface block, or a *statement function*.

inquiry function. An *intrinsic function* whose result depends on properties of the principal *argument* other than the value of the argument.

intent (12.5.2.1). An attribute of a *dummy argument* that is neither a *procedure* nor a *pointer*, which indicates whether it is used to transfer data into the procedure, out of the procedure, or both.

instance of a subprogram (12.5.2.4). The copy of a *subprogram* that is created when a *procedure* defined by the subprogram is *invoked*.

interface block (12.3.2.1). A sequence of *statements* from an INTERFACE statement to the corresponding END INTERFACE statement.

interface body (12.3.2.1). A sequence of *statements* in an *interface block* from a FUNCTION or SUBROUTINE statement to the corresponding END statement.

interface of a procedure (12.3). See *procedure interface*.

internal file (9.2.2). A character *variable* that is used to transfer and convert *data* from internal storage to internal storage.

internal procedure (2.2.4.3). A *procedure* that is defined by an *internal subprogram*.

internal subprogram (2.2). A *subprogram* contained in a *main program* or another subprogram.

intrinsic (2.5.7). An adjective applied to *types, operations, assignment statements,* and *procedures* that are defined in the standard and may be used in any *scoping unit* without further definition or specification.

invoke (2.2.4).

(1) To call a *subroutine* by a CALL *statement* or by a *defined assignment statement*.

(2) To call a *function* by a *reference* to it by *name* or *operator* during the evaluation of an *expression*.

keyword (2.5.2). *Statement keyword* or *argument keyword*.

kind type parameter. A parameter whose values label the available kinds of an *intrinsic type*.

label. See *statement label*.

length of a character string (4.3.2.1). The number of *characters* in the *character string*.

lexical token (3.2). A sequence of one or more characters with an indivisible interpretation.

line. A source-form *record* containing from 0 to 132 *characters*.

literal constant (2.4.4). A *constant* without a *name*.

local entity (14.1.2). An *entity* identified by a *lexical token* whose *scope* is a *scoping unit*.

main program (2.2.3, 11.1). A *program unit* that is not a *module*, *subprogram*, or *block data program unit*.

many-one array section (6.2.2.3.2). An *array section* with a *vector subscript* having two or more elements with the same value.

module (2.2.5, 11.3). A *program unit* that contains or accesses definitions to be accessed by other program units.

module procedure (2.2.4.2). A *procedure* that is defined by a *module subprogram*.

module subprogram (2.2). A *subprogram* that is contained in a *module* but is not an *internal subprogram*.

name (3.2.2). A *lexical token* consisting of a letter followed by up to 30 alphanumeric characters (letters, digits, and underscores). Note that in FORTRAN 77, this was called a symbolic name.

name association (14.6.1). *Argument association*, *use association*, or *host association*.

named. Having a *name*.

named constant (2.4.4). A *constant* that has a *name*. Note that in FORTRAN 77, this was called a symbolic constant.

numeric storage unit (2.4.9). The unit of storage for holding a *datum* of *type* default real, default integer, or default logical.

numeric type. Integer, real or complex *type*.

object (2.4.3.1). *Data object*.

obsolescent feature (1.6). A feature in FORTRAN 77 that is considered to have been redundant but that is still in frequent use.

operand (2.5.8). An *expression* that precedes or succeeds an *operator*.

operation (7.1.2). A computation involving one or two *operands*.

operator (2.5.8). A *lexical token* that specifies an *operation*.

pointer (2.4.8). A *named data object* whose *type*, *type parameters*, and *rank* are specified in a *type declaration statement* containing the POINTER attribute. A pointer must not be *referenced* or *defined* unless it is *pointer associated* with a *target*. If it is an *array*, it does not have a *shape* unless it is *pointer associated*.

pointer assignment (7.5.2). The *pointer association* of a *pointer* with a *target* by the execution of a *pointer assignment statement* or the execution of an *assignment statement* for a *data object* of *derived type* having the pointer as a *subobject*.

pointer assignment statement (7.5.2). A *statement* of the form *pointer-name* => *target*.

pointer associated (6.3, 7.5.2). The relationship between a *pointer* and a *target* following a *pointer assignment* or a valid execution of an ALLOCATE *statement*.

pointer association (14.6.2). The process by which a *pointer* becomes *pointer associated* with a *target*.

present (12.5.2.8). A *dummy argument* is **present** in an *instance of a subprogram* if it is *associated* with an *actual argument* and the actual argument is a dummy argument that is present in the invoking *procedure* or is not a dummy argument of the invoking procedure.

procedure (2.2.4, 12.1). A computation that may be *invoked* during program execution. It may be a *function* or a *subroutine*. It may be an *intrinsic* procedure, an *external procedure*, a *module procedure*, an *internal procedure*, a *dummy procedure*, or a *statement function*. A *subprogram* may define more than one procedure if it contains ENTRY *statements*.

procedure interface (12.3). The *characteristics* of a *procedure*, the *name* of the procedure, the name of each *dummy argument*, and the *generic identifiers* (if any) by which it may be *referenced*.

processor (1.2). The combination of a computing system and the mechanism by which *executable programs* are transformed for use on that computing system.

program. See *executable program* and *main program*.

program unit (2.2). The fundamental component of an *executable program*. A sequence of *statements* and comment lines. It may be a *main program*, a *module*, an *external subprogram*, or a *block data program unit*.

rank (2.4.7). The number of dimensions of an *array*. Zero for a *scalar*.

record (9.1). A sequence of values that is treated as a whole within a *file*.

reference (2.5.5). The appearance of a *data object name* or *subobject designator* in a context requiring the value at that point during execution, or the appearance of a *procedure* name, its *operator* symbol, or a *defined assignment statement* in a context requiring execution of the procedure at that point. Note that neither the act of defining a *variable* nor the appearance of the name of a procedure as an *actual argument* is regarded as a reference.

scalar (2.4.6).

(1) A single *datum* that is not an *array*.

(2) Not having the property of being an *array*.

scope (14). That part of an *executable program* within which a *lexical token* has a single interpretation. It may be an *executable program*, a *scoping unit*, a single *statement*, or a part of a statement.

scoping unit (2.2.1). One of the following:

(1) A *derived type* definition,

(2) An *interface body*, excluding any interface bodies contained within it, or

(3) A *program unit* or *subprogram*, excluding derived type definitions, interface bodies, and subprograms contained within it.

section subscript (6.2.2). A *subscript*, *vector subscript*, or *subscript triplet* in an *array section selector*.

selector. A syntactic mechanism for designating

(1) Part of a *data object*. It may designate a *substring*, an *array element*, an *array section*, or a *structure component*.

(2) The set of values for which a CASE *block* is executed.

shape (2.4.7). For an *array*, the *rank* and *extents*. The shape may be represented by the rank-one array whose elements are the extents in each dimension.

size (2.4.7). For an *array*, the total number of elements.

standard module (1.7). A *module* standardized as a separate collateral standard.

statement (3.3). A sequence of *lexical tokens*. It usually consists of a single line, but the ampersand symbol may be used to continue a statement from one line to another and the semicolon symbol may be used to separate statements within a line.

statement entity (14). An *entity* identified by a *lexical token* whose *scope* is a single *statement* or part of a statement.

statement function (12.5.4). A *procedure* specified by a single *statement* that is similar in form to an *assignment statement*.

statement keyword (2.5.2). A word that is part of the syntax of a *statement* and that may be used to identify the statement.

statement label (3.2.5). A *lexical token* consisting of up to five digits that precedes a *statement* and may be used to refer to the statement.

storage association (14.6.3). The relationship between two *storage sequences* if a storage unit of one is the same as a storage unit of the other.

storage sequence (14.6.3.1). A sequence of contiguous *storage units*.

storage unit (14.6.3.1, 2.4.9). A *character storage unit* or a *numeric storage unit*.

stride (6.2.2.3.1). The increment specified in a *subscript triplet*.

structure (2.4.1.2). A *scalar data object* of *derived type*.

structure component (6.1.2). The part of a *structure* corresponding to a *component* of its *type*.

subobject (2.4.3.2). A portion of a *named data object* that may be *referenced* or *defined* independently of other portions. It may be an *array element*, an *array section*, a *structure component*, or a *substring*.

subobject designator (2.5.1). A *name*, followed by one of more of the following: *component selectors*, *array section* selectors, *array element selectors*, *and substring selectors*.

subprogram (2.2). A *function subprogram* or a *subroutine subprogram*. Note that in FORTRAN 77, a *block data program unit* was called a subprogram.

subroutine (2.2.4). A *procedure* that is *invoked* by a CALL *statement* or by a *defined assignment statement*.

subroutine subprogram (12.5.2.3). A sequence of *statements* beginning with a SUBROUTINE statement that is not in an *interface block* and ending with the corresponding END statement.

subscript (6.2.2). One of the list of *scalar* integer *expressions* in an *array element selector*. Note that in FORTRAN 77, the whole list was called the subscript.

subscript triplet (6.2.2). An item in the list of an *array section selector* that contains a colon and specifies a regular sequence of integer values.

substring (6.1.1). A contiguous portion of a *scalar character string*. Note that an *array section* can include a *substring selector*; the result is called an array section and not a substring.

target (5.1.2.8). A *named data object* specified in a *type declaration statement* containing the TARGET *attribute*, a data object created by an ALLOCATE statement for a pointer, or a *subobject* of such an object.

transformational function. An *intrinsic function* that is neither an *elemental* function nor an *inquiry function*. It usually has *array arguments* and an array result whose elements have values that depend on the values of many of the elements of the arguments.

type (4). *Data type*.

type declaration statement (5). An INTEGER, REAL, DOUBLE PRECISION, COMPLEX, CHARACTER, LOGICAL, or TYPE (*type-name*) *statement*.

type parameter (2.4.1.1). A parameter of an *intrinsic data type*. KIND= and LEN= are the type parameters.

type parameter values (4.3). The values of the *type parameters* of a *data entity* of an *intrinsic data type*.

undefined (2.5.4). For a *data object*, the property of not having a determinate value.

use association (14.6.1.2). The association of *names* in different *scoping units* specified by a USE *statement*.

variable (2.4.5). A *data object* whose value can be *defined* and redefined during the execution of an *executable program*. It may be a *named* data object, an *array element*, an *array section*, a *structure*

1 *component*, or a *substring*. Note that in FORTRAN 77, a variable was always *scalar* and named.

2 **vector subscript** (6.2.2.3.2). A *section subscript* that is an integer *expression* of *rank* one.

3 **whole array** (6.2.1). A *named array*.

APPENDIX B. DECREMENTAL FEATURES

B.1 Deleted Features. The deleted features are those features of FORTRAN 77 that are redundant and considered largely unused. Section 1.6.1 describes the nature of the deleted features. The list of deleted features in this standard is empty.

B.2 Obsolescent Features. The obsolescent features are those features of FORTRAN 77 that are redundant and for which better methods are available in FORTRAN 77. Section 1.6.2 describes the nature of obsolescent features. The obsolescent features are:

(1) Arithmetic IF — use the IF statement (8.1.2.4) or IF construct (8.1.2)

(2) Real and double precision DO control variables and DO loop control expressions — use integer (8.1.4.1)

(3) Shared DO termination and termination on a statement other than END DO or CONTINUE — use an END DO or a CONTINUE statement for each DO statement

(4) Branching to an END IF statement from outside its IF block — branch to the statement following the END IF

(5) Alternate return — see B.2.1

(6) PAUSE statement — see B.2.2

(7) ASSIGN and assigned GO TO statements — see B.2.3

(8) Assigned FORMAT specifiers — see B.2.4

B.2.1 Alternate Return. An alternate return introduces labels into an argument list to allow the called procedure to direct the execution of the caller upon return. The same effect can be achieved with a return code that is used in a computed GO TO statement or CASE construct on return. This avoids an irregularity in the syntax and semantics of argument association. For example,

```
CALL SUBR_NAME (X, Y, Z, *100, *200, *300)
```

may be replaced by

```
CALL SUBR_NAME (X, Y, Z, RETURN_CODE)
SELECT CASE (RETURN_CODE)
   CASE (1)
      ...
   CASE (2)
      ...
   CASE (3)
      ...
   CASE DEFAULT
      ...
END SELECT
```

B.2.2 PAUSE Statement. Execution of a PAUSE statement requires operator or system-specific intervention to resume execution. In most cases, the same functionality can be achieved as effectively and in a more portable way with the use of an appropriate READ statement that awaits some input data.

B.2.3 ASSIGN and Assigned GO TO Statements. The ASSIGN statement allows a label to be dynamically assigned to an integer variable, and the assigned GO TO statement allows "indirect branching" through this variable. This hinders the readability of the program flow, especially if the integer variable also is used in arithmetic operations. The two totally different usages of the integer variable can be an obscure source of error.

These statements have commonly been used to simulate internal procedures, which now can be coded directly.

B.2.4 Assigned FORMAT Specifiers. The ASSIGN statement also allows the label of a FORMAT statement to be dynamically assigned to an integer variable, which can later be used as a format specifier in READ, WRITE, or PRINT statements. This hinders readability, permits inconsistent usage of the integer variable, and can be an obscure source of error.

This functionality is available via character variables, arrays, and constants.

APPENDIX C. SECTION NOTES

C.1 Section 1 Notes.

C.1.1 Conformance (1.4). The standard requires a standard-conforming processor to be capable of detecting and reporting the use within a program unit of forms designated as deleted or obsolescent and of additional forms or relationships, where such use can be detected by reference to the numbered syntax rules and their associated constraints. It is recommended that the processor be accompanied by documentation that specifies the limits it imposes on the size and complexity of a program and the means of reporting when these limits are exceeded, that defines the additional forms and relationships it allows, and that defines the means of reporting the use of additional forms and relationships and the use of deleted or obsolescent forms. Note that in this context, the use of a deleted form is the use of an additional form.

It is recommended that the processor be accompanied by documentation that specifies the methods or semantics or processor-dependent facilities.

C.2 Section 2 Notes.

C.2.1 Keywords. Argument keywords can make procedure references more readable and allow actual arguments to be in any order. This latter property permits optional arguments. (2.5.2)

C.3 Section 3 Notes.

C.3.1 Representable Characters (3.1.6). FORTRAN 77 allowed any character to occur in a character context. This standard provides a new feature to allow source programs to contain characters of more than one kind (4.3.2.1). Characters of different kinds are often identified by control characters (called "escape" or "shift" characters). It is difficult, if not impossible, for example, to process, edit, or print files where control characters may not have their intended meaning (as in FORTRAN 77) and where other occurrences may have a control meaning. To provide compatibility with FORTRAN 77 and to allow this standard to meet portability goals, the following approach is incorporated:

(1) In fixed source form, the definition of *rep-char* is not changed.

(2) A processor may restrict the set of allowed control characters when a program contains characters of different kinds.

(3) Control characters are not allowed in character contexts in free source form.

C.3.2 Comment Lines (3.3.1.1, 3.3.2.1). The standard does not restrict the number of consecutive comment lines. The limit on the number of continuation lines permitted for a statement should not be construed as being a limitation on the number of consecutive comment lines.

C.3.3 Statement Labels (3.2.5). There are 99999 unique statement labels and a processor must accept 99999 as a statement label. However, a processor may have an implementation limit on the total number of unique statement labels in one program unit.

C.3.4 Source Form (3.3). In fixed source form, an exclamation point (!) in character position 6 is interpreted as a continuation indicator unless it appears within commentary indicated by a "C" or "*" in character position 1 or by another "!" in character positions 1–5. (3.3.2.3)

The source form of FORTRAN 77, FORTRAN 66, and the initial Fortran in 1954 was predicated on a common form of input, the 80-column card. However, on the IBM 704, only 72 columns could be used and the remaining eight columns were designated as commentary. In some implementations of FORTRAN 77, these columns are so used. They contain "line numbers" and are used by an editor to manage changes to a program. (3.3.2)

The Fortran standards subcommittee believes that 66 positions are inadequate to represent readable Fortran source code, particularly with "long" names and the use of indentation. Consequently, in the new source form, this standard relaxes the FORTRAN 77 restriction on source line size.

Given the need for an incompatible new source form in Fortran, additional restrictions of the rigid card form are relaxed. Positions six and seven are no longer "special" and the continuation mark is on the line being continued rather than on the continuation line. Blank characters are generally significant in the new source form, but other features of the new form apply to either form, and are allowed in either. (3.3.1)

The rule allowing optional blanks at specific places in some keywords (for example, ENDIF or END IF) is intended to permit a reasonable choice to users accustomed to insignificant blanks.

C.4 Section 4 Notes.

C.4.1 Zero (4.3.1). A processor must not consider a negative zero to be different from a positive zero.

C.4.2 Characters (4.2). Free source form allows only graphic characters as representable characters. Almost all control characters have uses or effects that effectively preclude their use in character literals. Nevertheless, for compatibility with FORTRAN 77, control characters remain permitted in principle in fixed source form.

C.4.3 Intrinsic and Derived Data Types (4.3, 4.4). FORTRAN 77 provided only data types explicitly defined in the standard (logical, integer, real, double precision, complex, and character). This standard provides those intrinsic types and provides derived types to allow the creation of new data types. A derived-type definition specifies a data structure consisting of components of intrinsic types and of derived types. Such a type definition does not represent a data object, but rather, a template for declaring named objects of that derived type. For example, the definition

```
TYPE POINT
   INTEGER X_COORD
   INTEGER Y_COORD
END TYPE POINT
```

specifies a new derived type named POINT which is composed of two components of intrinsic type integer (X_COORD and Y_COORD). The statement TYPE (POINT) FIRST, LAST declares two data objects, FIRST and LAST, that can hold values of type POINT.

FORTRAN 77 provided REAL and DOUBLE PRECISION intrinsic types as approximations to mathematical real numbers. This standard generalizes REAL as an intrinsic type with a type parameter that selects the approximation method. The type parameter is named KIND and has values that are processor dependent. DOUBLE PRECISION is treated as a synonym for REAL (*k*), where *k* is the implementation-defined kind type parameter value KIND (0.0D0).

Real literal constants may be specified with a kind type parameter to ensure that they have a particular kind type parameter value (4.3.1.2).

For example, with the specifications

```
INTEGER Q
PARAMETER (Q = 8)
REAL (Q) B
```

the literal constant 10.93_Q has the same precision as the variable B.

X3.9-1978 did not allow zero-length character strings. They are permitted by this standard (4.3.2.1).

Objects are of different derived type if they are declared using different derived-type definitions. For example,

```
TYPE APPLES
   INTEGER NUMBER
END TYPE APPLES
TYPE ORANGES
   INTEGER NUMBER
END TYPE ORANGES
TYPE (APPLES) COUNT1
TYPE (ORANGES) COUNT2
COUNT1 = COUNT2 ! Erroneous statement mixing apples and oranges
```

Even though all components of objects of type APPLES and objects of type ORANGES have identical intrinsic types, the objects are of different types.

C.4.4 Selection of the Approximation Methods. This standard permits the selection of the real approximation method for an entire program to be parameterized through the use of the parameterized real data type and module. This is accomplished by defining a named integer constant, say FLOAT, to have a specific kind type parameter value, and to use that named constant in all real, complex, and derived-type declarations. For example, the specification statements

```
INTEGER FLOAT
PARAMETER (FLOAT = 8)
REAL (FLOAT) X, Y
COMPLEX (FLOAT) Z
```

specify that the approximation method corresponding to a kind type parameter value of 8 is supplied for the data objects X, Y, and Z in the program unit. The kind type parameter value FLOAT can be made available to an entire program by placing the INTEGER and PARAMETER specification statements in a module and accessing the named constant FLOAT with a USE statement. Note that by changing 8 to 4 once in the module, a different approximation method is selected.

To avoid the use of the processor-dependent values 4 or 8, replace 8 by KIND (0.0) or KIND (0.0D0). Another way to avoid these processor-dependent values is to select the kind value using the intrinsic inquiry function SELECTED_REAL_KIND. This function, given integer arguments P and R specifying minimum requirements for decimal precision and decimal exponent range, respectively, returns the kind type parameter value of the approximation method that has at least P decimal digits of precision and at least a range for positive numbers of 10^{-R} to 10^{R}. In the above specification statement, the 8 may be replaced by, for instance, SELECTED_REAL_KIND (10, 50), which requires an approximation method to be selected with at least 10 decimal digits of precision and an exponent range from 10^{-50} to 10^{50}.

C.4.5 Storage of Nonsequenced Derived Types (4.4.1). A structure resolves into a sequence of components of intrinsic type. Unless the structure includes a SEQUENCE statement, the use of this terminology in no way implies that these components are stored in this, or any other, order. Nor is there any requirement that contiguous storage be used. The sequence merely refers to the fact that in writing the definitions there will necessarily be an order in which the components appear, and this will define a sequence of components. This order is of limited significance since a component of an object of derived type will always be accessed by a component name except in the following contexts: the sequence of expressions in a derived-type value constructor, the data values in namelist input data, and the inclusion of the structure in an input/output list of a formatted data transfer, where it is expanded to this sequence of components. Provided the processor adheres to the defined order in these cases, it is otherwise free to organize the storage of the components for any structure in memory as best suited to the particular architecture.

C.4.6 Pointers. This standard introduces pointers as names that can change dynamically their association with a target object. In a sense, a normal variable is a name with a fixed association with a specific object. A normal variable name refers to the same storage space throughout the lifetime of a variable. A pointer name may refer to different storage space, or even no storage space, at different times. A variable may be considered to be a descriptor for space to hold values of the appropriate type, type parameters, and array rank such that the values stored in the

descriptor are fixed when the variable is created by its declaration. A pointer also may be considered to be a descriptor, but one whose values may be changed dynamically so as to describe different pieces of storage. When a pointer is declared, space to hold the descriptor is created, but the space for the target object is not created.

A derived type may have one or more components that are defined to be pointers. It may have a component that is a pointer to an object of the same derived type. This "recursive" data definition allows dynamic data structures such as linked lists, trees, and graphs to be constructed. For example,

```
TYPE CELL           ! Define a "recursive" type
   INTEGER :: VAL
   TYPE (CELL), POINTER :: NEXT_CELL
END TYPE CELL

TYPE (CELL), TARGET :: HEAD
TYPE (CELL), POINTER :: CURRENT, TEMP  ! Declare pointers
INTEGER :: IOEM, K

HEAD % VAL = 0
CURRENT => HEAD                    ! CURRENT points to head of list
DO
   READ (*, *, IOSTAT = IOEM) K    ! Read next value, if any
   IF (IOEM /= 0) EXIT
   ALLOCATE (TEMP)                 ! Create new cell each iteration
   TEMP % VAL = K                  ! Assign value to cell
   NULLIFY (TEMP % NEXT_CELL)      ! Set status to disassociated
   CURRENT % NEXT_CELL => TEMP     ! Attach new cell to list
   CURRENT => TEMP                 ! CURRENT points to new end of list
END DO
```

A list is now constructed and the last linked cell contains a disassociated pointer. A loop can be used to "walk through" the list.

```
CURRENT => HEAD
DO
   WRITE (*, *) CURRENT % VAL
   IF (.NOT. ASSOCIATED (CURRENT % NEXT_CELL)) EXIT
   CURRENT => CURRENT % NEXT_CELL
END DO
```

C.5 Section 5 Notes.

C.5.1 Type Declaration Statements (5.1). Type declaration statements in FORTRAN 77 required different attributes of an entity to be specified in different statements (INTEGER, SAVE, DATA, etc.). This standard allows the attributes of an entity to be specified in a single extended form of the type statement. For example,

```
INTEGER, DIMENSION (10, 10), SAVE :: A, B, C
REAL, PARAMETER :: PI = 3.14159265, E = 2.718281828
```

To retain compatibility and consistency with FORTRAN 77, most of the attributes that may be specified in the extended type statement may alternatively be specified in separate statements.

If the kind type parameter is omitted from a REAL declaration, the objects are of default real type. This corresponds to the FORTRAN 77 real type (5.1.1.2).

C.5.2 The POINTER Attribute (5.1.2.7). The pointer attribute must be specified to declare a pointer. The type, type parameters, and rank, which may be specified in the same statement or with one or more attribute specification statements, determine the characteristics of the target objects that may be associated with the pointers declared in the statement. An obvious model for interpreting declarations of pointers is that such declarations create for each name a descriptor. Such a descriptor includes all the data necessary to describe fully and locate in memory an object and all subobjects of the type, type parameters, and rank specified. The descriptor is created empty; it does not contain values describing how to access an actual memory space. These descriptor values will be filled in when the pointer is associated with actual target space.

The following example illustrates the use of pointers in an iterative algorithm:

```
PROGRAM DYNAM_ITER
   REAL, DIMENSION (:, :), POINTER :: A, B, SWAP  ! Declare pointers
   ...
   READ (*, *) N, M
   ALLOCATE (A (N, M), B (N, M))  ! Allocate target arrays
   ! Read values into A
   ...
   ITER: DO
      ...
      ! Apply  transformation of values in A to produce values in B
      ...
      IF (CONVERGED) EXIT ITER
      ! Swap A and B
      SWAP => A; A => B; B => SWAP
   END DO ITER
   ...
END
```

C.5.3 The TARGET Attribute (5.1.2.8). The TARGET attribute must be specified for any nonpointer object that may, during the execution of the program, become associated with a pointer. This attribute is defined solely for optimization purposes. It allows the processor to assume that any nonpointer object not explicitly declared as a target may be referred to only by way of its original declared name. In particular, it means that implicitly-declared objects must not be used as pointer targets. This will allow a processor to perform optimizations that otherwise would not be possible in the presence of certain pointers.

The following example illustrates the use of the TARGET attribute in an iterative algorithm:

```
PROGRAM ITER
   REAL, DIMENSION (1000, 1000), TARGET :: A, B
   REAL, DIMENSION (:, :), POINTER      :: IN, OUT, SWAP
   ...
   ! Read values into A
   ...
   IN => A            ! Associate IN with target A
   OUT => B           ! Associate OUT with target B
   ...
```

```
   ITER:DO
      ...
      ! Apply transformation of IN values to produce OUT
      ...
      IF (CONVERGED) EXIT ITER
      ! Swap IN and OUT
      SWAP => IN; IN => OUT; OUT => SWAP
   END DO ITER
   ...
END
```

C.5.4 PARAMETER Statements and IMPLICIT NONE (5.2.10, 5.3). Because an implicitly typed named constant may precede an IMPLICIT statement only if that IMPLICIT statement serves to confirm the type of the named constant, it follows that if an IMPLICIT NONE statement is to appear, it must precede all PARAMETER statements.

C.5.5 EQUIVALENCE Statement Extensions (5.5.1). The EQUIVALENCE statement has been extended to allow the equivalencing of sequence structures and the equivalencing of objects of intrinsic type with nondefault type parameters, but there are strict rules regarding the appearance of these objects in an EQUIVALENCE statement.

Structures that appear in EQUIVALENCE statements must be sequence structures. If a sequence structure is not of numeric sequence type or of character sequence type, it must be equivalenced only to objects of the same type.

A numeric sequence structure may be equivalenced to another numeric sequence structure, an object of default integer type, default real type, double precision real type, default complex type, or default logical type such that components of the structure ultimately become associated only with objects of these types.

A character sequence structure may be equivalenced to an object of default character type or another character sequence structure.

Other objects may be equivalenced only to objects of the same type and kind type parameters.

C.5.6 COMMON Statement Extensions (5.5.2). Modules provide global access to all objects; however, the COMMON statement also has been extended to allow access in more than one scoping unit to objects with the POINTER attribute, to sequence structures, and to objects of intrinsic type with nondefault type parameters.

A common block is permitted to contain sequences of different storage units, provided each scoping unit that accesses the common block specifies an identical sequence of storage units for the common block. This extension allows a single common block to contain both numeric and character objects.

Association in different scoping units between objects of default type, objects of double precision real type, and sequence structures is permitted according to the rules for equivalence objects (5.5.1).

C.6 Section 6 Notes.

C.6.1 Substrings (6.1.1). Substrings are of zero length when the starting point exceeds the ending point. This was not allowed in FORTRAN 77. This standard also allows substrings of literal character constants and named character constants.

C.6.2 Array Element References (6.2.2). A subscript reference to an element outside the declared bounds is not standard conforming, as in FORTRAN 77.

C.6.3 Structure Components (6.1.2). Components of a structure are referenced by writing the components of successive levels of the structure hierarchy until the desired component is described. For example,

```
TYPE ID_NUMBERS
   INTEGER SSN
   INTEGER EMPLOYEE_NUMBER
END TYPE ID_NUMBERS

TYPE PERSON_ID
   CHARACTER (LEN=30) LAST_NAME
   CHARACTER (LEN=1) MIDDLE_INITIAL
   CHARACTER (LEN=30) FIRST_NAME
   TYPE (ID_NUMBERS) NUMBER
END TYPE PERSON_ID

TYPE PERSON
   INTEGER AGE
   TYPE (PERSON_ID) ID
END TYPE PERSON

TYPE (PERSON) GEORGE, MARY

PRINT *, GEORGE % AGE              ! Print the AGE component
PRINT *, MARY % ID % LAST_NAME     ! Print LAST_NAME of MARY
PRINT *, MARY % ID % NUMBER % SSN ! Print SSN of MARY
PRINT *, GEORGE % ID % NUMBER  ! Print SSN and EMPLOYEE_NUMBER of GEORGE
```

A structure component may be a data object of intrinsic type as in the case of GEORGE%AGE or it may be of derived type as in the case of GEORGE%ID%NUMBER. The resultant component may be a scalar or an array of intrinsic or derived type.

```
TYPE LARGE
   INTEGER ELT (10)
   INTEGER VAL
END TYPE LARGE

TYPE (LARGE) A (5)         ! 5 element array, each of whose elements
                           ! includes a 10 element array ELT and
                           ! a scalar VAL.
PRINT *, A (1)             ! Prints 10 element array ELT and scalar VAL.
PRINT *, A (1) % ELT (3)   ! Prints scalar element 3
                           ! of array element 1 of A.
PRINT *, A (2:4) % VAL     ! Prints scalar VAL for array elements
                           ! 2 to 4 of A.
```

C.6.4 Pointer Allocation and Association. The effect of ALLOCATE, DEALLOCATE, NULLIFY, and pointer assignment is that they are interpreted as changing the values in the descriptor that is the pointer. An ALLOCATE is assumed to create space for a suitable object and to "assign" to the pointer the values necessary to describe that space. A NULLIFY breaks the association of the pointer with the space. A DEALLOCATE breaks the association and releases the space. Depending on the implementation, it could be seen as setting a flag in the pointer that indicates whether the values in the descriptor are valid, or it could clear the descriptor values to some (say zero) value indicative of the pointer not currently pointing to anything. A pointer assignment copies the values necessary to describe the space occupied by the target into the descriptor that is the pointer. Descriptors are copied, values of objects are not.

If PA and PB are both pointers and PB currently is associated with a target, then

```
PA => PB
```

results in PA being associated with the same target as PB. If PB was disassociated, then PA becomes disassociated.

The standard is specified so that such associations are direct and independent. A subsequent statement

```
PB => D
```

or

```
ALLOCATE (PB)
```

has no effect on the association of PA with its target. A statement

```
DEALLOCATE (PB)
```

leaves PA as a "dangling pointer" to space that has been released. The program must not use PA again until it becomes associated via pointer assignment or an ALLOCATE statement.

DEALLOCATE should only be used to release space that was created by a previous ALLOCATE. Thus the following is invalid:

```
REAL, TARGET :: T
REAL, POINTER :: P
   ...
P => T
DEALLOCATE (P) ! Not allowed: P's target was not allocated
```

The basic principle is that ALLOCATE, NULLIFY, and pointer assignment primarily affect the pointer rather than the target. ALLOCATE creates a new target but, other than breaking its connection with the specified pointer, it has no effect on the old target. Neither NULLIFY nor pointer assignment has any effect on targets. A given piece of memory that was allocated and associated with a pointer will become inaccessible to a program if the pointer is nullified and no other pointer was associated with this piece of memory. Such pieces of memory may be reused by the processor if this is expedient. However, whether such inaccessible memory is in fact reused is entirely proc-

essor dependent.

C.6.5 Partial Summary of Array Name Appearances.

Table C.1 Allowed Appearances of Array Names

Place of Appearance	Explicit Shape Array	Structure Component Array	Target Array	Allocatable Array	Assumed Shape Array	Assumed Size Array
dummy-arg	Yes	No	Yes	No	Yes	Yes
use-stmt	Yes	No	Yes	Yes	No	No
save-stmt	Yes	No	Yes	Yes	No	No
namelist-stmt	Yes	No	No	No	No	No
equivalence-stmt	Yes	No	No	No	No	No
data-stmt	Yes	No	No	No	No	No
common-stmt	Yes	No	No	No	No	No
type-declaration-stmt	Yes	Yes	Yes	Yes	Yes	Yes
format	Yes	Yes	Yes	Yes	Yes	Yes
actual-arg in a reference to a procedure	Yes	Yes	Yes	Yes	Yes	Yes
input-item-list or *output-item-list*	Yes	Yes	Yes	Yes	Yes	No
internal-file-unit	Yes	Yes	Yes	Yes	Yes	No
primary	Yes	Yes	Yes	Yes	Yes	No
assignment-stmt	Yes	Yes	Yes	Yes	Yes	No
vector-subscript	Yes	Yes	Yes	Yes	Yes	No
pointer-assignment-stmt	No	No	Yes	No	No	No
allocate-stmt	No	No	Yes	Yes	No	No
deallocate-stmt or *nullify-stm*	No	No	Yes	Yes	No	No
function name, *result name*, or *entry name*	Yes	No	Yes	No	No	No

C.7 Section 7 Notes.

C.7.1 Character Assignment. The FORTRAN 77 restriction that none of the character positions being defined in the character assignment statement may be referenced in the expression has been removed (7.5.1.5).

C.7.2 Evaluation of Function References. If more than one function reference appears in a statement, they may be executed in any order (subject to a function result being evaluated after the evaluation of its arguments) and their values must not depend on the order of execution. This lack of dependence on order of evaluation permits parallel execution of the function references (7.1.7.1).

C.7.3 Pointers in Expressions. A pointer is basically considered to be like any other variable when it is used as a primary in an expression. If a pointer is used as an operand to an operator that expects a value, the pointer will automatically deliver the value contained in the space currently described by the pointer, that is, the value of the target object currently associated with the

pointer. In value-demanding expression contexts, pointers are dereferenced.

C.7.4 Pointers on the Left Side of an Assignment. A pointer that appears on the left of an intrinsic assignment statement also is dereferenced and is taken to be referring to the space that is its current target. Therefore, the assignment statement specifies the normal copying of the value of the right-hand expression into this target space. All the normal rules of intrinsic assignment hold; the type and type parameters of the expression and the pointer target must agree and the shapes must be conformable.

For intrinsic assignment of derived types, nonpointer components are assigned and pointer components are pointer assigned. Dereferencing is applied only to entire scalar objects, not selectively to pointer subobjects.

For example, suppose a type such as

```
TYPE CELL
   INTEGER :: VAL
   TYPE (CELL), POINTER :: NEXT_CELL
ENDTYPE
```

is defined and objects such as HEAD and CURRENT are declared using

```
TYPE (CELL), TARGET :: HEAD
TYPE (CELL), POINTER :: CURRENT
```

If a linked list has been created and attached to HEAD and the pointer CURRENT has been allocated space, statements such as

```
CURRENT = HEAD
CURRENT = CURRENT % NEXT_CELL
```

cause the contents of the cells referenced on the right to be copied to the cell referred to by CURRENT. In particular, the right-hand side of the second statement causes the pointer component in the cell, CURRENT, to be selected. This pointer is dereferenced because it is in an expression context to produce the target's integer value and a pointer to a cell that is contained in the target's NEXT_CELL component. The left-hand side causes the pointer CURRENT to be dereferenced to produce its present target, namely space to hold a cell (an integer and a cell pointer). The integer value on the right is copied to the integer space on the left and the pointer components are pointer assigned (the descriptor on the right is copied into the space for a descriptor on the left). When a statement such as

```
CURRENT => CURRENT % NEXT_CELL
```

is executed, the descriptor value in CURRENT % NEXT_CELL is copied to the descriptor named CURRENT. In this case, CURRENT is made to point at a different target.

In the intrinsic assignment statement, the space associated with the current pointer does not change but the values stored in that space do. In the pointer assignment, the current pointer is made to associate with different space. Using the intrinsic assignment causes a linked list of cells to be moved up through the current "window"; the pointer assignment causes the current pointer to be moved down through the list of cells.

C.8 Section 8 Notes.

C.8.1 Loop Control. Fortran provides several forms of loop control:

(1) With an iteration count and a DO variable. This is the classic Fortran DO loop.

(2) Test a logical condition before each execution of the loop (DO WHILE).

(3) DO "forever".

C.8.2 The CASE Construct. At most one case block is selected for execution within a CASE construct, and there is no fall-through from one block into another block within a CASE construct. Thus there is no requirement for the user to exit explicitly from a block.

C.8.3 Examples of Invalid DO Constructs. The following are all examples of invalid skeleton DO constructs:

Example 1:

```
DO I = 1, 10
   ...
END DO LOOP    ! No matching construct name
```

Example 2:

```
LOOP: DO 1000 I = 1, 10    ! No matching construct name
   ...
1000  CONTINUE
```

Example 3:

```
LOOP1: DO
   ...
END DO LOOP2    ! Construct names don't match
```

Example 4:

```
DO I = 1, 10    ! Label required or ...
   ...
1010 CONTINUE   ! ... END DO required
```

Example 5:

```
DO 1020 I = 1, 10
   ...
1021 END DO         ! Labels don't match
```

Example 6:

```
FIRST: DO I = 1, 10
   SECOND: DO J = 1, 5
      ...
   END DO FIRST    ! Improperly nested DOs
END DO SECOND
```

C.9 Section 9 Notes.

C.9.1 Input/Output Records (9.1). What is called a "record" in Fortran is commonly called a "logical record". There is no concept in Fortran of a "physical record".

An endfile record does not necessarily have any physical embodiment. The processor may use a record count or other means to register the position of the file at the time an ENDFILE statement is executed, so that it can take appropriate action when that position is reached again during a read operation. The endfile record, however it is implemented, is considered to exist for the BACKSPACE statement (9.1.3).

C.9.2 Files (9.2). This standard accommodates, but does not require, file cataloging. To do this, several concepts are introduced.

C.9.2.1 File Connection (9.3). Before any input/output may be performed on a file, it must be connected to a unit. The unit then serves as a designator for that file as long as it is connected. To be connected does not imply that "buffers" have or have not been allocated, that "file-control tables" have or have not been filled out, or that any other method of implementation has been

used. Connection means that (barring some other fault) a READ or WRITE statement may be executed on the unit, hence on the file. Without a connection, a READ or WRITE statement must not be executed.

C.9.2.2 File Existence (9.2.1.1). Totally independent of the connection state is the property of existence, this being a file property. The processor "knows" of a set of files that exist at a given time for a given executable program. This set would include tapes ready to read, files in a catalog, a keyboard, a printer, etc. The set may exclude files inaccessible to the executable program because of security, because they are already in use by another executable program, etc. This standard does not specify which files exist, hence wide latitude is available to a processor to implement security, locks, privilege techniques, etc. Existence is a convenient concept to designate all of the files that an executable program can potentially process.

All four combinations of connection and existence may occur:

Connect	Exist	Examples
Yes	Yes	A card reader loaded and ready to be read
Yes	No	A printer before the first line is written
No	Yes	A file named 'JOAN' in the catalog
No	No	A file on a reel of tape, not known to the processor

Means are provided to create, delete, connect, and disconnect files.

C.9.2.3 File Names (9.3.4.1). A file may have a name. The form of a file name is not specified. If a system does not have some form of cataloging or tape labeling for at least some of its files, all file names will disappear at the termination of execution. This is a valid implementation. Nowhere does this standard require names to survive for any period of time longer than the execution time span of an executable program. Therefore, this standard does not impose cataloging as a prerequisite. The naming feature is intended to allow use of a cataloging system where one exists.

C.9.2.4 File Access (9.2.1.2). This standard does not address problems of security, protection, locking, and many other concepts that may be part of the concept of "right of access". Such concepts are considered to be in the province of an operating system.

The OPEN and INQUIRE statements can be extended naturally to consider these things.

Possible access methods for a file are: sequential and direct. The processor may implement two different types of files, each with its own access method. It might also implement one type of file with two different access methods.

Direct access to files is of a simple and commonly available type, that is, fixed-length records. The key is a positive integer.

C.9.2.5 Nonadvancing Input/Output (9.2.1.3.1). Data transfer statements affect the positioning of an external file. In FORTRAN 77, if no error or end-of-file condition exists, the file is positioned after the record just read or written and that record becomes the preceding record. This standard contains the record positioning ADVANCE= specifier in a data transfer statement that provides the capability of maintaining a position within the current record from one formatted data transfer statement to the next data transfer statement. The value NO provides this capability. The value YES positions the file after the record just read or written. The default is YES.

The tab edit descriptor and the slash are still appropriate for use with this type of record access but the tab will not reposition before the left tab limit.

A BACKSPACE of a file that is currently positioned within a record causes the specified unit to be positioned before the current record.

If the last data transfer statement was WRITE and the file is currently positioned within a record, the file will be positioned implicitly after the current record before an ENDFILE record is written to the file, that is, a REWIND, BACKSPACE, or ENDFILE statement following a nonadvancing WRITE statement causes the file to be positioned at the end of the current output record before the endfile record is written to the file.

This standard provides a SIZE= specifier to be used with nonadvancing data transfer statements. The variable in the SIZE= specifier will contain the count of the number of characters that make up the sequence of values read by the data edit descriptors in this input statement.

The count is especially helpful if there is only one list item in the input list since it will contain the number of characters that were present for the item.

The EOR= specifier is provided to indicate when an end-of-record condition has been encountered during a nonadvancing data transfer statement. The end-of-record condition is not an error condition. If this specifier is not present, this standard does not specify what must be done when an end-of-record is encountered. If this specifier is present, the current input list item that required more characters than the record contained will be padded with blanks if PAD= 'YES' is in effect. This means that the iolist item was successfully completed. The file will then be positioned after the current record. The IOSTAT= specifier, if present, will be defined with a processor-dependent negative value and the data transfer statement will be terminated. Program execution will continue with the statement specified in the EOR= specifier. The EOR= specifier gives the capability of taking control of execution when the end-of-record has been found. Implied-DO variables are undefined when an end-of-record condition occurs. The SIZE= specifier, if present, will contain the number of characters read with the data edit descriptors during this READ statement.

For nonadvancing input, the processor is not required to read partial records. The processor may read the entire record into an internal buffer and make successive portions of the record available to successive input statements.

C.9.3 OPEN Statement (9.3.4). A file may become connected to a unit in either of two ways: preconnection or execution of an OPEN statement. Preconnection is performed prior to the beginning of execution of an executable program by means external to Fortran. For example, it may be done by job control action or by processor-established defaults. Execution of an OPEN statement is not required to access preconnected files (9.3.3).

The OPEN statement provides a means to access existing files that are not preconnected. An OPEN statement may be used in either of two ways: with a file name (open-by-name) and without a file name (open-by-unit). A unit is given in either case. Open-by-name connects the specified file to the specified unit. Open-by-unit connects a processor-determined default file to the specified unit. (The default file may or may not have a name.)

Therefore, there are three ways a file may become connected and hence processed: preconnection, open-by-name, and open-by-unit. Once a file is connected, there is no means in standard Fortran to determine how it became connected.

An OPEN statement may also be used to create a new file. In fact, any of the foregoing three connection methods may be performed on a file that does not exist. When a unit is preconnected, writing the first record creates the file. With the other two methods, execution of the OPEN statement creates the file.

When an OPEN statement is executed, the unit specified in the OPEN may or may not already be connected to a file. If it is already connected to a file (either through preconnection or by a prior OPEN), then omitting the FILE= specifier in the OPEN statement implies that the file is to remain connected to the unit. Such an OPEN statement may be used to change the values of the BLANK=, DELIM=, or PAD= specifiers.

Note that, since an OPEN that specifies STATUS = 'SCRATCH' is not allowed to have a FILE= specifier, such an OPEN always attempts to retain any connection that the specified unit may have.

If the unit were already connected to a file, and if that connection did not have a STATUS of SCRATCH, then the OPEN would be illegal because the value of the STATUS= specifier must not be changed by the OPEN.

The following examples illustrate these rules. In the first example, unit 10 is preconnected to a SCRATCH file; the OPEN statement changes the value of PAD= to YES.

```
CHARACTER (LEN = 20) CH1
WRITE (10, '(A)') 'THIS IS RECORD 1'
OPEN (UNIT = 10, STATUS = 'SCRATCH', PAD = 'YES')
REWIND 10
READ (10, '(A20)') CH1    ! CH1 now has the value
                          ! 'THIS IS RECORD 1    '
```

In the next example, unit 12 is first connected to a file named FRED, with a status of OLD. The second OPEN statement then opens unit 12 again, retaining the connection to the file FRED, but changing the value of the DELIM= specifier to QUOTE.

```
CHARACTER (LEN = 25) CH2, CH3
OPEN (12, FILE = 'FRED', STATUS = 'OLD', DELIM = 'NONE')
CH2 = '"THIS STRING HAS QUOTES."'
              ! Quotes in string CH2
WRITE (12, *) CH2           ! Written with no delimiters
OPEN (12, DELIM = 'QUOTE')  ! Now quote is the delimiter
REWIND 12
READ (12, *) CH3  ! CH3 now has the value
                  ! 'THIS STRING HAS QUOTES.  '
```

The next example is invalid because it attempts to change the value of the STATUS= specifier.

```
OPEN (10, FILE = 'FRED', STATUS = 'OLD')
WRITE (10, *) A, B, C
OPEN (10, STATUS = 'SCRATCH')    ! Attempts to make FRED
                                 ! a SCRATCH file
```

The previous example could be made valid by closing the unit first, as in the next example.

```
OPEN (10, FILE = 'FRED', STATUS = 'OLD')
WRITE (10, *) A, B, C
CLOSE (10)
OPEN (10, STATUS = 'SCRATCH')    ! Opens a different
                                 ! SCRATCH file
```

C.9.4 Connection Properties (9.3.2). When a unit becomes connected to a file, either by execution of an OPEN statement or by preconnection, the following connection properties may be established:

(1) An access method, which is sequential or direct, is established for the connection (9.3.4.3).

(2) A form, which is formatted or unformatted, is established for a connection to a file that exists or is created by the connection. For a connection that results from execution of an OPEN statement, a default form (which depends on the access method, as described in 9.2.1.2) is established if no form is specified. For a preconnected file that exists, a form is established by preconnection. For a preconnected file that does not exist, a form may be established, or the establishment of a form may be delayed until the file is created (for example, by execution of a formatted or unformatted WRITE statement) (9.3.4.4).

(3) A record length may be established. If the access method is direct, the connection establishes a record length that specifies the length of each record of the file. An existing file with records that are not all of equal length must not be connected for direct access.

If the access method is sequential, records of varying lengths are permitted. In this case,

the record length established specifies the maximum length of a record in the file (9.3.4.5).

(4) A blank significance property, which is ZERO or NULL, is established for a connection for which the form is formatted. This property has no effect on output. For a connection that results from execution of an OPEN statement, the blank significance property is NULL by default if no blank significance property is specified. For a preconnected file, the property is NULL.

The blank significance property of the connection is effective at the beginning of each formatted input statement. During execution of the statement, any BN or BZ edit descriptors encountered may temporarily change the effect of embedded and trailing blanks (9.3.4.6).

FORTRAN 77 did not define default values for the blank significance properties of internal and preconnected files. This standard defines the default values for these files to be NULL, matching that of files connected by the OPEN statement.

A processor has wide latitude in adapting these concepts and actions to its own cataloging and job control conventions. Some processors may require job control action to specify the set of files that exist or that will be created by an executable program. Some processors may require no job control action prior to execution. This standard enables processors to perform dynamic open, close, or file creation operations, but it does not require such capabilities of the processor.

The meaning of "open" in contexts other than Fortran may include such things as mounting a tape, console messages, spooling, label checking, security checking, etc. These actions may occur upon job control action external to Fortran, upon execution of an OPEN statement, or upon execution of the first read or write of the file. The OPEN statement describes properties of the connection to the file and may or may not cause physical activities to take place. It is a place for an implementation to define properties of a file beyond those required in standard Fortran.

C.9.5 CLOSE Statement (9.3.5). Similarly, the actions of dismounting a tape, protection, etc. of a "close" may be implicit at the end of a run. The CLOSE statement may or may not cause such actions to occur. This is another place to extend file properties beyond those of standard Fortran. Note, however, that the execution of a CLOSE statement on a unit followed by an OPEN statement on the same unit to the same file or to a different file is a permissible sequence of events. The processor must not deny this sequence solely because the implementation chooses to do the physical act of closing the file at the termination of execution of the program.

C.9.6 INQUIRE Statement (9.6). Table C.1 indicates the values assigned to the INQUIRE statement specifier variables when no error condition is encountered during execution of the INQUIRE statement.

Table C.1 Values Assigned to INQUIRE Specifier Variables

Specifier	INQUIRE by File		INQUIRE by Unit	
	Unconnected	Connected	Connected	Unconnected
EXIST=	.TRUE. if file exists, .FALSE. otherwise		.TRUE. if unit exists, .FALSE. otherwise	
OPENED=	.FALSE.	.TRUE.		.FALSE.
NUMBER=	–1	unit no.		–1
NAMED=	.TRUE.		.TRUE. if file named, .FALSE. otherwise	.FALSE.
NAME=	filename (may not be same as FILE= value)		filename if named, else undefined	undefined
ACCESS=	UNDEFINED	SEQUENTIAL or DIRECT		UNDEFINED
SEQUENTIAL=	YES, NO, or UNKNOWN			UNKNOWN
DIRECT=	YES, NO, or UNKNOWN			UNKNOWN
FORM=	UNDEFINED	FORMATTED or UNFORMATTED		UNDEFINED
FORMATTED=	YES, NO, or UNKNOWN			UNKNOWN
UNFORMATTED=	YES, NO, or UNKNOWN			UNKNOWN
RECL=	undefined	if direct access, record length; else maximum record length		undefined
NEXTREC=	undefined	if direct access, next record #; else undefined		undefined
BLANK=	UNDEFINED	NULL, ZERO, or UNDEFINED		UNDEFINED
DELIM=	UNDEFINED	APOSTROPHE, QUOTE, NONE, or UNDEFINED		UNDEFINED
PAD=	YES	YES or NO		YES
POSITION=	UNDEFINED	REWIND, APPEND, ASIS, or UNDEFINED		UNDEFINED
ACTION=	UNDEFINED	READ, WRITE, or READWRITE		UNDEFINED
IOLENGTH=	RECL= value for *output-item-list*			

C.9.7 Keyword Specifiers. Keyword forms of specifiers are used because there are many specifiers and a positional notation is difficult to remember. The keyword form sets a style for processor extensions. The UNIT= and FMT= keywords are offered for completeness, but their use is optional. Thus, compatibility with ANSI X3.9-1966 (FORTRAN 66) and FORTRAN 77 is achieved.

C.9.8 Format Specifications (9.4.1.1). Format specifications may be included in the READ and WRITE statements, as in:

```
READ (UNIT = 10, FMT = '(I3, A4, F10.2)') K, ALPH, X
```

C.9.9 Unformatted Input/Output (9.4.4.4.1). Unformatted input/output involving derived-type list items forms the single exception to the rule that the appearance of an aggregate list item (such as an array) is equivalent to the appearance of its expanded list of component parts. This exception permits the processor greater latitude in improving efficiency or in matching the processor-dependent sequence of values for a derived-type object to similar sequences for aggregate objects used by means other than Fortran. However, formatted input/output of all list items and unformatted input/output of list items other than those of derived types adhere to the above rule.

C.9.10 Input/Output Restrictions. An example of a restriction on input/output statements (9.8) is that an input statement must not specify that data are to be read from a printer.

C.9.11 Pointers in an Input/Output List. Data transfers always involve the movement of values between a file and internal storage. A pointer as such cannot be read or written. A pointer may, therefore, appear as an item in an input/output list if it is currently associated with a target that can receive a value (input) or can deliver a value (output). A derived type object with one or more pointer components must not appear as an item in an input/output list because the value of a pointer component is the descriptor for a location in memory. As such, this has no processor-independent representation.

C.9.12 Derived Type Objects in an Input/Output List (9.4.2). A component of a derived type may be declared to be private (4.4, 5.1.2.2). A derived-type object must not appear in an input/output list if any of its components or subobjects of any of its components have been declared to be private and its derived type definition does not appear in the same module as the data transfer statement.

In a formatted input/output statement, edit descriptors are associated with effective list items, which are always scalar and of intrinsic type. The rules in 9.4.2 determine the set of effective list items corresponding to each actual list item in the statement. These rules may have to be applied repetitively until all of the effective list items are scalar items of intrinsic type.

C.10 Section 10 Notes.

C.10.1 Character Constant Format Specification (10.1.2, 10.7.1). If a character constant is used as a format specifier in an input/output statement, care must be taken that the value of the character constant is a valid format specification. In particular, if a format specification delimited by apostrophes contains an apostrophe edit descriptor, two apostrophes must be written to delimit the apostrophe edit descriptor and four apostrophes must be written for each apostrophe that occurs within the apostrophe edit descriptor. For example, the text:

```
 2 ISN'T 3
```

may be written by various combinations of output statements and format specifications:

```
    WRITE (6, 100) 2, 3
100 FORMAT (1X, I1, 1X, 'ISN''T', 1X, I1)

    WRITE (6, '(1X, I1, 1X, ''ISN''''T'', 1X, I1)') 2, 3

    WRITE (6, '(A)') ' 2 ISN''T 3'
```

Note that doubling of internal apostrophes usually may be avoided by using quotation marks to delimit the format specification and doubling of internal quotation marks usually may be avoided by using apostrophes as delimiters.

C.10.2 T Edit Descriptor (10.6.1.1). The T edit descriptor includes the carriage control character (9.4.5) in lines that are to be printed. T1 specifies the vertical spacing character and T2 specifies the first character that is printed.

C.10.3 Length of Formatted Records. The length of a formatted record is not always specified exactly and may be processor dependent (10.8.2, 10.9.2).

C.10.4 Number of Records (10.3, 10.4, 10.6.2). The number of records read by an explicitly formatted advancing input statement can be determined from the following rule: a record is read at the beginning of the format scan (even if the input list is empty), at each slash edit descriptor encountered in the format, and when a format rescan occurs at the end of the format.

The number of records written by an explicitly formatted advancing output statement can be determined from the following rule: a record is written when a slash edit descriptor is encountered in the format, when a format rescan occurs at the end of the format, and at completion of execution of the output statement (even if the output list is empty). Thus, the occurrence of n successive slashes between two other edit descriptors causes $n - 1$ blank lines if the records are printed. The occurrence of n slashes at the beginning or end of a complete format specification causes n blank lines if the records are printed. However, a complete format specification containing n slashes ($n > 0$) and no other edit descriptors causes $n + 1$ blank lines if the records are printed. For example, the statements

```
  PRINT 3
3 FORMAT (/)
```

will write two records that cause two blank lines if the records are printed.

C.10.5 List-Directed Input/Output (10.8). List-directed input/output allows data editing according to the type of the list item instead of by a format specifier. It also allows data to be free-field, that is, separated by commas or blanks.

If no list items are specified in a list-directed input/output statement, one input record is skipped or one empty output record is written.

C.10.6 List-Directed Input (10.8.1). The following examples illustrate list-directed input. A blank character is represented by b.

Example 1:

Program:

```
J = 3
READ *, I
READ *, J
```

Sequential input file:

record 1: `b1b,4bbbbb`
record 2: `,2bbbbbbbb`

Result: I = 1, J = 3.

Explanation: The second READ statement reads the second record. The initial comma in the record designates a null value; therefore, J is not redefined.

Example 2:

Program:

```
CHARACTER A *8, B *1
READ *, A, B
```

Sequential input file:

record 1: 'bbbbbbbb'
record 2: 'QXY'b'Z'

Result: A = 'bbbbbbbb', B = 'Q'

Explanation: In the first record, the rightmost apostrophe is interpreted as delimiting the constant (it cannot be the first of a pair of embedded apostrophes representing a single apostrophe because this would involve the prohibited "splitting" of the pair by the end of a record); therefore, A is set to the character constant 'bbbbbbbb'. The end of a record acts as a blank, which in this case is a value separator because it occurs between two constants.

C.10.7 Namelist List Items for Character Input (10.9.1.3). Corresponding to a namelist input list item of character data type, the character constant must be delimited either with apostrophes or with quotes. The delimiter is required to avoid ambiguity between undelimited character constants and object names. The value of the DELIM= specifier, if any, in the OPEN statement for an external file is ignored during namelist input (9.3.4.9).

C.10.8 Namelist Output Records (10.9.2.2). Namelist output records produced with a DELIM= specifier with a value of NONE and which contain a character constant may not be acceptable as namelist input records because the processor may not be able to distinguish between character values and object names in a name-value sequence when delimiters are absent.

C.11 Section 11 Notes.

C.11.1 Main Program and Block Data Program Unit (11.1, 11.4). The name of the main program or of a block data program unit has no explicit use within the Fortran language. It is available for documentation and for possible use by a processor.

A processor may implement an unnamed main program or unnamed block data program unit assigning it a default name. However, this name must not conflict with any other global name in a standard-conforming executable program. This might be done by making the default name one which is not permitted in a standard-conforming program (for example, by including a character not normally allowed in names) or by providing some external mechanism such that for any given program the default name can be changed to one that is otherwise unused.

C.11.2 Examples of Host Association (11.2.2). The first two examples are valid examples of host association. The third example is an invalid example of host association.

Example 1:

```
PROGRAM A
INTEGER I, J
   ...
CONTAINS
   SUBROUTINE B
      INTEGER I   ! Declaration of I hides
                  ! program A's declaration of I
         ...
      I = J       ! Use of variable J from program A
                  ! through host association
   END SUBROUTINE B
END PROGRAM A
```

Example 2:

```
PROGRAM A
   TYPE T
      ...
   END TYPE T
   ...
CONTAINS
   SUBROUTINE B
      IMPLICIT TYPE (T) (C)   ! Refers to type T declared below
                              ! in subroutine B, not type T
                              ! declared above in program A
      TYPE T
         ...
      END TYPE T
   END SUBROUTINE B
END PROGRAM A
```

Example 3:

```
PROGRAM Q
   REAL (KIND = 1) :: C
      ...
CONTAINS
   SUBROUTINE R
      REAL (KIND = KIND (C)) :: D  ! Invalid declaration
                                   ! See below
      REAL (KIND = 2) :: C
         ...
   END SUBROUTINE R
END PROGRAM Q
```

In the declaration of D in subroutine R, the use of C would refer to the declaration of C in subroutine R, not program Q. However, it is invalid because the declaration of C must occur before it is used in the declaration of D.

C.11.3 Dependent Compilation (11.3). This standard, like its predecessors, is intended to permit the implementation of conforming processors in which a program can be broken into multiple units, each of which can be separately translated in preparation for execution. Such processors are commonly described as supporting separate compilation. There is an important difference between the way separate compilation can be implemented under this standard and the way it could be implemented under the previous standards. Under the previous standards, any information required to translate a program unit was specified in that program unit. Each translation was thus totally independent of all others. Under this standard, a program unit can use information that was specified in a separate module and thus may be dependent on that module. The implementation of this dependency in a processor may be that the translation of a program unit may depend on the results of translating one or more modules. Processors implementing the dependency this way are commonly described as supporting dependent compilation.

The dependencies involved here are new only in the sense that the Fortran processor is now aware of them. The same information dependencies existed under the previous standards, but it was the programmer's responsibility to transport the information necessary to resolve them by making redundant specifications of the information in multiple program units. The availability of separate but dependent compilation offers several potential advantages over the redundant textual specification of information:

(1) Specifying information at a single place in the program ensures that different program units using that information will be translated consistently. Redundant specification leaves the possibility that different information will erroneously be specified. Even if some kind of textual inclusion facility is used to ensure that the text of the specifications is identical in all involved program units, the presence of other specifications (for example, an IMPLICIT statement) may change the interpretation of that text.

(2) During the revision of a program, it is possible for a processor to assist in determining whether different program units have been translated using different (incompatible) versions of a module, although there is no requirement that a processor provide such assistance. Inconsistencies in redundant textual specification of information, on the other hand, tend to be much more difficult to detect.

(3) Putting information in a module provides a way of packaging it. Without modules, redundant specifications frequently must be interleaved with other specifications in a program unit, making convenient packaging of such information difficult.

(4) Because a processor may be implemented such that the specifications in a module are translated once and then repeatedly referenced, there is the potential for greater efficiency than when the processor must translate redundant specifications of information in multiple program units.

The exact meaning of the requirement that the public portions of a module be available at the time of reference is processor defined. For example, a processor could consider a module to be available only after it has been compiled and require that if the module has been compiled separately, the result of that compilation must be identified to the compiler when compiling program units that use it.

C.11.3.1 USE Statement and Dependent Compilation (11.3.2). Another benefit of the USE statement is its enhanced facilities for name management. If one needs to use only selected entities in a module, one can do so without having to worry about the names of all the other entities in that module. If one needs to use two different modules that happen to contain entities with the same name, there are several ways to deal with the conflict. If none of the entities with the same name are to be used, they can simply be ignored. If the name happens to refer to the same entity in both modules (for example, if both modules obtained it from a third module), then there is no confusion about what the name denotes and the name can be freely used. If the entities are different and one or both is to be used, the local renaming facility in the USE statement makes it possible to give those entities different names in the program unit containing the USE statements.

A typical implementation of dependent but separate compilation may involve storing the result of translating a module in a file (or file element) whose name is derived from the name of the module. Note, however, that the name of a module is limited only by the Fortran rules and not by the names allowed in the file system. Thus the processor may have to provide a mapping between Fortran names and file system names.

The result of translating a module could reasonably either contain only the information textually specified in the module (with "pointers" to information originally textually specified in other modules) or contain all information specified in the module (including copies of information originally specified in other modules). Although the former approach would appear to save on storage space, the latter approach can greatly simplify the logic necessary to process a USE statement and can avoid the necessity of imposing a limit on the logical "nesting" of modules via the USE statement.

Variables declared in a module retain their definition status on much the same basis as variables in a common block. That is, saved variables retain their definition status throughout the execution of a program, while variables that are not saved retain their definition status only during the execution of scoping units that reference the module. In some cases, it may be appropriate to put a USE statement such as

```
USE MY_MODULE, ONLY:
```

in a scoping unit in order to assure that other procedures that it references can communicate through the module. In such a case, the scoping unit would not access any entities from the module, but the variables not saved in the module would retain their definition status throughout the execution of the scoping unit.

There is an increased potential for undetected errors in a scoping unit that uses both implicit typing and the USE statement. For example, in the program fragment

```
SUBROUTINE SUB
   USE MY_MODULE
   IMPLICIT INTEGER (I-N), REAL (A-H, O-Z)
   X = F (B)
   A = G (X) + H (X + 1)
END SUBROUTINE
```

X could be either an implicitly typed real variable or a variable obtained from the module MY_MODULE and might change from one to the other because of changes in MY_MODULE unrelated to the action performed by SUB. Logic errors resulting from this kind of situation can be extremely difficult to locate. Thus, the use of these features together is discouraged.

C.11.3.2 Accessibility Attributes (11.3.1). The PUBLIC and PRIVATE attributes, which can be declared only in modules, divide the entities in a module into those which are actually relevant to a scoping unit referencing the module and those that are not. This information may be used to improve the performance of a Fortran processor. For example, it may be possible to discard much of the information on the private entities once a module has been translated, thus saving on both storage and the time to search it. Similarly, it may be possible to recognize that two versions of a module differ only in the private entities they contain and avoid retranslating program units that use that module when switching from one version of the module to the other.

C.11.4 Pointers in Modules. A pointer from a module program unit may be accessible in a procedure via use association. Such pointers have a lifetime that is greater than targets that are declared in the procedure, unless such targets are saved. Therefore, if such a pointer is associated with a local target, there is the possibility that when the procedure completes execution, the target will cease to exist leaving the pointer "dangling". This standard considers such pointers to be in an undefined state. They are neither associated nor disassociated. They must not be used again in the program until their status has been reestablished. There is no requirement on a processor to be able to detect when a pointer target ceases to exist.

C.11.5 Example of a Module (11.3). In addition to providing a portable means of avoiding the redundant specification of information in multiple program units, a module provides a convenient means of "packaging" related entities, such as the definitions of the representation and operations of an abstract data type. The following example of a module defines a data abstraction for a SET data type where the elements of each set are of type integer. The standard set operations of UNION, INTERSECTION, and DIFFERENCE are provided. The CARDINALITY function returns the cardinality of (number of elements in) its set argument. Two functions returning logical values are included, ELEMENT and SUBSET. ELEMENT extends the operator .IN. and SUBSET extends the operator <=. ELEMENT determines if a given scalar integer value is an element of a given set, and SUBSET determines if a given set is a subset of another given set. (Two sets may be checked for equality by comparing cardinality and checking that one is a subset of the other, or checking to see if each is a subset of the other.)

The transfer function SETF converts a vector of integer values to the corresponding set, with duplicate values removed. Thus, a vector of constant values can be used as set constants. An inverse transfer function VECTOR returns the elements of a set as a vector of values in ascending order. An assignment coercion allows assignment between sets of different sizes, and checks to see if the receiving set data object has an adequate maximum size (returning the null set if not). In this SET implementation, set data objects have a maximum size (number of elements in set) of 200.

```
MODULE INTEGER_SETS

INTEGER, PARAMETER :: MAX_SET_CARD = 200
```

```
 1  TYPE SET                                  ! Define SET data type
 2     PRIVATE
 3     INTEGER CARD
 4     INTEGER ELEMENT (MAX_SET_CARD)
 5  END TYPE SET

 6  INTERFACE OPERATOR (.IN.)
 7     MODULE PROCEDURE ELEMENT
 8  END INTERFACE

 9  INTERFACE OPERATOR (<=)
10     MODULE PROCEDURE SUBSET
11  END INTERFACE

12  INTERFACE OPERATOR (+)
13     MODULE PROCEDURE UNION
14  END INTERFACE

15  INTERFACE OPERATOR (-)
16     MODULE PROCEDURE DIFFERENCE
17  END INTERFACE

18  INTERFACE OPERATOR (*)
19     MODULE PROCEDURE INTERSECTION
20  END INTERFACE

21  CONTAINS

22  INTEGER FUNCTION CARDINALITY (A)    ! Returns cardinality of set A
23     TYPE (SET) A
24     CARDINALITY = A % CARD
25  END FUNCTION CARDINALITY

26  LOGICAL FUNCTION ELEMENT (X, A)           ! Determines if
27     INTEGER X                              ! element X is in set A
28     TYPE (SET) A
29     ELEMENT = ANY (A % ELEMENT (1 : A % CARD) .EQ. X)
30  END FUNCTION ELEMENT

31  FUNCTION UNION (A, B)                     ! Union of sets A and B
32     TYPE (SET) A, B, UNION
33     INTEGER J
34     UNION = A
35     DO J = 1, B % CARD
36        IF (.NOT. (B % ELEMENT (J) .IN. A)) THEN
37           IF (UNION % CARD < MAX_SET_CARD) THEN
38              UNION % CARD = UNION % CARD + 1
39              UNION % ELEMENT (UNION % CARD) = &
40                    B % ELEMENT (J)
41           ELSE
42              ! Maximum set size exceeded . . .
43           END IF
44        END IF
45     END DO
46  END FUNCTION UNION
```

```
 1  FUNCTION DIFFERENCE (A, B)            ! Difference of sets A and B
 2     TYPE (SET) A, B, DIFFERENCE
 3     INTEGER J, X
 4     DIFFERENCE % CARD = 0              ! The empty set
 5     DO J = 1, A % CARD
 6        X = A % ELEMENT (J)
 7        IF (.NOT. (X .IN. B)) DIFFERENCE = DIFFERENCE + SET (1, (/ X /))
 8     END DO
 9  END FUNCTION DIFFERENCE

10  FUNCTION INTERSECTION (A, B)        ! Intersection of sets A and B
11     TYPE (SET) A, B, INTERSECTION
12     INTERSECTION = A - (A - B)
13  END FUNCTION INTERSECTION

14  LOGICAL FUNCTION SUBSET (A, B)           ! Determines if set A is
15     TYPE (SET) A, B                       ! a subset of set B
16     INTEGER I
17     SUBSET = A % CARD <= B % CARD
18     IF (.NOT. SUBSET) RETURN              ! For efficiency
19     DO I = 1, A % CARD
20        SUBSET = SUBSET .AND. (A % ELEMENT (I) .IN. B)
21     END DO
22  END FUNCTION SUBSET

23  TYPE (SET) FUNCTION SETF (V)      ! Transfer function between a vector
24     INTEGER V (:)                  ! of elements and a set of elements
25     INTEGER J                      ! removing duplicate elements
26     SETF % CARD = 0
27     DO J = 1, SIZE (V)
28        IF (.NOT. (V (J) .IN. SETF)) THEN
29           IF (SETF % CARD < MAX_SET_CARD) THEN
30              SETF % CARD = SETF % CARD + 1
31              SETF % ELEMENT (SETF % CARD) = V (J)
32           ELSE
33              ! Maximum set size exceeded
34              EXIT
35           END IF
36        END IF
37     END DO
38  END FUNCTION SETF

39  FUNCTION VECTOR (A)               ! Transfer the values of set A
40     TYPE (SET) A                   ! into a vector in ascending order
41     INTEGER, POINTER :: VECTOR (:)
42     INTEGER I, J, K
43     ALLOCATE (VECTOR (A % CARD))
44     VECTOR = A % ELEMENT (1 : A % CARD)
```

```
    DO I = 1, A % CARD - 1          ! Use a better sort if
       DO J = I + 1, A % CARD       ! A % CARD is large
          IF (VECTOR (I) > VECTOR (J)) THEN
             K = VECTOR (J); VECTOR (J) = VECTOR (I); VECTOR (I) = K
          END IF
       END DO
    END DO
END FUNCTION VECTOR

END MODULE INTEGER_SETS
```

Examples of using INTEGER_SETS (A, B, and C are variables of type SET; X is an integer variable):

```
! Check to see if A has more than 10 elements
IF (CARDINALITY (A) > 10) ...

! Check for X an element of A but not of B
IF (X .IN. (A - B)) ...

! C is the union of A and the result of B intersected
! with the integers 1 to 100
C = A + B * SETF ((/ (I, I = 1, 100) /))

! Does A have any even numbers in the range 1:100?
IF (CARDINALITY (A * SETF ((/ (I, I = 2, 100, 2) /)) > 0) ...

PRINT *, VECTOR (B) ! Print out the elements of set B, in ascending order
```

C.12 Section 12 Notes.

C.12.1 External Procedures (12.3.2.2). Of the various types of procedures described in this section, only external procedures have global names. An implementation may wish to assign global names to other entities in the Fortran program such as internal procedures, intrinsic procedures, procedures implementing intrinsic operators, procedures implementing input/output operations, etc. If this is done, it is the responsibility of the processor to ensure that none of these names conflicts with any of the names of the external procedures or other globally named entities in a standard-conforming program. For example, this might be done by including in each such added name a character that is not allowed in a standard-conforming name.

There is a potential portability problem in a scoping unit that references an external procedure without declaring it in either an EXTERNAL statement or a procedure interface block. On a different processor, the name of that procedure may be the name of a nonstandard intrinsic procedure and the processor would be permitted to interpret those procedure references as references to that intrinsic procedure. (On that processor, the program would also be viewed as not conforming to the standard because of the references to the nonstandard intrinsic procedure.) Declaration in an EXTERNAL statement or a procedure interface block causes the references to be to the external procedure regardless of the availability of an intrinsic procedure with the same name. Note that declaration of the type of a procedure is not enough to make it external, even if the type is inconsistent with the type of the result of an intrinsic of the same name.

C.12.2 Procedures Defined by Means Other Than Fortran (12.5.3). A processor is not required to provide any means other than Fortran for defining external procedures. Among the means that might be supported are the machine assembly language, other high level languages, the Fortran language extended with nonstandard features, and the Fortran language as supported by another Fortran processor (for example, a previously existing FORTRAN 77 processor).

Procedures defined by means other than Fortran are considered external procedures because their definitions are not contained within a Fortran program unit and because they are referenced using

global names. The use of the term external should not be construed as any kind of restriction on the way in which these procedures may be defined. For example, if the means other than Fortran has its own facilities for internal and external procedures, it is permissible to use them. If the means other than Fortran can create an "internal" procedure with a global name, it is permissible for such an "internal" procedure to be considered by Fortran to be an external procedure. The means other than Fortran for defining external procedures, including any restrictions on the structure for organization of those procedures, are entirely processor dependent.

A Fortran processor may limit its support of procedures defined by means other than Fortran such that these procedures may affect entities in the Fortran environment only on the same basis as procedures written in Fortran. For example, it might prohibit the value of a local variable from being changed by a procedure reference unless that variable were one of the arguments to the procedure.

C.12.3 Procedure Interfaces (12.3). In FORTRAN 77, the interface to an external procedure was always deduced from the form of references to that procedure and any declarations of the procedure name in the referencing program unit. In this standard, features such as argument keywords and optional arguments make it impossible to deduce sufficient information about the dummy arguments from the nature of the actual arguments to be associated with them, and features such as array-valued function results and pointer function results make necessary extensions to the declaration of a procedure that cannot be done in a way that would be analogous with the handling of such declarations in FORTRAN 77. Hence, mechanisms are provided through which all the information about a procedure's interface may be made available in a scoping unit that references it. A procedure whose interface must be deduced as in FORTRAN 77 is described as having an implicit interface. A procedure whose interface is fully known is described as having an explicit interface.

A scoping unit is allowed to contain a procedure interface block for procedures that do not exist in the executable program, provided the procedure described is never referenced. The purpose of this rule is to allow implementations in which the use of a module providing procedure interface blocks describing the interface of every routine in a library would not automatically cause each of those library routines to be a part of the program referencing the module. Instead, only those library procedures actually referenced would be a part of the executable program. (In implementation terms, the mere presence of a procedure interface block would not generate an external reference in such an implementation.)

C.12.4 Argument Association and Evaluation (12.4.1). There is a significant difference between the argument association allowed in this standard and that supported by FORTRAN 77 and FORTRAN 66. In FORTRAN 77 and 66, actual arguments were limited to consecutive storage units. With the exception of assumed length character dummy arguments, the structure imposed on that sequence of storage units was always determined in the invoked procedure and not taken from the actual argument. Thus it was possible to implement FORTRAN 66 and FORTRAN 77 argument association by supplying only the location of the first storage unit (except for character arguments, where the length would also have to be supplied). However, this standard allows arguments that do not reside in consecutive storage locations (for example, an array section), and dummy arguments that assume additional structural information from the actual argument (for example, assumed-shape dummy arguments). Thus, the mechanism to implement the argument association allowed in this standard must be more general.

Because there are practical advantages to a processor that can support references to and from procedures defined by a FORTRAN 77 processor, requirements for explicit interfaces have been added to make it possible to determine whether a simple (FORTRAN 66/FORTRAN 77) argument association implementation mechanism is sufficient or whether the more general mechanism is necessary (12.3.1.1). Thus a processor can be implemented whose procedures expect the simple mechanism to be used whenever the procedure's interface is one which uses only FORTRAN 77 features and which expects the more general mechanism otherwise (for example, if there are assumed-shape or optional arguments). At the point of reference, the appropriate mechanism can be determined from the interface if it is explicit and can be assumed to be the simple mechanism if it is not. Note that if the simple mechanism is determined to be what the procedure expects, it may be necessary for the processor to allocate consecutive temporary storage for the actual argument, copy the actual argument to the temporary storage, reference the procedure using the temporary storage in

place of the actual argument, copy the contents of temporary storage back to the actual argument, and deallocate the temporary storage.

Note that while this is the specific implementation method these rules were designed to support, it is not the only one possible. For example, on some processors, it may be possible to implement the general argument association in such a way that the information involved in FORTRAN 77 argument association may be found in the same places and the "extra" information is placed so it does not disturb a procedure expecting only FORTRAN 77 argument association. With such an implementation, argument association could be translated without regard to whether the interface is explicit or implicit. Alternatively, it would be possible to disallow discontiguous arguments when calling procedures defined by the FORTRAN 77 processor and let any copying to and from contiguous storage be done explicitly in the program. Yet another possibility would be not to allow references to procedures defined by a FORTRAN 77 processor.

The provisions for expression evaluation give the processor considerable flexibility for obtaining expression values in the most efficient way possible. This includes not evaluating an operand, for example, if the value of the expression can be determined otherwise (7.1.7.1). This flexibility applies to function argument evaluation, including the order of argument evaluation, delaying argument evaluation, and omitting argument evaluation. A processor may delay the evaluation of an argument in a procedure reference until the execution of the procedure refers to the value of that argument, provided delaying the evaluation of the argument does not otherwise affect the results of the executable program. The processor may, with similar restrictions, entirely omit the evaluation of an argument not referenced in the execution of the procedure. This gives processors latitude for optimization (for example, for parallel processing).

Note that successive commas must not be used to omit optional arguments.

C.12.5 Argument Intent Specification (12.4.1.1). Argument intent specifications serve several purposes in addition to documenting the intended use of dummy arguments. A processor can check whether an INTENT (IN) dummy argument is used in a way that could redefine it. A slightly more sophisticated processor could check to see whether an INTENT (OUT) dummy argument could possibly be referenced before it is defined. If the procedure's interface is explicit, the processor can also verify that actual arguments corresponding to INTENT (OUT) or INTENT (INOUT) dummy arguments are definable. A more sophisticated processor could use this information to optimize the translation of the referencing scoping unit by taking advantage of the fact that actual arguments corresponding to INTENT (IN) dummy arguments will not be changed and that any prior value of an actual argument corresponding to an INTENT (OUT) dummy argument will not be referenced and can thus be discarded.

Note that INTENT (OUT) means that the value of the argument after invoking the procedure is entirely the result of executing that procedure. If there is any possibility that an argument should retain its current value rather than being redefined, INTENT (INOUT) should be used rather than INTENT (OUT), even if there is no explicit reference to the value of the dummy argument.

Note also that INTENT (INOUT) is not equivalent to the default. The argument corresponding to an INTENT (INOUT) dummy argument always must be definable, while an argument corresponding to a dummy argument with default intent need be definable only if the dummy argument is actually redefined.

C.12.6 Dummy Argument Restrictions (12.5.2.9). The restrictions on entities associated with dummy arguments are intended to allow a processor to translate a procedure on the assumption that each dummy argument is distinct from any other entity accessible in the procedure. This allows a variety of optimizations in the translation of the procedure, including implementations of argument association in which the value of the actual argument is maintained in a register or in local storage.

C.12.7 Pointers and Targets as Arguments. If a dummy argument is declared to be a pointer, it may be matched only by an actual argument that also is a pointer, and the characteristics of both arguments must agree. A model for such an association is that descriptor values of the actual pointer are copied to the dummy pointer. If the actual pointer has an associated target, this target becomes accessible via the dummy pointer. If the dummy pointer becomes associated with a different target during execution of the procedure, this target will be accessible via the actual pointer after the procedure completes execution. If the dummy pointer becomes associated with a local target that ceases to exist when the procedure completes, the actual pointer will be left dangling in an undefined state. Such dangling pointers must not be used.

C.12.8 The ASSOCIATED Function (13.13.13). The ASSOCIATED intrinsic function may be used to test whether a pointer is associated with a target. The one-argument form is used for this purpose. In the two-argument form, the ASSOCIATED function tests whether the pointer first argument is associated with the space that is referred to by the second argument. In most cases, it will be used to test if two pointers are associated with the same target.

C.12.9 Internal Procedure Restrictions. This standard does not allow internal procedures to be used as actual arguments, in part to simplify the problem of ensuring that internal procedures with recursive hosts access entities from the correct instance of the host. If, as an extension, a processor allows internal procedures to be used as actual arguments, the correct instance in this case is the instance in which the procedure is supplied as an actual argument, even if the corresponding dummy argument is eventually invoked from a different instance.

C.12.10 The Result Variable (12.5.2.2). The result variable is similar to any other variable local to a function subprogram. Its existence begins when execution of the function is initiated and ends when execution of the function is terminated. However, because the final value of this variable is used subsequently in the evaluation of the expression that invoked the function, an implementation may wish to defer releasing the storage occupied by that variable until after its value has been used in expression evaluation.

C.13 Section 13 Notes.

C.13.1 Summary of Features. This section is a summary of the principal array features.

C.13.1.1 Whole Array Expressions and Assignments (7.5.1.2, 7.5.1.5). An important new feature is that whole array expressions and assignments are permitted. For example, the statement

```
A = B + C * SIN (D)
```

where A, B, C, and D are arrays of the same shape, is permitted. It is interpreted element-by-element; that is, the sine function is taken on each element of D, each result is multiplied by the corresponding element of C, added to the corresponding element of B, and assigned to the corresponding element of A. Functions, including user-written functions, may be array valued and may overload scalar versions having the same name. All arrays in an expression or across an assignment must conform; that is, have exactly the same shape (number of dimensions and set of lengths in each dimension), but scalars may be included freely and these are interpreted as being broadcast to a conforming array. Expressions are evaluated before any assignment takes place.

C.13.1.2 Array Sections (2.4.7, 6.2.2.3). Whenever whole arrays may be used, it is also possible to use subarrays called "sections". For example:

```
A (:, 1:N, 2, 3:1:-1)
```

consists of a subarray containing the whole of the first dimension, positions 1 to N of the second dimension, position 2 of the third dimension and positions 1 to 3 in reverse order of the fourth dimension. This is an artificial example chosen to illustrate the different forms. Of course, the most common use is to select a row or column of an array, for example:

```
A (:, J)
```

C.13.1.3 WHERE Statement (7.5.3). The WHERE statement applies a conforming logical array as a mask on the individual operations in the expression and in the assignment. For example:

```
WHERE (A .GT. 0) B = LOG (A)
```

takes the logarithm only for positive components of A and makes assignments only in these positions.

The WHERE statement also has a block form (WHERE construct).

C.13.1.4 Automatic and Allocatable Arrays (5.1, 5.1.2.4.3). A major advance for writing modular software is the presence of automatic arrays, created on entry to a subprogram and destroyed on return, and allocatable arrays whose rank is fixed but whose actual size and lifetime is fully under the programmer's control through explicit ALLOCATE and DEALLOCATE statements. The declarations

```
SUBROUTINE X (N, A, B)
   REAL WORK (N, N); REAL, ALLOCATABLE :: HEAP (:, :)
```

specify an automatic array WORK and an allocatable array HEAP. Note that a stack is an adequate storage mechanism for the implementation of automatic arrays, but a heap will be needed for allocatable arrays.

C.13.1.5 Array Constructors (4.5). Arrays, and in particular array constants, may be constructed with array constructors exemplified by:

```
(/ 1.0, 3.0, 7.2 /)
```

which is a rank-one array of size 3,

```
(/ (1.3, 2.7, L = 1, 10), 7.1 /)
```

which is a rank-one array of size 21 and contains the pair of real constants 1.3 and 2.7 repeated 10 times followed by 7.1, and

```
(/ (I, I = 1, N) /)
```

which contains the integers 1, 2, ..., N. Only rank-one arrays may be constructed in this way, but higher dimensional arrays may be made from them by means of the intrinsic function RESHAPE.

C.13.1.6 Intrinsic Functions. All of the FORTRAN 77 intrinsic functions and all of the scalar intrinsic functions that have been added to the language have been extended to be applicable to arrays. Each such function is applied element-by-element to produce an array of the same shape. In addition, the following array intrinsics have been added, many of which return array-valued results.

C.13.1.6.1 Vector and Matrix Multiply Functions.

`DOT_PRODUCT (VECTOR_A, VECTOR_B)`	Dot product of two arrays
`MATMUL (MATRIX_A, MATRIX_B)`	Matrix multiplication

C.13.1.6.2 Array Reduction Functions.

`ALL (MASK, DIM)`	True if all values are true
`ANY (MASK, DIM)`	True if any value is true
`COUNT (MASK, DIM)`	Number of true elements in an array.
`MAXVAL (ARRAY, DIM, MASK)`	Maximum value in an array
`MINVAL (ARRAY, DIM, MASK)`	Minimum value in an array
`PRODUCT (ARRAY, DIM, MASK)`	Product of array elements
`SUM (ARRAY, DIM, MASK)`	Sum of array elements

C.13.1.6.3 Array Inquiry Functions.

`ALLOCATED (ARRAY)`	Array allocation status
`LBOUND (ARRAY, DIM)`	Declared lower dimension bounds of an array
`SHAPE (SOURCE)`	Declared shape of an array or scalar
`SIZE (ARRAY, DIM)`	Declared total number of array elements
`UBOUND (ARRAY, DIM)`	Declared upper dimension bounds of an array

C.13.1.6.4 Array Construction Functions.

`MERGE (TSOURCE, FSOURCE, MASK)`	Merge under mask
`PACK (ARRAY, MASK, VECTOR)`	Pack an array into a vector under a mask
`SPREAD (SOURCE, DIM, NCOPIES)`	Replicates an array by adding a dimension
`UNPACK (VECTOR, MASK, FIELD)`	Unpack a vector into an array under a mask

C.13.1.6.5 Array Reshape Function.

`RESHAPE (SOURCE, SHAPE, PAD, ORDER)`	Reshape an array

C.13.1.6.6 Array Manipulation Functions.

`CSHIFT (ARRAY, SHIFT, DIM)`	Circular shift
`EOSHIFT (ARRAY, SHIFT, BOUNDARY, DIM)`	End-off shift
`TRANSPOSE (MATRIX)`	Transpose of matrix

C.13.1.6.7 Array Location Functions.

`MAXLOC (ARRAY, MASK)`	Location of a maximum value in an array
`MINLOC (ARRAY, MASK)`	Location of a minimum value in an array

C.13.2 Examples. The array features have the potential to simplify the way that almost any array-using program is conceived and written. Many algorithms involving arrays can now be written conveniently as a series of computations with whole arrays.

C.13.2.1 Unconditional Array Computations. At the simplest level, statements such as

```
A = B + C
```

or

```
S = SUM (A)
```

can take the place of entire DO loops. The loops were required to perform array addition or to sum all the elements of an array.

Further examples of unconditional operations on arrays that are simple to write are:

matrix multiply	P = MATMUL (Q, R)
largest array element	L = MAXVAL (P)
factorial N	F = PRODUCT ((/ (K, K = 2, N) /))

The Fourier sum $F = \sum_{i=1}^{N} a_i \times \cos x_i$ may also be computed without writing a DO loop if one makes use of the element-by-element definition of array expressions as described in Section 7. Thus, we can write

```
F = SUM (A * COS (X))
```

The successive stages of calculation of F would then involve the arrays:

```
A              =   (/ A (1), ..., A (N) /)
X              =   (/ X (1), ..., X (N) /)
COS (X)        =   (/ COS (X (1)), ..., COS (X (N)) /)
A * COS (X)    =   (/ A (1) * COS (X (1)), ..., A (N) * COS (X (N)) /)
```

The final scalar result is obtained simply by summing the elements of the last of these arrays. Thus, the processor is dealing with arrays at every step of the calculation.

C.13.2.2 Conditional Array Computations. Suppose we wish to compute the Fourier sum in the above example, but to include only those terms $a(i)\cos x(i)$ that satisfy the condition that the coefficient $a(i)$ is less than 0.01 in absolute value. More precisely, we are now interested in evaluating the conditional Fourier sum

$$CF = \sum_{|a_i| < 0.01} a_i \times \cos x_i$$

where the index runs from 1 to N as before.

This can be done by using the MASK parameter of the SUM function, which restricts the summation of the elements of the array A * COS (X) to those elements that correspond to true elements of MASK. Clearly, the mask required is the logical array expression ABS (A) .LT. 0.01. Note that the stages of evaluation of this expression are:

```
A                =   (/ A (1), ..., A (N) /)
ABS (A)          =   (/ ABS (A (1)), ..., ABS (A (N)) /)
ABS (A) .LT. 0.01  =   (/ ABS (A (1) .LT. 0.01, ..., ABS (A (N)) .LT. 0.01 /)
```

The conditional Fourier sum we arrive at is:

```
CF = SUM (A * COS (X), MASK = ABS (A) .LT. 0.01)
```

If the mask is all false, the value of CF is zero.

The use of a mask to define a subset of an array is crucial to the action of the WHERE statement. Thus for example, to set an entire array to zero, we may write simply A = 0; but to set only the negative elements to zero, we need to write the conditional assignment

```
WHERE (A .LT. 0)  A = 0
```

The WHERE statement complements ordinary array assignment by providing array assignment to any subset of an array that can be restricted by a logical expression.

In the Ising model described below, the WHERE statement predominates in use over the ordinary array assignment statement.

C.13.2.3 A Simple Program: The Ising Model. The Ising model is a well-known Monte Carlo simulation in 3-dimensional Euclidean space which is useful in certain physical studies. We will consider in some detail how this might be programmed. The model may be described in terms of a logical array of shape N by N by N. Each gridpoint is a single logical variable which is to be interpreted as either an up-spin (true) or a down-spin (false).

The Ising model operates by passing through many successive states. The transition to the next state is governed by a local probabilistic process. At each transition, all gridpoints change state simultaneously. Every spin either flips to its opposite state or not according to a rule that depends only on the states of its 6 nearest neighbors in the surrounding grid. The neighbors of gridpoints on the boundary faces of the model cube are defined by assuming cubic periodicity. In effect, this extends the grid periodically by replicating it in all directions throughout space.

The rule states that a spin is flipped to its opposite parity for certain gridpoints where a mere 3 or fewer of the 6 nearest neighbors currently have the same parity as it does. Also, the flip is executed only with probability P (4), P (5), or P (6) if as many as 4, 5, or 6 of them have the same parity as it does. (The rule seems to promote neighborhood alignments that may presumably lead to equilibrium in the long run.)

C.13.2.3.1 Problems To Be Solved. Some of the programming problems that we will need to solve in order to translate the Ising model into Fortran statements using entire arrays are:

(1) Counting nearest neighbors that have the same spin;

(2) Providing an array-valued function to return an array of random numbers; and

(3) Determining which gridpoints are to be flipped.

C.13.2.3.2 Solutions in Fortran. The arrays needed are:

```
LOGICAL ISING (N, N, N), FLIPS (N, N, N)
INTEGER ONES (N, N, N), COUNT (N, N, N)
REAL THRESHOLD (N, N, N)
```

The array-valued function needed is:

```
FUNCTION RAND (N)
REAL RAND (N, N, N)
```

The transition probabilities are specified in the array

```
REAL P (6)
```

The first task is to count the number of nearest neighbors of each gridpoint *g* that have the same spin as *g*.

Assuming that ISING is given to us, the statements

```
ONES = 0
WHERE (ISING) ONES = 1
```

make the array ONES into an exact analog of ISING in which 1 stands for an up-spin and 0 for a down-spin.

The next array we construct, COUNT, will record for every gridpoint of ISING the number of spins to be found among the 6 nearest neighbors of that gridpoint. COUNT will be computed by adding together 6 arrays, one for each of the 6 relative positions in which a nearest neighbor is found. Each of the 6 arrays is obtained from the ONES array by shifting the ONES array one place circularly along one of its dimensions. This use of circular shifting imparts the cubic periodicity.

```
COUNT = CSHIFT (ONES, SHIFT = -1, DIM = 1)  &
      + CSHIFT (ONES, SHIFT =  1, DIM = 1)  &
      + CSHIFT (ONES, SHIFT = -1, DIM = 2)  &
      + CSHIFT (ONES, SHIFT =  1, DIM = 2)  &
      + CSHIFT (ONES, SHIFT = -1, DIM = 3)  &
      + CSHIFT (ONES, SHIFT =  1, DIM = 3)
```

At this point, COUNT contains the count of nearest neighbor up-spins even at the gridpoints where the Ising model has a down-spin. But we want a count of down-spins at those gridpoints, so we correct COUNT at the down (false) points of ISING by writing:

```
WHERE (.NOT. ISING)  COUNT = 6 - COUNT
```

Our object now is to use these counts of what may be called the "like-minded nearest neighbors" to decide which gridpoints are to be flipped. This decision will be recorded as the true elements of an array FLIP. The decision to flip will be based on the use of uniformly distributed random numbers from the interval $0 \leq p < 1$. These will be provided at each gridpoint by the array-valued function RAND. The flip will occur at a given point if and only if the random number at that point is less than a certain threshold value. In particular, by making the threshold value equal to 1 at the

points where there are 3 or fewer like-minded nearest neighbors, we guarantee that a flip occurs at those points (because p is always less than 1). Similarly, the threshold values corresponding to counts of 4, 5, and 6 are set to P (4), P (5), and P (6) in order to achieve the desired probabilities of a flip at those points (P (4), P (5), and P (6) are input parameters in the range 0 to 1).

The thresholds are established by the statements:

```
THRESHOLD = 1.0
WHERE (COUNT .EQ. 4) THRESHOLD = P (4)
WHERE (COUNT .EQ. 5) THRESHOLD = P (5)
WHERE (COUNT .EQ. 6) THRESHOLD = P (6)
```

and the spins that are to be flipped are located by the statement:

```
FLIPS = RAND (N) .LE. THRESHOLD
```

All that remains to complete one transition to the next state of the ISING model is to reverse the spins in ISING wherever FLIPS is true:

```
WHERE (FLIPS)  ISING = .NOT. ISING
```

C.13.2.3.3 The Complete Fortran Subroutine. The complete code, enclosed in a subroutine that performs a sequence of transitions, is as follows:

```
SUBROUTINE TRANSITION (N, ISING, ITERATIONS, P)

   LOGICAL ISING (N, N, N), FLIPS (N, N, N)
   INTEGER ONES (N, N, N), COUNT (N, N, N)
   REAL THRESHOLD (N, N, N), P (6)

   DO I = 1, ITERATIONS
      ONES = 0
      WHERE (ISING)  ONES = 1
      COUNT = CSHIFT (ONES, -1, 1) + CSHIFT (ONES, 1, 1) &
            + CSHIFT (ONES, -1, 2) + CSHIFT (ONES, 1, 2) &
            + CSHIFT (ONES, -1, 3) + CSHIFT (ONES, 1, 3)
      WHERE (.NOT. ISING)  COUNT = 6 - COUNT
      THRESHOLD = 1.0
      WHERE (COUNT .EQ. 4)  THRESHOLD = P (4)
      WHERE (COUNT .EQ. 5)  THRESHOLD = P (5)
      WHERE (COUNT .EQ. 6)  THRESHOLD = P (6)
      FLIPS = RAND (N) .LE. THRESHOLD
      WHERE (FLIPS)  ISING = .NOT. ISING
   END DO

CONTAINS
   FUNCTION RAND (N)
      REAL RAND (N, N, N)
      CALL RANDOM (HARVEST = RAND)
      RETURN
   END FUNCTION RAND
END
```

C.13.2.3.4 Reduction of Storage. The array ISING could be removed (at some loss of clarity) by representing the model in ONES all the time. The array FLIPS can be avoided by combining the two statements that use it as:

```
WHERE (RAND (N) .LE. THRESHOLD)  ISING = .NOT. ISING
```

but an extra temporary array would probably be needed. Thus, the scope for saving storage while performing whole array operations is limited. If N is small, this will not matter and the use of whole array operations is likely to lead to good execution speed. If N is large, storage may be very

important and adequate efficiency will probably be available by performing the operations plane by plane. The resulting code is not as elegant, but all the arrays except ISING will have size of order N^2 instead of N^3.

C.13.3 FORmula TRANslation and Array Processing. Many mathematical formulas can be translated directly into Fortran by use of the array processing features.

We assume the following array declarations:

```
REAL X (N), A (M, N)
```

Some examples of mathematical formulas and corresponding Fortran expressions follow.

C.13.3.1 A Sum of Products. The expression

$$\sum_{j=1}^{N} \prod_{i=1}^{M} a_{ij}$$

can be formed using the Fortran expression

```
SUM (PRODUCT (A, DIM=1))
```

The argument DIM=1 means that the product is to be computed down each column of A. If A had the value

$$\begin{bmatrix} B & C & D \\ E & F & G \end{bmatrix}$$

the result of this expression is BE + CF + DG.

C.13.3.2 A Product of Sums. The expression

$$\prod_{i=1}^{M} \sum_{j=1}^{N} a_{ij}$$

can be formed using the Fortran expression

```
PRODUCT (SUM (A, DIM = 2))
```

The argument DIM = 2 means that the sum is to be computed along each row of A. If A had the value

$$\begin{bmatrix} B & C & D \\ E & F & G \end{bmatrix}$$

the result of this expression is (B+C+D)(E+F+G).

C.13.3.3 Addition of Selected Elements. The expression

$$\sum_{x_i > 0.0} x_i$$

can be formed using the Fortran expression

```
SUM (X, MASK = X .GT. 0.0)
```

The mask locates the positive elements of the array of rank one. If X has the vector value (0.0, –0.1, 0.2, 0.3, 0.2, –0.1, 0.0), the result of this expression is 0.7.

C.13.4 Sum of Squared Residuals. The expression

$$\sum_{i=1}^{N} (x_i - x_{\text{mean}})^2$$

can be formed using the Fortran statements

```
XMEAN = SUM (X) / SIZE (X)
SS = SUM ((X - XMEAN) ** 2)
```

Thus, SS is the sum of the squared residuals.

C.13.5 Vector Norms: Infinity-Norm and One-Norm. The infinity-norm of vector X = (X (1), ..., X (N)) is defined as the largest of the numbers ABS (X (1)), ..., ABS (X (N)) and therefore has the value MAXVAL (ABS (X)).

The one-norm of vector X is defined as the *sum* of the numbers ABS (X (1)), ..., ABS (X (N)) and therefore has the value SUM (ABS (X)).

C.13.6 Matrix Norms: Infinity-Norm and One-Norm. The infinity-norm of the matrix A = (A (I, J)) is the largest row-sum of the matrix ABS (A (I, J)) and therefore has the value MAXVAL (SUM (ABS , DIM = 2)).

The one-norm of the matrix A = (A (I, J)) is the largest column-sum of the matrix ABS (A (I, J)) and therefore has the value MAXVAL (SUM (ABS (A), DIM = 1)).

C.13.7 Logical Queries. The intrinsic functions allow quite complicated questions about tabular data to be answered without use of loops or conditional constructs. Consider, for example, the questions asked below about a simple tabulation of students' test scores.

Suppose the rectangular table T (M, N) contains the test scores of M students who have taken N different tests. T is an integer matrix with entries in the range 0 to 100.

Example: The scores on 4 tests made by 3 students are held as the table

$$T = \begin{bmatrix} 85 & 76 & 90 & 60 \\ 71 & 45 & 50 & 80 \\ 66 & 45 & 21 & 55 \end{bmatrix}$$

Question: What is each student's top score?

Answer: MAXVAL (T, DIM = 2); in the example: [90, 80, 66].

Question: What is the average of all the scores?

Answer: SUM (T) / SIZE (T); in the example: 62.

Question: How many of the scores in the table are above average?

Answer: ABOVE = T .GT. SUM (T) / SIZE (T); N = COUNT (ABOVE); in the example: ABOVE is the logical array (t = true, . = false):

$$\begin{bmatrix} t & t & t & . \\ t & . & . & t \\ t & . & . & . \end{bmatrix}$$

and COUNT (ABOVE) is 6.

Question: What was the lowest score in the above-average group of scores?

Answer: MINVAL (T, MASK = ABOVE), where ABOVE is as defined previously; in the example: 66.

Question: Was there a student whose scores were all above average?

Answer: With ABOVE as previously defined, the answer is yes or no according as the value of the expression ANY (ALL (ABOVE, DIM = 2)) is true or false; in the example, the answer is no.

C.13.8 Parallel Computations. The most straightforward kind of parallel processing is to do the same thing at the same time to many operands. Matrix addition is a good example of this very simple form of parallel processing. Thus, the array assignment A = B + C specifies that corresponding elements of the identically-shaped arrays B and C be added together in parallel and that the resulting sums be assigned in parallel to the array A.

The process being done in parallel in the example of matrix addition is of course the process of addition; the array feature that implements matrix addition as a parallel process is the element-by-element evaluation of array expressions.

These observations lead us to look to element-by-element computation as a means of implementing other simple parallel processing algorithms.

C.13.9 Example of Element-by-Element Computation. Several polynomials of the same degree may be evaluated at the same point by arranging their coefficients as the rows of a matrix and applying Horner's method for polynomial evaluation to the columns of the matrix so formed.

The procedure is illustrated by the code to evaluate the three cubic polynomials

$$P(t) = 1+2t - 3t^2 + 4t^3$$

$$Q(t) = 2-3t + 4t^2 - 5t^3$$

$$R(t) = 3+4t - 5t^2 + 6t^3$$

in parallel at the point t = X and to place the resulting vector of numbers [P (X), Q (X), R (X)] in the real array RESULT (3).

The code to compute RESULT is just the one statement

```
RESULT = M (:, 1) + X * (M (:, 2) + X * (M (:, 3) + X * M (:, 4)))
```

where M represents the matrix M (3, 4) with value

$$\begin{bmatrix} 1 & 2 & -3 & 4 \\ 2 & -3 & 4 & -5 \\ 3 & 4 & -5 & 6 \end{bmatrix}$$

C.13.10 Bit Manipulation and Inquiry Procedures. The procedures IOR, IAND, NOT, IEOR, ISHFT, ISHFTC, IBITS, MVBITS, BTEST, IBSET, and IBCLR are defined by MIL-STD 1753 for scalar arguments and are extended in this standard to accept array arguments and to return array-valued results.

C.14 Section 14 Notes.

C.14.1 Storage Association of Zero-Sized Objects. Zero-sized objects may occur in a storage association context as the result of changing a parameter. For example, a program might contain the following declarations:

```
INTEGER, PARAMETER :: PROBSIZE = 10
INTEGER, PARAMETER :: ARRAYSIZE = PROBSIZE * 100
REAL, DIMENSION (ARRAYSIZE) :: X
INTEGER, DIMENSION (ARRAYSIZE) :: IX
   ...
COMMON / EXAMPLE / A, B, C, X, Y, Z
EQUIVALENCE (X, IX)
   ...
```

If the first statement is subsequently changed to set PROBSIZE to zero, the program still will conform to the standard.

APPENDIX D. SYNTAX RULES

This appendix contains two parts.

The first part is an extraction of all syntax rules and constraints in the order in which they occur in the standard.

The second part is a cross reference with an entry for each terminal symbol and each nonterminal symbol in the syntax rules. The symbols are sorted alphabetically within three categories: nonterminal symbols that are defined, nonterminal symbols that are not defined, and terminal symbols.

Note that except for those ending with *-name*, the only undefined nonterminal symbols are *letter*, *digit*, *special-character*, and *rep-char*. As described in 1.5.2, symbols ending with *-name* are defined by the rule:

xyz-name is *name*

Before processing the cross references, all occurrences of *-list* and *scalar-* in the symbol names were removed.

D.1 Syntax Rules and Constraints. Each of the following sections contains the syntax rules and constraints from one section of the standard.

D.1.1 Introduction.

D.1.2 Fortran Terms and Concepts.

R201 *executable-program* is *program-unit*
[*program-unit*] ...

R202 *program-unit* is *main-program*
or *external-subprogram*
or *module*
or *block-data*

R1101 *main-program* is [*program-stmt*]
[*specification-part*]
[*execution-part*]
[*internal-subprogram-part*]
end-program-stmt

R203 *external-subprogram* is *function-subprogram*
or *subroutine-subprogram*

R1218 *function-subprogram* is *function-stmt*
[*specification-part*]
[*execution-part*]
[*internal-subprogram-part*]
end-function-stmt

R1222 *subroutine-subprogram* is *subroutine-stmt*
[*specification-part*]
[*execution-part*]
[*internal-subprogram-part*]
end-subroutine-stmt

R1104 *module* is *module-stmt*
[*specification-part*]
[*module-subprogram-part*]
end-module-stmt

R1110 *block-data* is *block-data-stmt*
[*specification-part*]
end-block-data-stmt

R204 *specification-part* is [*use-stmt*] ...
[*implicit-part*]
[*declaration-construct*] ...

R205 *implicit-part* is [*implicit-part-stmt*] ...
implicit-stmt

R206 *implicit-part-stmt* is *implicit-stmt*
or *parameter-stmt*
or *format-stmt*
or *entry-stmt*

R207 *declaration-construct* is *derived-type-def*
or *interface-block*
or *type-declaration-stmt*
or *specification-stmt*
or *parameter-stmt*
or *format-stmt*
or *entry-stmt*
or *stmt-function-stmt*

R208 *execution-part* is *executable-construct*
[*execution-part-construct*] ...

R209 *execution-part-construct* is *executable-construct*
or *format-stmt*
or *data-stmt*
or *entry-stmt*

R210 *internal-subprogram-part* is *contains-stmt*
internal-subprogram
[*internal-subprogram*] ...

R211 *internal-subprogram* is *function-subprogram*
or *subroutine-subprogram*

R212 *module-subprogram-part* is *contains-stmt*
module-subprogram
[*module-subprogram*] ...

R213 *module-subprogram* is *function-subprogram*
or *subroutine-subprogram*

R214 *specification-stmt* is *access-stmt*
or *allocatable-stmt*
or *common-stmt*
or *data-stmt*
or *dimension-stmt*
or *equivalence-stmt*
or *external-stmt*
or *intent-stmt*
or *intrinsic-stmt*
or *namelist-stmt*
or *optional-stmt*
or *pointer-stmt*
or *save-stmt*
or *target-stmt*

R215 *executable-construct* is *action-stmt*
or *case-construct*
or *do-construct*
or *if-construct*
or *where-construct*

R216 *action-stmt* is *allocate-stmt*
or *assignment-stmt*
or *backspace-stmt*
or *call-stmt*
or *close-stmt*
or *computed-goto-stmt*
or *continue-stmt*
or *cycle-stmt*
or *deallocate-stmt*
or *endfile-stmt*
or *end-function-stmt*
or *end-program-stmt*
or *end-subroutine-stmt*
or *exit-stmt*
or *goto-stmt*
or *if-stmt*
or *inquire-stmt*
or *nullify-stmt*
or *open-stmt*
or *pointer-assignment-stmt*
or *print-stmt*
or *read-stmt*
or *return-stmt*
or *rewind-stmt*
or *stop-stmt*
or *where-stmt*
or *write-stmt*
or *arithmetic-if-stmt*
or *assign-stmt*
or *assigned-goto-stmt*
or *pause-stmt*

Constraint: An *execution-part-construct* must not contain an *end-function-stmt*, an *end-program-stmt*, or an *end-subroutine-stmt*.

D.1.3 Characters, Lexical Tokens, and Source Form.

R301 *character* is *alphanumeric-character*
or *special-character*

R302 *alphanumeric-character* is *letter*
or *digit*
or *underscore*

R303 *underscore* is _

R304 *name* is *letter* [*alphanumeric-character*] ...

Constraint: The maximum length of a *name* is 31 characters.

R305 *constant* is *literal-constant*
or *named-constant*

R306 *literal-constant* is *int-literal-constant*
or *real-literal-constant*
or *complex-literal-constant*
or *logical-literal-constant*
or *char-literal-constant*
or *boz-literal-constant*

R307 *named-constant* is *name*

R308 *int-constant* is *constant*

Constraint: *int-constant* must be of type integer.

R309 *char-constant* is *constant*

Constraint: *char-constant* must be of type character.

R310 *intrinsic-operator* is *power-op*
or *mult-op*
or *add-op*
or *concat-op*
or *rel-op*
or *not-op*
or *and-op*
or *or-op*
or *equiv-op*

R708 *power-op* is **

R709 *mult-op* is *
or /

R710 *add-op* is +
or -

R712 *concat-op* is //

R714 *rel-op* is .EQ.
or .NE.
or .LT.
or .LE.
or .GT.
or .GE.
or ==
or /=
or <
or <=
or >
or >=

R719 *not-op* is .NOT.

R720 *and-op* is .AND.

R721 *or-op* is .OR.

R722 *equiv-op* is .EQV.
or .NEQV.

R311 *defined-operator* is *defined-unary-op*
or *defined-binary-op*
or *generic-intrinsic-op*

R704 *defined-unary-op* is . *letter* [*letter*] ... .

R724 *defined-binary-op* is . *letter* [*letter*] ... .

R312 *generic-intrinsic-op* is *intrinsic-operator*

Constraint: A *defined-unary-op* and a *defined-binary-op* must not contain more than 31 letters and must not be the same as any *intrinsic-operator* or *logical-literal-constant*.

R313 *label* is *digit* [*digit* [*digit* [*digit* [*digit*]]]]

Constraint: At least one digit in a *label* must be nonzero.

D.1.4 Intrinsic and Derived Data Types.

R401 *signed-digit-string* is [*sign*] *digit-string*

R402 *digit-string* is *digit* [*digit*] ...

R403 *signed-int-literal-constant* is [*sign*] *int-literal-constant*

R404 *int-literal-constant* is *digit-string* [_ *kind-param*]

R405 *kind-param* is *digit-string*
or *scalar-int-constant-name*

R406 *sign* is +
or –

Constraint: The value of *kind-param* must be nonnegative.

Constraint: The value of *kind-param* must specify a representation method that exists on the processor.

R407 *boz-literal-constant* is *binary-constant*
or *octal-constant*
or *hex-constant*

Constraint: A *boz-literal-constant* may appear only in a DATA statement.

R408 *binary-constant* is B ' *digit* [*digit*] ... '
or B " *digit* [*digit*] ... "

Constraint: *digit* must have one of the values 0 or 1.

R409 *octal-constant* is O ' *digit* [*digit*] ... '
or O " *digit* [*digit*] ... "

Constraint: *digit* must have one of the values 0 through 7.

R410 *hex-constant* is Z ' *hex-digit* [*hex-digit*] ... '
or Z " *hex-digit* [*hex-digit*] ... "

R411 *hex-digit* is digit
or A
or B
or C
or D
or E
or F

R412 *signed-real-literal-constant* is [*sign*] *real-literal-constant*

R413 *real-literal-constant* is *significand* [*exponent-letter exponent*] [_ *kind-param*]
or *digit-string exponent-letter exponent* [_ *kind-param*]

R414 *significand* is *digit-string* . [*digit-string*]
or . *digit-string*

R415 *exponent-letter* is E
or D

R416 *exponent* is *signed-digit-string*

Constraint: If both *kind-param* and *exponent-letter* are present, *exponent-letter* must be E.

Constraint: The value of *kind-param* must specify an approximation method that exists on the processor.

R417 *complex-literal-constant* is (*real-part* , *imag-part*)

R418 *real-part* is *signed-int-literal-constant*

or *signed-real-literal-constant*

R419 *imag-part* is *signed-int-literal-constant*
or *signed-real-literal-constant*

R420 *char-literal-constant* is [*kind-param* _] ' [*rep-char*] ... '
or [*kind-param* _] " [*rep-char*] ... "

Constraint: The value of *kind-param* must specify a representation method that exists on the processor.

R421 *logical-literal-constant* is .TRUE. [_ *kind-param*]
or .FALSE. [_ *kind-param*]

Constraint: The value of *kind-param* must specify a representation method that exists on the processor.

R422 *derived-type-def* is *derived-type-stmt*
[*private-sequence-stmt*] ...
component-def-stmt
[*component-def-stmt*] ...
end-type-stmt

R423 *private-sequence-stmt* is PRIVATE
or SEQUENCE

R424 *derived-type-stmt* is TYPE [, *access-spec* ::] *type-name*

Constraint: The same *private-sequence-stmt* must not appear more than once in a given *derived-type-def*.

Constraint: If SEQUENCE is present, all derived types specified in component definitions must be sequence types.

Constraint: An *access-spec* (5.1.2.2) or a PRIVATE statement within the definition is permitted only if the type definition is within the specification part of a module.

Constraint: If a component of a derived type is of a type declared to be private, either all components of the derived type must be private or the derived type must be private.

Constraint: A derived type *type-name* must not be the same as the name of any intrinsic type nor the same as any other accessible derived *type-name*.

R425 *end-type-stmt* is END TYPE [*type-name*]

Constraint: If END TYPE is followed by a *type-name*, the *type-name* must be the same as that in the corresponding *derived-type-stmt*.

R426 *component-def-stmt* is *type-spec* [[, *component-attr-spec-list*] ::] ■
■ *component-decl-list*

R427 *component-attr-spec* is POINTER
or DIMENSION (*component-array-spec*)

Constraint: No *component-attr-spec* may appear more than once in a given *component-def-stmt*.

Constraint: If the POINTER attribute is not specified for a component, a *type-spec* in the *component-def-stmt* must specify an intrinsic type or a previously defined derived type.

Constraint: If the POINTER attribute is specified for a component, a *type-spec* in the *component-def-stmt* must specify an intrinsic type or any accessible derived type including the type being defined.

R428 *component-array-spec* is *explicit-shape-spec-list*
or *deferred-shape-spec-list*

R429 *component-decl* is *component-name* [(*component-array-spec*)] ■

■ [* *char-length*]

Constraint: If the POINTER attribute is not specified, each *component-array-spec* must be an *explicit-shape-spec-list*.

Constraint: If the POINTER attribute is specified, each *component-array-spec* must be a *deferred-shape-spec-list*.

Constraint: The * *char-length* option is permitted only if the type specified is character.

Constraint: A *char-length* in a *component-decl* must be an integer constant expression.

Constraint: Each bound in the *explicit-shape-spec* (R428) must be an integer constant expression.

R430 *structure-constructor* is *type-name* (*expr-list*)

R431 *array-constructor* is (/ *ac-value-list* /)

R432 *ac-value* is *expr*
or *ac-implied-do*

R433 *ac-implied-do* is (*ac-value-list* , *ac-implied-do-control*)

R434 *ac-implied-do-control* is *ac-do-variable* = *scalar-int-expr* , ■
▩ *scalar-int-expr* [, *scalar-int-expr*]

R435 *ac-do-variable* is *scalar-int-variable*

Constraint: *ac-do-variable* must be a named variable.

Constraint: Each *ac-value* in the sequence must have the same type and type parameters.

D.1.5 Data Object Declarations and Specifications.

R501 *type-declaration-stmt* is *type-spec* [[, *attr-spec*] ... ::] *entity-decl-list*

R502 *type-spec* is INTEGER [*kind-selector*]
or REAL [*kind-selector*]
or DOUBLE PRECISION
or COMPLEX [*kind-selector*]
or CHARACTER [*char-selector*]
or LOGICAL [*kind-selector*]
or TYPE (*type-name*)

R503 *attr-spec* is PARAMETER
or *access-spec*
or ALLOCATABLE
or DIMENSION (*array-spec*)
or EXTERNAL
or INTENT (*intent-spec*)
or INTRINSIC
or OPTIONAL
or POINTER
or SAVE
or TARGET

R504 *entity-decl* is *object-name* [(*array-spec*)] ■
■ [* *char-length*] [= *initialization-expr*]
or *function-name* [(*array-spec*)] [* *char-length*]

R505 *kind-selector* is ([KIND =] *scalar-int-initialization-expr*)

Constraint: The same *attr-spec* must not appear more than once in a given *type-declaration-stmt*.

Constraint: The *function-name* must be the name of an external function, an intrinsic function, a function dummy procedure, or a statement function.

Constraint: The = *initialization-expr* must appear if the statement contains a PARAMETER attribute (5.1.2.1).

Constraint: If = *initialization-expr* appears, a double colon separator must appear before the *entity-decl-list*.

Constraint: The = *initialization-expr* must not appear if *object-name* is a dummy argument, a function result, an object in a named common block unless the type declaration is in a block data program unit, an object in blank common, an allocatable object, a pointer, an external name, an intrinsic name, or an automatic object.

Constraint: The * *char-length* option is permitted only if the type specified is character.

Constraint: The ALLOCATABLE attribute may be used only when declaring an array that is not a dummy argument or a function result.

Constraint: An array declared with a POINTER or an ALLOCATABLE attribute must be specified with an *array-spec* that is a *deferred-shape-spec-list* (5.1.2.4.3).

Constraint: The *array-spec* for a *function-name* that does not have the pointer attribute must be an *explicit-shape-spec-list*.

Constraint: The *array-spec* for a *function-name* that does have the pointer attribute must be a *deferred-shape-spec-list*.

Constraint: An object must not have both the TARGET attribute and the PARAMETER attribute.

Constraint: If the POINTER attribute is specified, the INTENT, EXTERNAL, and INTRINSIC attributes must not be specified.

Constraint: If the TARGET attribute is specified, The EXTERNAL and INTRINSIC attributes must not be specified.

Constraint: The PARAMETER attribute must not be specified for dummy arguments, pointers, functions, or objects in a common block.

Constraint: The INTENT and OPTIONAL attributes may be specified only for dummy arguments.

Constraint: An entity must not have the PUBLIC attribute if its type has the PRIVATE attribute.

Constraint: The SAVE attribute must not be specified for an object that is in a common block, a dummy argument, a procedure, a function result, or an automatic data object.

Constraint: An entity must not have the EXTERNAL attribute if it has the INTRINSIC attribute.

Constraint: An entity in a *type-declaration-stmt* must not have the EXTERNAL or INTRINSIC attribute specified unless it is a function.

Constraint: An array must not have both the ALLOCATABLE attribute and the POINTER attribute.

Constraint: An entity must not be given explicitly any attribute more than once in a scoping unit.

Constraint: The value specified in a *kind-selector* must be nonnegative.

R506 *char-selector* is *length-selector*
or ([LEN=] *type-param-value* , ■
■ [KIND=] *scalar-int-initialization-expr*)
or (KIND= *scalar-int-initialization-expr* ■
■ [, LEN= *type-param-value*])

R507 *length-selector* is ([LEN =] *type-param-value*)
or * *char-length* [,]

R508 *char-length* is (*type-param-value*)
or *scalar-int-literal-constant*

Constraint: The optional comma in a *length-selector* is permitted only if no double colon separator appears in the *type-declaration-stmt*.

R509 *type-param-value* **is** *specification-expr*
or *

R510 *access-spec* **is** PUBLIC
or PRIVATE

Constraint: An *access-spec* attribute may appear only in the *specification-part* of a module.

R511 *intent-spec* **is** IN
or OUT
or INOUT

Constraint: The INTENT attribute may appear only in the *specification-part* of a subprogram or interface body (12.3.2.1).

Constraint: The INTENT attribute must not be specified for a dummy argument that is a dummy procedure or a dummy pointer.

R512 *array-spec* **is** *explicit-shape-spec-list*
or *assumed-shape-spec-list*
or *deferred-shape-spec-list*
or *assumed-size-spec*

Constraint: The maximum rank is seven.

R513 *explicit-shape-spec* **is** [*lower-bound* :] *upper-bound*

R514 *lower-bound* **is** *scalar-int-expr*

R515 *upper-bound* **is** *scalar-int-expr*

Constraint: An explicit-shape array whose bounds depend on the values of nonconstant expressions must be a dummy argument, a function result, or an automatic array of a procedure.

Constraint: The bounds in an explicit-shape array declaration must be specification expressions (7.1.6.2).

R516 *assumed-shape-spec* **is** [*lower-bound*] :

R517 *deferred-shape-spec* **is** :

R518 *assumed-size-spec* **is** [*explicit-shape-spec-list* ,] [*lower-bound* :] *

Constraint: The function name of an array-valued function must not be declared as an assumed-size array.

R519 *intent-stmt* **is** INTENT (*intent-spec*) [::] *dummy-arg-name-list*

Constraint: An *intent-stmt* may appear only in the *specification-part* of a subprogram or an interface body (12.3.2.1).

Constraint: *dummy-arg-name* must not be the name of a dummy procedure or a dummy pointer.

R520 *optional-stmt* **is** OPTIONAL [::] *dummy-arg-name-list*

Constraint: An *optional-stmt* may occur only in the scoping unit of a subprogram or an interface block.

R521 *access-stmt* **is** *access-spec* [[::] *access-id-list*]

R522 *access-id* **is** *use-name*
or *generic-spec*

Constraint: An *access-stmt* may appear only in the scoping unit of a module. Only one accessibility statement with an omitted *access-id-list* is permitted in the scoping unit of a module.

Constraint: Each *access-id* must be the name of a named variable, nonintrinsic procedure, derived type, named constant, or namelist group.

Constraint: A *access-id* in a PUBLIC statement must not be the name of a module procedure that has a dummy argument or function result of a type that has PRIVATE accessibility, and such a procedure must not be given PUBLIC accessibility by default.

R523 *save-stmt* is SAVE [[::] *saved-entity-list*]

R524 *saved-entity* is *object-name*
or / *common-block-name* /

Constraint: An *object-name* must not be a dummy argument name, a procedure name, a function result name, an automatic data object name, a namelist group name, or the name of an entity in a common block.

Constraint: If a SAVE statement with an omitted saved entity list occurs in a scoping unit, no other explicit occurrence of the SAVE attribute or SAVE statement is permitted in the same scoping unit.

R525 *dimension-stmt* is DIMENSION [::] *array-name* (*array-spec*)
[, *array-name* (*array-spec*)] ...

R526 *allocatable-stmt* is ALLOCATABLE [::] *array-name*
[(*deferred-shape-spec-list*)]
[, *array-name* [(*deferred-shape-spec-list*)]] ...

Constraint: The *array-name* must not be a dummy argument or function result.

Constraint: If the DIMENSION attribute for an *array-name* is specified elsewhere in the scoping unit, the *array-spec* must be a *deferred-shape-spec-list*.

R527 *pointer-stmt* is POINTER [::] *object-name*
[(*deferred-shape-spec-list*)]
[, *object-name* [(*deferred-shape-spec-list*)]] ...

Constraint: The INTENT attribute must not be specified for an *object-name*.

Constraint: If the DIMENSION attribute for an *object-name* is specified elsewhere in the scoping unit, the *array-spec* must be a *deferred-shape-spec-list*.

Constraint: The PARAMETER attribute must not be specified for *object-name*.

R528 *target-stmt* is TARGET [::] *object-name* [(*array-spec*)]
[, *object-name* [(*array-spec*)]] ...

Constraint: The PARAMETER attribute must not be specified for an *object-name*.

R529 *data-stmt* is DATA *data-stmt-set* [[,] *data-stmt-set*] ...

R530 *data-stmt-set* is *data-stmt-object-list* / *data-stmt-value-list* /

R531 *data-stmt-object* is *variable*
or *data-implied-do*

R532 *data-stmt-value* is [*data-stmt-repeat* *] *data-stmt-constant*

R533 *data-stmt-constant* is *scalar-constant*
or *signed-int-literal-constant*
or *signed-real-literal-constant*
or *structure-constructor*
or *boz-literal-constant*

R534 *data-stmt-repeat* is *scalar-int-constant*

R535 *data-implied-do* is (*data-i-do-object-list* , *data-i-do-variable* =
scalar-int-expr , *scalar-int-expr* [, *scalar-int-expr*])

R536 *data-i-do-object* is *array-element*

or *data-implied-do*

Constraint: *array-element* must not be a subobject with a constant parent.

R537 *data-i-do-variable* is *scalar-int-variable*

Constraint: *data-i-do-variable* must be a named variable.

Constraint: The DATA statement repeat factor must be positive or zero. If the DATA statement repeat factor is a named constant, it must have been declared previously in the scoping unit or made accessible by use association or host association.

Constraint: If a *data-stmt-constant* is a *structure-constructor*, each component must be a constant expression.

Constraint: A variable whose name or designator is included in a *data-stmt-object-list* or a *data-i-do-object-list* must not be: a dummy argument, made accessible by use association or host association, in a named common block unless the DATA statement is in a block data program unit, in a blank common block, a function name, a function result name, an automatic object, a pointer, or an allocatable array.

Constraint: A subscript in an array element *data-i-do-object* must be an expression whose primaries are either constants or DO variables of the containing *data-implied-do*s.

Constraint: A *scalar-int-expr* of a *data-implied-do* must involve as primaries only constants or DO variables of the containing *data-implied-do*s.

R538 *parameter-stmt* is PARAMETER (*named-constant-def-list*)

R539 *named-constant-def* is *named-constant* = *initialization-expr*

R540 *implicit-stmt* is IMPLICIT *implicit-spec-list*
or IMPLICIT NONE

R541 *implicit-spec* is *type-spec* (*letter-spec-list*)

R542 *letter-spec* is *letter* [– *letter*]

Constraint: If IMPLICIT NONE is specified in a scoping unit, it must precede any PARAMETER statements that appear in the scoping unit and there must be no other IMPLICIT statements in the scoping unit.

Constraint: If the minus and second letter appear, the second letter must follow the first letter alphabetically.

R543 *namelist-stmt* is NAMELIST / *namelist-group-name* / ■
■ *namelist-group-object-list* ■
■ [[,] / *namelist-group-name* / ■
■ *namelist-group-object-list*] ...

R544 *namelist-group-object* is *variable-name*

Constraint: A *namelist-group-object* must not be an array dummy argument with nonconstant bounds, a variable with assumed parameters, an automatic object, a pointer, a structure containing a pointer, an allocatable array, or a subobject of any of the preceding objects.

Constraint: If a *namelist-group-name* has the PUBLIC attribute, no item in the *namelist-group-object-list* may have the PRIVATE attribute.

R545 *equivalence-stmt* is EQUIVALENCE *equivalence-set-list*

R546 *equivalence-set* is (*equivalence-object* , *equivalence-object-list*)

R547 *equivalence-object* is *variable-name*
or *array-element*
or *substring*

Constraint: An *equivalence-object* must not be a dummy argument, a pointer, an allocatable array, a nonsequence structure, a sequence structure containing a pointer, an automatic object, a function name, an entry name, a result name, or a subobject of any of the preceding objects.

Constraint: Each subscript or substring range expression in an *equivalence-object* must be an integer initialization expression (7.1.6.1).

Constraint: If an *equivalence-object* is of type default integer, default real, double precision real, default complex, default logical, or numeric sequence type, all of the objects in the equivalence set must be of these types.

Constraint: If an *equivalence-object* is of type default character or character sequence type, all of the objects in the equivalence set must be of these types.

Constraint: If an *equivalence-object* is of a derived type that is not a numeric sequence or character sequence type, all of the objects in the equivalence set must be of the same type.

Constraint: If an *equivalence-object* is of an intrinsic type other than default integer type, default real type, double precision real type, default complex type, default logical type, or default character type, all of the objects in the equivalence set must be of the same type with the same kind type parameter values.

R548 *common-stmt* is COMMON [/ [*common-block-name*] /]
■ *common-block-object-list* ■
■ [[,] / [*common-block-name*] / ■
■ *common-block-object-list*] ...

R549 *common-block-object* is *variable-name* [(*explicit-shape-spec-list*)]

Constraint: Only one appearance of a given *variable-name* is permitted in all *common-block-object-lists* within a scoping unit.

Constraint: A *common-block-object* must not be a dummy argument, an allocatable array, an automatic object, a function name, an entry name, or a result name.

Constraint: Each bound in the *explicit-shape-spec* must be an integer initialization expression.

Constraint: If a *common-block-object* is of a derived type, it must be a sequence type (4.4.1).

Constraint: If a *variable-name* appears with an *explicit-shape-spec-list*, it must not have the POINTER attribute.

D.1.6 Use of Data Objects.

R601 *variable* is *scalar-variable-name*
or *array-variable-name*
or *subobject*

Constraint: *array-variable-name* must be the name of a *variable* that is an array.

Constraint: *subobject* must not be a subobject designator (for example, a substring) whose parent is a constant.

R602 *subobject* is *array-element*
or *array-section*
or *structure-component*
or *substring*

R603 *logical-variable* is *variable*

Constraint: *logical-variable* must be of type logical.

R604 *default-logical-variable* is *variable*

Constraint: *default-logical-variable* must be of type default logical.

R605 *char-variable* is *variable*

Constraint: *char-variable* must be of type character.

R606 *default-char-variable* is *variable*

Constraint: *default-char-variable* must be of type default character.

R607 *int-variable* is *variable*

Constraint: *int-variable* must be of type integer.

R608 *default-int-variable* is *variable*

Constraint: *default-int-variable* must be of type default integer.

R609 *substring* is *parent-string* (*substring-range*)

R610 *parent-string* is *scalar-variable-name*
or *array-element*
or *scalar-structure-component*
or *scalar-constant*

R611 *substring-range* is [*scalar-int-expr*] : [*scalar-int-expr*]

Constraint: *parent-string* must be of type character.

R612 *structure-component* is *parent-structure* % *component-name*

R613 *parent-structure* is *scalar-variable-name*
or *array-variable-name*
or *array-element*
or *array-section*
or *structure-component*
or *named-constant*

Constraint: If *parent-structure* is an array, the component must not be an array and must not have the pointer attribute.

Constraint: *parent-structure* must be of derived type.

Constraint: *component-name* must be a component from the derived-type definition of the type of *parent-structure*.

R614 *array-element* is *parent-array* (*subscript-list*)

Constraint: The number of subscripts must equal the rank of the array.

R615 *array-section* is *parent-array* (*section-subscript-list*) [(*substring-range*)]

Constraint: If *substring-range* is present, *parent-array* must be of type character.

Constraint: At least one *section-subscript* must be a *subscript-triplet* or *vector-subscript*.

Constraint: The number of *section-subscript*s must equal the rank of the array.

R616 *parent-array* is *array-name*
or *structure-component*

Constraint: A *structure-component* may appear only if the component specified is an array.

R617 *subscript* is *scalar-int-expr*

R618 *section-subscript* is *subscript*
or *subscript-triplet*
or *vector-subscript*

R619 *subscript-triplet* is [*subscript*] : [*subscript*] [: *stride*]

R620 *stride* is *scalar-int-expr*

R621 *vector-subscript* is *int-expr*

Constraint: A *vector-subscript* must be an integer array expression of rank one.

Constraint: The second *subscript* must not be omitted from a *subscript-triplet* in the last dimension of an assumed-size array.

R622 *allocate-stmt* is ALLOCATE (*allocation-list* ■ ■ [, STAT = *stat-variable*])

R623 *stat-variable* is *scalar-int-variable*

Constraint: The *stat-variable* must not be allocated within the ALLOCATE statement in which it appears.

R624 *allocation* is *allocate-object* [(*explicit-shape-spec-list*)]

R625 *allocate-object* is *variable-name*
or *structure-component*

Constraint: Each *allocate-object* must be a pointer or an allocatable array.

Constraint: A bound in an *allocation explicit-shape-spec* must not be an expression involving as a primary an array inquiry function (13.10.15) whose argument is any other object in the same ALLOCATE statement.

Constraint: The number of *explicit-shape-specs* in an *allocation explicit-shape-spec-list* must be the same as the rank of the pointer or allocatable array.

R626 *nullify-stmt* is NULLIFY (*pointer-object-list*)

R627 *pointer-object* is *variable-name*
or *structure-component*

Constraint: Each *pointer-object* must have the POINTER attribute.

R628 *deallocate-stmt* is DEALLOCATE (*allocate-object-list* ■ ■ [, STAT = *stat-variable*])

Constraint: Each *allocate-object* must be a pointer or an allocatable array.

Constraint: The *stat-variable* must not be deallocated within the same DEALLOCATE statement.

D.1.7 Expressions and Assignment.

R701 *primary* is *constant*
or *constant-subobject*
or *variable*
or *array-constructor*
or *structure-constructor*
or *function-reference*
or (*expr*)

R702 *constant-subobject* is *subobject*

Constraint: *subobject* must be a subobject designator whose parent is a constant.

Constraint: A *variable* that is a *primary* must not be an assumed-size array.

R703 *level-1-expr* is [*defined-unary-op*] *primary*

R704 *defined-unary-op* is . *letter* [*letter*] ... .

Constraint: A *defined-unary-op* must not contain more than 31 letters and must not be the same as any *intrinsic-operator* or *logical-literal-constant*.

R705 *mult-operand* is *level-1-expr* [*power-op mult-operand*]

R706 *add-operand* is [*add-operand mult-op*] *mult-operand*

R707 *level-2-expr* is [[*level-2-expr*] *add-op*] *add-operand*

R708 *power-op* is **

R709 *mult-op* is *
or /

R710 *add-op* is +
or –

R711 *level-3-expr* is [*level-3-expr concat-op*] *level-2-expr*

R712 *concat-op* is //

R713 *level-4-expr* is [*level-3-expr rel-op*] *level-3-expr*

R714 *rel-op* is .EQ.
or .NE.
or .LT.
or .LE.
or .GT.
or .GE.
or ==
or /=
or <
or <=
or >
or >=

R715 *and-operand* is [*not-op*] *level-4-expr*

R716 *or-operand* is [*or-operand and-op*] *and-operand*

R717 *equiv-operand* is [*equiv-operand or-op*] *or-operand*

R718 *level-5-expr* is [*level-5-expr equiv-op*] *equiv-operand*

R719 *not-op* is .NOT.

R720 *and-op* is .AND.

R721 *or-op* is .OR.

R722 *equiv-op* is .EQV.
or .NEQV.

R723 *expr* is [*expr defined-binary-op*] *level-5-expr*

R724 *defined-binary-op* is . *letter* [*letter*] ... .

Constraint: A *defined-binary-op* must not contain more than 31 letters and must not be the same as any *intrinsic-operator* or *logical-literal-constant*.

R725 *logical-expr* is *expr*

Constraint: *logical-expr* must be type logical.

R726 *char-expr* is *expr*

Constraint: *char-expr* must be type character.

R727 *default-char-expr* is *expr*

Constraint: *default-char-expr* must be of type default character.

R728 *int-expr* is *expr*

Constraint: *int-expr* must be type integer.

R729 *numeric-expr* is *expr*

Constraint: *numeric-expr* must be of type integer, real or complex.

R730 *initialization-expr* is *expr*

R731 *char-initialization-expr* is *char-expr*

R732 *int-initialization-expr* is *int-expr*

R733 *logical-initialization-expr* is *logical-expr*

R734 *specification-expr* is *scalar-int-expr*

Constraint: The *scalar-int-expr* must be a restricted expression.

R735 *assignment-stmt* is *variable* = *expr*

Constraint: A *variable* in an *assignment-stmt* must not be an assumed-size array.

R736 *pointer-assignment-stmt* is *pointer-object* => *target*

R737 *target* is *variable*
or *function-reference*

Constraint: The *pointer-object* must have the POINTER attribute. The target object must have one of the attributes TARGET or POINTER or it must be a subobject of an object with one of these attributes.

Constraint: The *target* must be of the same type, type parameters, and rank as the pointer.

Constraint: The *target* must not be an array section with a vector subscript.

Constraint: The *function-reference* must deliver a pointer result.

R738 *where-stmt* is WHERE (*mask-expr*) *assignment-stmt*

R739 *where-construct* is *where-construct-stmt*
[*assignment-stmt*] ...
[*elsewhere-stmt*
[*assignment-stmt*] ...]
end-where-stmt

R740 *where-construct-stmt* is WHERE (*mask-expr*)

R741 *mask-expr* is *logical-expr*

R742 *elsewhere-stmt* is ELSEWHERE

R743 *end-where-stmt* is END WHERE

Constraint: In each *assignment-stmt*, the *mask-expr* and the variable being defined must be arrays of the same shape.

D.1.8 Execution Control.

R801 *block* is [*execution-part-construct*] ...

R802 *if-construct* is *if-then-stmt*
block
[*else-if-stmt*
block] ...
[*else-stmt*
block]
end-if-stmt

R803 *if-then-stmt* is [*if-construct-name* :] IF (*scalar-logical-expr*) THEN

R804 *else-if-stmt* is ELSE IF (*scalar-logical-expr*) THEN [*if-construct-name*]

R805 *else-stmt* is ELSE [*if-construct-name*]

R806 *end-if-stmt* is END IF [*if-construct-name*]

Constraint: If the *if-then-stmt* of an *if-construct* is identified by an *if-construct-name*, the corresponding *end-if-stmt* must specify the same *if-construct-name*. If the *if-then-stmt* of an *if-construct* is not identified by an *if-construct-name*, the corresponding *end-if-stmt* must not specify an *if-construct-name*. If an *else-if-stmt* or *else-stmt* is identified by an *if-construct-name*, the corresponding *if-then-stmt* must specify the same *if-construct-name*.

R807 *if-stmt* is IF (*scalar-logical-expr*) *action-stmt*

Constraint: The *action-stmt* in the *if-stmt* must not be an *if-stmt*, *end-program-stmt*, *end-function-stmt*, or *end-subroutine-stmt*.

R808 *case-construct* is *select-case-stmt*
[*case-stmt*
block] ...
end-select-stmt

R809 *select-case-stmt* is [*case-construct-name* :] SELECT CASE (*case-expr*)

R810 *case-stmt* is CASE *case-selector* [*case-construct-name*]

R811 *end-select-stmt* is END SELECT [*case-construct-name*]

Constraint: If the *select-case-stmt* of a *case-construct* is identified by a *case-construct-name*, the corresponding *end-select-stmt* must specify the same *case-construct-name*. If the *select-case-stmt* of a *case-construct* is not identified by a *case-construct-name*, the corresponding *end-select-stmt* must not specify a *case-construct-name*. If a *case-stmt* is identified by a *case-construct-name*, the corresponding *select-case-stmt* must specify the same *case-construct-name*.

R812 *case-expr* is *scalar-int-expr*
or *scalar-char-expr*
or *scalar-logical-expr*

R813 *case-selector* is (*case-value-range-list*)
or DEFAULT

Constraint: No more than one of the selectors of one of the CASE statements may be DEFAULT.

R814 *case-value-range* is *case-value*
or *case-value* :
or : *case-value*
or *case-value* : *case-value*

R815 *case-value* is *scalar-int-initialization-expr*
or *scalar-char-initialization-expr*
or *scalar-logical-initialization-expr*

Constraint: For a given *case-construct*, each *case-value* must be of the same type as *case-expr*. For character type, length differences are allowed, but the kind type parameters must be the same.

Constraint: A *case-value-range* using a colon must not be used if *case-expr* is of type logical.

Constraint: For a given *case-construct*, the *case-value-ranges* must not overlap; that is, there must be no possible value of the *case-expr* that matches more than one *case-value-range*.

R816 *do-construct* is *block-do-construct*
or *nonblock-do-construct*

R817 *block-do-construct* is *do-stmt*
do-block
end-do

R818 *do-stmt* is *label-do-stmt*
or *nonlabel-do-stmt*

R819 *label-do-stmt* is [*do-construct-name* :] DO *label* [*loop-control*]

R820 *nonlabel-do-stmt* is [*do-construct-name* :] DO [*loop-control*]

R821 *loop-control* is [,] *do-variable* = *scalar-numeric-expr* , ■
■ *scalar-numeric-expr* [, *scalar-numeric-expr*]
or [,] WHILE (*scalar-logical-expr*)

R822 *do-variable* is *scalar-variable*

Constraint: The *do-variable* must be a scalar integer, default real, or double precision real named variable.

Constraint: Each *scalar-numeric-expr* in *loop-control* must be of type integer, default real, or double precision real.

R823 *do-block* is *block*

R824 *end-do* is *end-do-stmt*
or *continue-stmt*

R825 *end-do-stmt* is END DO [*do-construct-name*]

Constraint: If the *do-stmt* of a *block-do-construct* is identified by a *do-construct-name*, the corresponding *end-do* must be an *end-do-stmt* specifying the same *do-construct-name*. If the *do-stmt* of a *block-do-construct* does not so specify a *do-construct-name*, the corresponding *end-do* must not specify a *do-construct-name*.

Constraint: If the *do-stmt* is a *nonlabel-do-stmt*, the corresponding *end-do* must be an *end-do-stmt*.

Constraint: If the *do-stmt* is a *label-do-stmt*, the corresponding *end-do* must be identified with the same *label*.

R826 *nonblock-do-construct* is *action-term-do-construct*
or *outer-shared-do-construct*

R827 *action-term-do-construct* is *label-do-stmt*
do-body
do-term-action-stmt

R828 *do-body* is [*execution-part-construct*] ...

R829 *do-term-action-stmt* is *action-stmt*

Constraint: A *do-term-action-stmt* must not be a *continue-stmt*, a *goto-stmt*, a *return-stmt*, a *stop-stmt*, an *exit-stmt*, a *cycle-stmt*, an *end-function-stmt*, an *end-subroutine-stmt*, an *end-program-stmt*, an *arithmetic-if-stmt*, or an *assigned-goto-stmt*.

Constraint: The *do-term-action-stmt* must be identified with a label and the corresponding *label-do-stmt* must refer to the same label.

R830 *outer-shared-do-construct* is *label-do-stmt*
do-body
shared-term-do-construct

R831 *shared-term-do-construct* is *outer-shared-do-construct*
or *inner-shared-do-construct*

R832 *inner-shared-do-construct* is *label-do-stmt*
do-body
do-term-shared-stmt

R833 *do-term-shared-stmt* is *action-stmt*

Constraint: A *do-term-shared-stmt* must not be a *goto-stmt*, a *return-stmt*, a *stop-stmt*, an *exit-stmt*, a *cycle-stmt*, an *end-function-stmt*, an *end-subroutine-stmt*, an *end-program-stmt*, an *arithmetic-if-stmt*, or an *assigned-goto-stmt*.

Constraint: The *do-term-shared-stmt* must be identified with a label and all of the *label-do-stmts* of the *shared-term-do-construct* must refer to the same label.

R834 *cycle-stmt* is CYCLE [*do-construct-name*]

Constraint: If a *cycle-stmt* refers to a *do-construct-name*, it must be within the range of that *do-construct*; otherwise, it must be within the range of at least one *do-construct*

R835 *exit-stmt* is EXIT [*do-construct-name*]

Constraint: If an *exit-stmt* refers to a *do-construct-name*, it must be within the range of that *do-construct*; otherwise, it must be within the range of at least one *do-construct*.

R836 *goto-stmt* is GO TO *label*

Constraint: The *label* must be the statement label of a branch target statement that appears in the same scoping unit as the *goto-stmt*.

R837 *computed-goto-stmt* is GO TO (*label-list*) [,] *scalar-int-expr*

Constraint: Each *label* in *label-list* must be the statement label of a branch target statement that appears in the same scoping unit as the *computed-goto-stmt*.

R838 *assign-stmt* is ASSIGN *label* TO *scalar-int-variable*

Constraint: The *label* must be the statement label of a branch target statement or *format-stmt* that appears in the same scoping unit as the *assign-stmt*.

Constraint: *scalar-int-variable* must be of type default integer.

R839 *assigned-goto-stmt* is GO TO *scalar-int-variable* [[,] (*label-list*)]

Constraint: Each *label* in *label-list* must be the statement label of a branch target statement that appears in the same scoping unit as the *assigned-goto-stmt*.

Constraint: *scalar-int-variable* must be of type default integer.

R840 *arithmetic-if-stmt* is IF (*scalar-numeric-expr*) *label* , *label* , *label*

Constraint: Each *label* must be the label of a branch target statement that appears in the same scoping unit as the *arithmetic-if-stmt*.

Constraint: The *scalar-numeric-expr* must not be of type complex.

R841 *continue-stmt* is CONTINUE

R842 *stop-stmt* is STOP [*stop-code*]

R843 *stop-code* is *scalar-char-constant*
or *digit* [*digit* [*digit* [*digit* [*digit*]]]]

Constraint: *scalar-char-constant* must be of type default character.

R844 *pause-stmt* is PAUSE [*stop-code*]

D.1.9 Input/Output Statements.

R901 *io-unit* is *external-file-unit*
or *
or *internal-file-unit*

R902 *external-file-unit* is *scalar-int-expr*

R903 *internal-file-unit* is *default-char-variable*

Constraint: The *char-variable* must not be an array section with a vector subscript.

R904 *open-stmt* is OPEN (*connect-spec-list*)

R905 *connect-spec* is [UNIT=] *external-file-unit*
or IOSTAT= *scalar-default-int-variable*
or ERR= *label*
or FILE= *file-name-expr*

or STATUS= *scalar-default-char-expr*
or ACCESS= *scalar-default-char-expr*
or FORM= *scalar-default-char-expr*
or RECL= *scalar-int-expr*
or BLANK= *scalar-default-char-expr*
or POSITION= *scalar-default-char-expr*
or ACTION= *scalar-default-char-expr*
or DELIM= *scalar-default-char-expr*
or PAD= *scalar-default-char-expr*

R906 *file-name-expr* is *scalar-default-char-expr*

Constraint: If the optional characters UNIT= are omitted from the unit specifier, the unit specifier must be the first item in the *connect-spec-list*.

Constraint: Each specifier must not appear more than once in a given *open-stmt*; an *external-file-unit* must be specified.

Constraint: The *label* used in the ERR= specifier must be the statement label of a branch target statement that appears in the same scoping unit as the OPEN statement.

R907 *close-stmt* is CLOSE (*close-spec-list*)

R908 *close-spec* is [UNIT=] *external-file-unit*
or IOSTAT= *scalar-default-int-variable*
or ERR= *label*
or STATUS= *scalar-default-char-expr*

Constraint: If the optional characters UNIT= are omitted from the unit specifier, the unit specifier must be the first item in the *close-spec-list*.

Constraint: Each specifier must not appear more than once in a given *close-stmt*; an *external-file-unit* must be specified.

Constraint: The *label* used in the ERR= specifier must be the statement label of a branch target statement that appears in the same scoping unit as the CLOSE statement.

R909 *read-stmt* is READ (*io-control-spec-list*) [*input-item-list*]
or READ *format* [, *input-item-list*]

R910 *write-stmt* is WRITE (*io-control-spec-list*) [*output-item-list*]

R911 *print-stmt* is PRINT *format* [, *output-item-list*]

R912 *io-control-spec* is [UNIT=] *io-unit*
or [FMT=] *format*
or [NML=] *namelist-group-name*
or REC= *scalar-int-expr*
or IOSTAT= *scalar-default-int-variable*
or ERR= *label*
or END= *label*
or ADVANCE= *scalar-default-char-expr*
or SIZE= *scalar-default-int-variable*
or EOR= *label*

Constraint: An *io-control-spec-list* must contain exactly one *io-unit* and may contain at most one of each of the other specifiers.

Constraint: An END=, EOR=, or SIZE= specifier must not appear in a *write-stmt*.

Constraint: The *label* in the ERR=, EOR=, or END= specifier must be the statement label of a branch target statement that appears in the same scoping unit as the data transfer statement.

Constraint: A *namelist-group-name* must not be present if an *input-item-list* or an *output-item-list* is present in the data transfer statement.

Constraint: An *io-control-spec-list* must not contain both a *format* and a *namelist-group-name*.

Constraint: If the optional characters UNIT= are omitted from the unit specifier, the unit specifier must be the first item in the control information list.

Constraint: If the optional characters FMT= are omitted from the format specifier, the format specifier must be the second item in the control information list and the first item must be the unit specifier without the optional characters UNIT=.

Constraint: If the optional characters NML= are omitted from the namelist specifier, the namelist specifier must be the second item in the control information list and the first item must be the unit specifier without the optional characters UNIT=.

Constraint: If the unit specifier specifies an internal file, the *io-control-spec-list* must not contain a REC= specifier or a *namelist-group-name*.

Constraint: If the REC= specifier is present, an END= specifier must not appear, a *namelist-group-name* must not appear, and the *format*, if any, must not be an asterisk specifying list-directed input/output.

Constraint: An ADVANCE= specifier may be present only in a formatted sequential input/output statement with explicit format specification (10.1) whose control information list does not contain an internal file unit specifier.

Constraint: If an EOR= specifier is present, and ADVANCE= specifier also must appear.

R913 *format* is *default-char-expr*
or *label*
or *
or *scalar-default-int-variable*

Constraint: The *label* must be the label of a FORMAT statement that appears in the same scoping unit as the statement containing the format specifier.

R914 *input-item* is *variable*
or *io-implied-do*

R915 *output-item* is *expr*
or *io-implied-do*

R916 *io-implied-do* is (*io-implied-do-object-list* , *io-implied-do-control*)

R917 *io-implied-do-object* is *input-item*
or *output-item*

R918 *io-implied-do-control* is *do-variable* = *scalar-numeric-expr* , ■
■ *scalar-numeric-expr* [, *scalar-numeric-expr*]

Constraint: A *variable* that is an *input-item* must not be an assumed-size array.

Constraint: The *do-variable* must be a scalar of type integer, default real, or double precision real.

Constraint: Each *scalar-numeric-expr* in an *io-implied-do-control* must be of type integer, default real, or double precision real.

Constraint: In an *input-item-list*, an *io-implied-do-object* must be an *input-item*. In an *output-item-list*, an *io-implied-do-object* must be an *output-item*.

R919 *backspace-stmt* is BACKSPACE *external-file-unit*
or BACKSPACE (*position-spec-list*)

R920 *endfile-stmt* is ENDFILE *external-file-unit*
or ENDFILE (*position-spec-list*)

R921 *rewind-stmt* is REWIND *external-file-unit*
or REWIND (*position-spec-list*)

R922 *position-spec* is [UNIT =] *external-file-unit*

or IOSTAT = *scalar-default-int-variable*
or ERR = *label*

Constraint: The *label* in the ERR= specifier must be the statement label of a branch target statement that appears in the same scoping unit as the file positioning statement.

Constraint: If the optional characters UNIT= are omitted from the unit specifier, the unit specifier must be the first item in the *position-spec-list*.

Constraint: A *position-spec-list* must contain exactly one *external-file-unit* and may contain at most one of each of the other specifiers.

R923 *inquire-stmt* is INQUIRE (*inquire-spec-list*)
or INQUIRE (IOLENGTH = *scalar-default-int-variable*) ■
■ *output-item-list*

R924 *inquire-spec* is [UNIT =] *external-file-unit*
or FILE = *file-name-expr*
or IOSTAT = *scalar-default-int-variable*
or ERR = *label*
or EXIST = *scalar-default-logical-variable*
or OPENED = *scalar-default-logical-variable*
or NUMBER = *scalar-default-int-variable*
or NAMED = *scalar-default-logical-variable*
or NAME = *scalar-default-char-variable*
or ACCESS = *scalar-default-char-variable*
or SEQUENTIAL = *scalar-default-char-variable*
or DIRECT = *scalar-default-char-variable*
or FORM = *scalar-default-char-variable*
or FORMATTED = *scalar-default-char-variable*
or UNFORMATTED = *scalar-default-char-variable*
or RECL = *scalar-default-int-variable*
or NEXTREC = *scalar-default-int-variable*
or BLANK = *scalar-default-char-variable*
or POSITION = *scalar-default-char-variable*
or ACTION = *scalar-default-char-variable*
or READ = *scalar-default-char-variable*
or WRITE = *scalar-default-char-variable*
or READWRITE = *scalar-default-char-variable*
or DELIM = *scalar-default-char-variable*
or PAD = *scalar-default-char-variable*

Constraint: An *inquire-spec-list* must contain one FILE= specifier or one UNIT= specifier, but not both, and at most one of each of the other specifiers.

Constraint: In the inquire by unit form of the INQUIRE statement, if the optional characters UNIT= are omitted from the unit specifier, the unit specifier must be the first item in the *inquire-spec-list*.

D.1.10 Input/Output Editing.

R1001 *format-stmt* is FORMAT *format-specification*

R1002 *format-specification* is ([*format-item-list*])

Constraint: The *format-stmt* must be labeled.

Constraint: The comma used to separate *format-items* in a *format-item-list* may be omitted as follows:

(1) Between a P edit descriptor and an immediately following F, E, EN, D, or G edit descriptor (10.6.5)

(2) Before a slash edit descriptor when the optional repeat specification is not present (10.6.2)

(3) After a slash edit descriptor

(4) Before or after a colon edit descriptor (10.6.3)

R1003 *format-item* **is** [*r*] *data-edit-desc*
or *control-edit-desc*
or *char-string-edit-desc*
or [*r*] (*format-item-list*)

R1004 *r* **is** *int-literal-constant*

Constraint: *r* must be positive.

Constraint: *r* must not have a kind parameter specified for it.

R1005 *data-edit-desc* **is** I *w* [. *m*]
or B *w* [. *m*]
or O *w* [. *m*]
or Z *w* [. *m*]
or F *w* . *d*
or E *w* . *d* [E *e*]
or EN *w* . *d* [E *e*]
or ES *w* . *d* [E *e*]
or G *w* . *d* [E *e*]
or L *w*
or A [*w*]
or D *w* . *d*

R1006 *w* **is** *int-literal-constant*

R1007 *m* **is** *int-literal-constant*

R1008 *d* **is** *int-literal-constant*

R1009 *e* **is** *int-literal-constant*

Constraint: *w* and *e* must be positive and *d* and *m* must be zero or positive.

Constraint: *w*, *m*, *d*, and *e* must not have kind parameters specified for them.

R1010 *control-edit-desc* **is** *position-edit-desc*
or [*r*] /
or :
or *sign-edit-desc*
or *k* P
or *blank-interp-edit-desc*

R1011 *k* **is** *signed-int-literal-constant*

Constraint: *k* must not have a kind parameter specified for it.

R1012 *position-edit-desc* **is** T *n*
or TL *n*
or TR *n*
or *n* X

R1013 *n* **is** *int-literal-constant*

Constraint: *n* must be positive.

Constraint: *n* must not have a kind parameter specified for it.

R1014 *sign-edit-desc* **is** S
or SP
or SS

R1015 *blank-interp-edit-desc* is BN
or BZ

R1016 *char-string-edit-desc* is *char-literal-constant*
or *c* H *rep-char* [*rep-char*] ...

R1017 *c* is *int-literal-constant*

Constraint: *c* must be positive.

Constraint: *c* must not have a kind parameter specified for it.

Constraint: The *rep-char* in the *c*H form must be of default character type.

Constraint: The *char-literal-constant* must not have a kind parameter specified for it.

D.1.11 Program Units.

R1101 *main-program* is [*program-stmt*]
[*specification-part*]
[*execution-part*]
[*internal-subprogram-part*]
end-program-stmt

R1102 *program-stmt* is PROGRAM *program-name*

R1103 *end-program-stmt* is END [PROGRAM [*program-name*]]

Constraint: In a *main-program*, the *execution-part* must not contain a RETURN statement or an ENTRY statement.

Constraint: The *program-name* may be included in the *end-program-stmt* only if the optional *program-stmt* is used and, if included, must be identical to the *program-name* specified in the *program-stmt*.

Constraint: An automatic object must not appear in the *specification-part* (R204) of a main program.

R1104 *module* is *module-stmt*
[*specification-part*]
[*module-subprogram-part*]
end-module-stmt

R1105 *module-stmt* is MODULE *module-name*

R1106 *end-module-stmt* is END [MODULE [*module-name*]]

Constraint: If the *module-name* is specified in the *end-module-stmt*, it must be identical to the *module-name* specified in the *module-stmt*.

Constraint: A module *specification-part* must not contain a *stmt-function-stmt* or a *format-stmt*.

Constraint: An automatic object must not appear in the *specification-part* (R204) of a module.

R1107 *use-stmt* is USE *module-name* [, *rename-list*]
or USE *module-name* , ONLY : [*only-list*]

R1108 *rename* is *local-name* => *use-name*

R1109 *only* is *access-id*
or [*local-name* =>] *use-name*

Constraint: Each *access-id* must be a public entity in the module.

Constraint: Each *use-name* must be the name of a public entity in the module.

R1110 *block-data* is *block-data-stmt*
[*specification-part*]
end-block-data-stmt

R1111 *block-data-stmt* is BLOCK DATA [*block-data-name*]

R1112 *end-block-data-stmt* is END [BLOCK DATA [*block-data-name*]]

Constraint: The *block-data-name* may be included in the *end-block-data-stmt* only if it was provided in the *block-data-stmt* and, if included, must be identical to the *block-data-name* in the *block-data-stmt*.

Constraint: A *block-data specification-part* may contain only USE statements, type declaration statements, IMPLICIT statements, PARAMETER statements, derived-type definitions, and the following specification statements: COMMON, DATA, DIMENSION, EQUIVALENCE, INTRINSIC, POINTER, SAVE, and TARGET.

Constraint: A type declaration statement in a *block-data specification-part* must not contain the ALLOCATABLE, EXTERNAL, INTENT, OPTIONAL, PRIVATE, or PUBLIC attribute specifiers.

D.1.12 Procedures.

R1201 *interface-block* is *interface-stmt*
[*interface-body*] ...
[*module-procedure-stmt*] ...
end-interface-stmt

R1202 *interface-stmt* is INTERFACE [*generic-spec*]

R1203 *end-interface-stmt* is END INTERFACE

R1204 *interface-body* is *function-stmt*
[*specification-part*]
end-function-stmt
or *subroutine-stmt*
[*specification-part*]
end-subroutine-stmt

R1205 *module-procedure-stmt* is MODULE PROCEDURE *procedure-name-list*

R1206 *generic-spec* is *generic-name*
or OPERATOR (*defined-operator*)
or ASSIGNMENT (=)

Constraint: An *interface-body* must not contain an *entry-stmt*, *data-stmt*, *format-stmt*, or *stmt-function-stmt*.

Constraint: The MODULE PROCEDURE specification is allowed only if the *interface-block* has a *generic-spec*.

Constraint: An *interface-block* must not appear in a BLOCK DATA program unit.

Constraint: An *interface-block* in a subprogram must not contain an *interface-body* for a procedure defined by that subprogram.

R1207 *external-stmt* is EXTERNAL *external-name-list*

R1208 *intrinsic-stmt* is INTRINSIC *intrinsic-procedure-name-list*

R1209 *function-reference* is *function-name* ([*actual-arg-spec-list*])

Constraint: The *actual-arg-spec-list* for a function reference must not contain an *alt-return-spec*.

R1210 *call-stmt* is CALL *subroutine-name* [([*actual-arg-spec-list*])]

R1211 *actual-arg-spec* is [*keyword* =] *actual-arg*

R1212 *keyword* is *dummy-arg-name*

R1213 *actual-arg* is *expr*
or *variable*

or *procedure-name*
or *alt-return-spec*

R1214 *alt-return-spec* is * *label*

Constraint: The *keyword* = must not appear if the interface of the procedure is implicit in the scoping unit.

Constraint: The *keyword* = may be omitted from an *actual-arg-spec* only if the *keyword* = has been omitted from each preceding *actual-arg-spec* in the argument list.

Constraint: Each *keyword* must be the name of a dummy argument in the explicit interface of the procedure.

Constraint: A *procedure-name actual-arg* must not be the name of an internal procedure and must not be the generic name of a procedure (12.3.2.1, 13.1). If it is the name of an intrinsic function, it must be a specific name for the function (13.12).

Constraint: The *label* used in the *alt-return-spec* must be the statement label of a branch target statement that appears in the same scoping unit as the *call-stmt*.

R1215 *function-subprogram* is *function-stmt*
[*specification-part*]
[*execution-part*]
[*internal-subprogram-part*]
end-function-stmt

R1216 *function-stmt* is [*prefix*] FUNCTION *function-name* ■
■ ([*dummy-arg-name-list*]) [RESULT (*result-name*)]

Constraint: The *result-name* must not appear in any specification statement in the scoping unit of the function subprogram.

R1217 *prefix* is *type-spec* [RECURSIVE]
or RECURSIVE [*type-spec*]

R1218 *end-function-stmt* is END [FUNCTION [*function-name*]]

Constraint: If RESULT is specified, *result-name* must not be the same as *function-name*.

Constraint: FUNCTION must be present on the *end-function-stmt* of an internal or module function.

Constraint: An internal function must not contain an ENTRY statement.

Constraint: An internal function must not contain an *internal-subprogram-part*.

Constraint: If a *function-name* is present on the *end-function-stmt*, it must be identical to the *function-name* specified in the *function-stmt*.

R1219 *subroutine-subprogram* is *subroutine-stmt*
[*specification-part*]
[*execution-part*]
[*internal-subprogram-part*]
end-subroutine-stmt

R1220 *subroutine-stmt* is [RECURSIVE] SUBROUTINE *subroutine-name* ■
■ [([*dummy-arg-list*])]

R1221 *dummy-arg* is *dummy-arg-name*
or *

R1222 *end-subroutine-stmt* is END [SUBROUTINE [*subroutine-name*]]

Constraint: SUBROUTINE must be present on the *end-subroutine-stmt* of an internal or module subroutine.

Constraint: An internal subroutine must not contain an ENTRY statement.

Constraint: An internal subroutine must not contain an *internal-subprogram-part*.

Constraint: If a *subroutine-name* is present on the *end-subroutine-stmt*, it must be identical to the *subroutine-name* specified in the *subroutine-stmt*.

R1223 *entry-stmt* is ENTRY *entry-name* [([*dummy-arg-list*]) ■
■ [RESULT (*result-name*)]]

Constraint: An *entry-stmt* may appear only in an *external-subprogram* or *module-subprogram*. An *entry-stmt* must not appear within an *executable-construct*.

Constraint: RESULT may be present only if the *entry-stmt* is contained in a function subprogram.

Constraint: Within the subprogram containing the *entry-stmt*, the *entry-name* must not appear as a dummy argument in the FUNCTION or SUBROUTINE statement or in another ENTRY statement and it must not appear in an EXTERNAL statement.

Constraint: A *dummy-arg* may be an alternate return indicator only if the ENTRY statement is contained in a subroutine subprogram.

Constraint: If RESULT is specified, *result-name* must not be the same as *entry-name*.

R1224 *return-stmt* is RETURN [*scalar-int-expr*]

Constraint: The *return-stmt* must be contained in the scoping unit of a function or subroutine subprogram.

Constraint: The *scalar-int-expr* is allowed only in the scoping unit of a subroutine subprogram.

R1225 *contains-stmt* is CONTAINS

R1226 *stmt-function-stmt* is *function-name* ([*dummy-arg-name-list*]) = *scalar-expr*

Constraint: The *scalar-expr* may be composed only of constants (literal and named), references to scalar variables and array elements, references to functions and function dummy procedures, and intrinsic operators. If a reference to another statement function appears in *scalar-expr*, its definition must have been provided earlier in the scoping unit.

Constraint: Named constants in *scalar-expr* must have been declared earlier in the scoping unit. If array elements appear in *scalar-expr*, the parent array must have been declared as an array earlier in the scoping unit. If a scalar variable, array element, function reference, or dummy function reference is typed by the implicit typing rules, its appearance in any subsequent type declaration statement must confirm this implied type and the values of any implied type parameters.

Constraint: The *function-name* and each *dummy-arg-name* must be specified, explicitly or implicitly, to be scalar data objects.

Constraint: A given *dummy-arg-name* may appear only once in any *dummy-arg-name-list*.

Constraint: Each scalar variable reference in *scalar-expr* may be either a reference to a dummy argument of the statement function or a reference to a variable within the same scoping unit as the statement function statement.

D.1.13 Intrinsic Procedures.

D.1.14 Scope, Association, and Definition.

D.2 Cross References.

Symbol	Defined in	Referenced in
ac-do-variable	R435	R434

	Symbol	Defined in	Referenced in				
1	*ac-implied-do*	R433	R432				
2	*ac-implied-do-control*	R434	R433				
3	*ac-value*	R432	R431	R433			
4	*access-id*	R522	R521	R1109			
5	*access-spec*	R510	R424	R503	R521		
6	*access-stmt*	R521	R214				
7	*action-stmt*	R216	R215	R807	R829	R833	
8	*action-term-do-construct*	R827	R826				
9	*actual-arg*	R1213	R1211				
10	*actual-arg-spec*	R1211	R1209	R1210			
11	*add-op*	R710	R310	R707			
12	*add-operand*	R706	R706	R707			
13	*allocatable-stmt*	R526	R214				
14	*allocate-object*	R625	R624	R628			
15	*allocate-stmt*	R622	R216				
16	*allocation*	R624	R622				
17	*alphanumeric-character*	R302	R301	R304			
18	*alt-return-spec*	R1214	R1213				
19	*and-op*	R720	R310	R716			
20	*and-operand*	R715	R716				
21	*arithmetic-if-stmt*	R840	R216				
22	*array-constructor*	R431	R701				
23	*array-element*	R614	R536	R547	R602	R610	R613
24	*array-section*	R615	R602	R613			
25	*array-spec*	R512	R503	R504	R525	R528	
26	*assign-stmt*	R838	R216				
27	*assigned-goto-stmt*	R839	R216				
28	*assignment-stmt*	R735	R216	R738	R739		
29	*assumed-shape-spec*	R516	R512				
30	*assumed-size-spec*	R518	R512				
31	*attr-spec*	R503	R501				
32	*backspace-stmt*	R919	R216				
33	*binary-constant*	R408	R407				
34	*blank-interp-edit-desc*	R1015	R1010				
35	*block*	R801	R802	R808	R823		
36	*block-data*	R1110	R202				
37	*block-data-stmt*	R1111	R1110				
38	*block-do-construct*	R817	R816				
39	*boz-literal-constant*	R407	R306	R533			
40	*c*	R1017	R1016				
41	*call-stmt*	R1210	R216				
42	*case-construct*	R808	R215				
43	*case-expr*	R812	R809				
44	*case-selector*	R813	R810				
45	*case-stmt*	R810	R808				
46	*case-value*	R815	R814				
47	*case-value-range*	R814	R813				
48	*char-constant*	R309	R843				
49	*char-expr*	R726	R731	R812			
50	*char-initialization-expr*	R731	R815				
51	*char-length*	R508	R429	R504	R507		
52	*char-literal-constant*	R420	R306	R1016			
53	*char-selector*	R506	R502				
54	*char-string-edit-desc*	R1016	R1003				
55	*char-variable*	R605	R				
56	*character*	R301	R				

	Symbol	Defined in	Referenced in				
1	*close-spec*	R908	R907				
2	*close-stmt*	R907	R216				
3	*common-block-object*	R549	R548				
4	*common-stmt*	R548	R214				
5	*complex-literal-constant*	R417	R306				
6	*component-array-spec*	R428	R427	R429			
7	*component-attr-spec*	R427	R426				
8	*component-decl*	R429	R426				
9	*component-def-stmt*	R426	R422				
10	*computed-goto-stmt*	R837	R216				
11	*concat-op*	R712	R310	R711			
12	*connect-spec*	R905	R904				
13	*constant*	R305	R308	R309	R533	R610	R701
14	*constant-subobject*	R702	R701				
15	*contains-stmt*	R1225	R210	R212			
16	*continue-stmt*	R841	R216	R824			
17	*control-edit-desc*	R1010	R1003				
18	*cycle-stmt*	R834	R216				
19	*d*	R1008	R1005				
20	*data-edit-desc*	R1005	R1003				
21	*data-i-do-object*	R536	R535				
22	*data-i-do-variable*	R537	R535				
23	*data-implied-do*	R535	R531	R536			
24	*data-stmt*	R529	R209	R214			
25	*data-stmt-constant*	R533	R532				
26	*data-stmt-object*	R531	R530				
27	*data-stmt-repeat*	R534	R532				
28	*data-stmt-set*	R530	R529				
29	*data-stmt-value*	R532	R530				
30	*deallocate-stmt*	R628	R216				
31	*declaration-construct*	R207	R204				
32	*default-char-expr*	R727	R905	R906	R908	R912	R913
33	*default-char-variable*	R606	R903	R924			
34	*default-int-variable*	R608	R905	R908	R912	R913	R922
35			R923				
36	*default-logical-variable*	R604	R924				
37	*deferred-shape-spec*	R517	R428	R512	R526	R527	
38	*defined-binary-op*	R724	R311	R723			
39	*defined-operator*	R311	R1206				
40	*defined-unary-op*	R704	R311	R703			
41	*derived-type-def*	R422	R207				
42	*derived-type-stmt*	R424	R422				
43	*digit-string*	R402	R401	R404	R405	R413	R414
44	*dimension-stmt*	R525	R214				
45	*do-block*	R823	R817				
46	*do-body*	R828	R827	R830	R832		
47	*do-construct*	R816	R215				
48	*do-stmt*	R818	R817				
49	*do-term-action-stmt*	R829	R827				
50	*do-term-shared-stmt*	R833	R832				
51	*do-variable*	R822	R821	R918			
52	*dummy-arg*	R1221	R1220	R1223			
53	*e*	R1009	R1005				
54	*else-if-stmt*	R804	R802				
55	*else-stmt*	R805	R802				
56	*elsewhere-stmt*	R742	R739				

	Symbol	Defined in	Referenced in				
1	*end-block-data-stmt*	R1112	R1110				
2	*end-do*	R824	R817				
3	*end-do-stmt*	R825	R824				
4	*end-function-stmt*	R1218	R216	R1204	R1215		
5	*end-if-stmt*	R806	R802				
6	*end-interface-stmt*	R1203	R1201				
7	*end-module-stmt*	R1106	R1104				
8	*end-program-stmt*	R1103	R216	R1101			
9	*end-select-stmt*	R811	R808				
10	*end-subroutine-stmt*	R1222	R216	R1204	R1219		
11	*end-type-stmt*	R425	R422				
12	*end-where-stmt*	R743	R739				
13	*endfile-stmt*	R920	R216				
14	*entity-decl*	R504	R501				
15	*entry-stmt*	R1223	R206	R207	R209		
16	*equiv-op*	R722	R310	R718			
17	*equiv-operand*	R717	R717	R718			
18	*equivalence-object*	R547	R546				
19	*equivalence-set*	R546	R545				
20	*equivalence-stmt*	R545	R214				
21	*executable-construct*	R215	R208	R209			
22	*executable-program*	R201	R				
23	*execution-part*	R208	R1101	R1215	R1219		
24	*execution-part-construct*	R209	R208	R801	R828		
25	*exit-stmt*	R835	R216				
26	*explicit-shape-spec*	R513	R428	R512	R518	R549	R624
27	*exponent*	R416	R413				
28	*exponent-letter*	R415	R413				
29	*expr*	R723	R430	R432	R701	R723	R725
30			R726	R727	R728	R729	R730
31			R735	R915	R1213	R1226	
32	*external-file-unit*	R902	R901	R905	R908	R919	R920
33			R921				
34	*external-stmt*	R1207	R214				
35	*external-subprogram*	R203	R202				
36	*file-name-expr*	R906	R905	R924			
37	*format*	R913	R909	R911	R912		
38	*format-item*	R1003	R1002	R1003			
39	*format-specification*	R1002	R1001				
40	*format-stmt*	R1001	R206	R207	R209		
41	*function-reference*	R1209	R701	R737			
42	*function-stmt*	R1216	R1204	R1215			
43	*function-subprogram*	R1215	R203	R211	R213		
44	*generic-intrinsic-op*	R312	R311				
45	*generic-spec*	R1206	R522	R1202			
46	*goto-stmt*	R836	R216				
47	*hex-constant*	R410	R407				
48	*hex-digit*	R411	R410				
49	*if-construct*	R802	R215				
50	*if-stmt*	R807	R216				
51	*if-then-stmt*	R803	R802				
52	*imag-part*	R419	R417				
53	*implicit-part*	R205	R204				
54	*implicit-part-stmt*	R206	R205				
55	*implicit-spec*	R541	R540				
56	*implicit-stmt*	R540	R205	R206			

	Symbol	Defined in	Referenced in				
1	*initialization-expr*	R730	R504	R539			
2	*inner-shared-do-construct*	R832	R831				
3	*input-item*	R914	R909	R917			
4	*inquire-spec*	R924	R923				
5	*inquire-stmt*	R923	R216				
6	*int-constant*	R308	R534				
7	*int-expr*	R728	R434	R514	R515	R535	R611
8			R617	R620	R621	R732	R734
9			R812	R837	R902	R905	R912
10			R1224				
11	*int-initialization-expr*	R732	R505	R506	R815		
12	*int-literal-constant*	R404	R306	R403	R508	R1004	R1006
13			R1007	R1008	R1009	R1013	R1017
14	*int-variable*	R607	R435	R537	R623	R838	R839
15	*intent-spec*	R511	R503	R519			
16	*intent-stmt*	R519	R214				
17	*interface-block*	R1201	R207				
18	*interface-body*	R1204	R1201				
19	*interface-stmt*	R1202	R1201				
20	*internal-file-unit*	R903	R901				
21	*internal-subprogram*	R211	R210				
22	*internal-subprogram-part*	R210	R1101	R1215	R1219		
23	*intrinsic-operator*	R310	R312				
24	*intrinsic-stmt*	R1208	R214				
25	*io-control-spec*	R912	R909	R910			
26	*io-implied-do*	R916	R914	R915			
27	*io-implied-do-control*	R918	R916				
28	*io-implied-do-object*	R917	R916				
29	*io-unit*	R901	R912				
30	*k*	R1011	R1010				
31	*keyword*	R1212	R1211				
32	*kind-param*	R405	R404	R413	R420	R421	
33	*kind-selector*	R505	R502				
34	*label*	R313	R819	R836	R837	R838	R839
35			R840	R905	R908	R912	R913
36			R922				
37	*label-do-stmt*	R819	R818	R827	R830	R832	
38	*length-selector*	R507	R506				
39	*letter-spec*	R542	R541				
40	*level-1-expr*	R703	R705				
41	*level-2-expr*	R707	R707	R711			
42	*level-3-expr*	R711	R711	R713			
43	*level-4-expr*	R713	R715				
44	*level-5-expr*	R718	R718	R723			
45	*literal-constant*	R306	R305				
46	*logical-expr*	R725	R733	R741	R803	R804	R807
47			R812				
48	*logical-initialization-expr*	R733	R815				
49	*logical-literal-constant*	R421	R306				
50	*logical-variable*	R603	R				
51	*loop-control*	R821	R819	R820			
52	*lower-bound*	R514	R513	R516	R518		
53	*m*	R1007	R1005				
54	*main-program*	R1101	R202				
55	*mask-expr*	R741	R738	R740			
56	*module*	R1104	R202				

	Symbol	Defined in	Referenced in			
1	*module-procedure-stmt*	R1205	R1201			
2	*module-stmt*	R1105	R1104			
3	*module-subprogram*	R213	R212			
4	*module-subprogram-part*	R212	R1104			
5	*mult-op*	R709	R310	R706		
6	*mult-operand*	R705	R705	R706		
7	*n*	R1013	R1012			
8	*name*	R304	R307			
9	*named-constant*	R307	R305	R539	R613	
10	*named-constant-def*	R539	R538			
11	*namelist-group-object*	R544	R543			
12	*namelist-stmt*	R543	R214			
13	*nonblock-do-construct*	R826	R816			
14	*nonlabel-do-stmt*	R820	R818			
15	*not-op*	R719	R310	R715		
16	*nullify-stmt*	R626	R216			
17	*numeric-expr*	R729	R821	R840	R918	
18	*octal-constant*	R409	R407			
19	*only*	R1109	R1107			
20	*open-stmt*	R904	R216			
21	*optional-stmt*	R520	R214			
22	*or-op*	R721	R310	R717		
23	*or-operand*	R716	R716	R717		
24	*outer-shared-do-construct*	R830	R826	R831		
25	*output-item*	R915	R910	R911	R917	R923
26	*parameter-stmt*	R538	R206	R207		
27	*parent-array*	R616	R614	R615		
28	*parent-string*	R610	R609			
29	*parent-structure*	R613	R612			
30	*pause-stmt*	R844	R216			
31	*pointer-assignment-stmt*	R736	R216			
32	*pointer-object*	R627	R626	R736		
33	*pointer-stmt*	R527	R214			
34	*position-edit-desc*	R1012	R1010			
35	*position-spec*	R922	R919	R920	R921	
36	*power-op*	R708	R310	R705		
37	*prefix*	R1217	R1216			
38	*primary*	R701	R703			
39	*print-stmt*	R911	R216			
40	*private-sequence-stmt*	R423	R422			
41	*program-stmt*	R1102	R1101			
42	*program-unit*	R202	R201			
43	*r*	R1004	R1003	R1010		
44	*read-stmt*	R909	R216			
45	*real-literal-constant*	R413	R306	R412		
46	*real-part*	R418	R417			
47	*rel-op*	R714	R310	R713		
48	*rename*	R1108	R1107			
49	*return-stmt*	R1224	R216			
50	*rewind-stmt*	R921	R216			
51	*save-stmt*	R523	R214			
52	*saved-entity*	R524	R523			
53	*section-subscript*	R618	R615			
54	*select-case-stmt*	R809	R808			
55	*shared-term-do-construct*	R831	R830			
56	*sign*	R406	R401	R403	R412	

	Symbol	Defined in	Referenced in				
1	*sign-edit-desc*	R1014	R1010				
2	*signed-digit-string*	R401	R416				
3	*signed-int-literal-constant*	R403	R418	R419	R533	R1011	
4	*signed-real-literal-constant*	R412	R418	R419	R533		
5	*significand*	R414	R413				
6	*specification-expr*	R734	R509				
7	*specification-part*	R204	R1101	R1104	R1110	R1204	R1215
8			R1219				
9	*specification-stmt*	R214	R207				
10	*stat-variable*	R623	R622	R628			
11	*stmt-function-stmt*	R1226	R207				
12	*stop-code*	R843	R842	R844			
13	*stop-stmt*	R842	R216				
14	*stride*	R620	R619				
15	*structure-component*	R612	R602	R610	R613	R616	R625
16			R627				
17	*structure-constructor*	R430	R533	R701			
18	*subobject*	R602	R601	R702			
19	*subroutine-stmt*	R1220	R1204	R1219			
20	*subroutine-subprogram*	R1219	R203	R211	R213		
21	*subscript*	R617	R614	R618	R619		
22	*subscript-triplet*	R619	R618				
23	*substring*	R609	R547	R602			
24	*substring-range*	R611	R609	R615			
25	*target*	R737	R736				
26	*target-stmt*	R528	R214				
27	*type-declaration-stmt*	R501	R207				
28	*type-param-value*	R509	R506	R507	R508		
29	*type-spec*	R502	R426	R501	R541	R1217	
30	*underscore*	R303	R302				
31	*upper-bound*	R515	R513				
32	*use-stmt*	R1107	R204				
33	*variable*	R601	R531	R603	R604	R605	R606
34			R607	R608	R701	R735	R737
35			R822				
36	*vector-subscript*	R621	R618				
37	*w*	R1006	R1005				
38	*where-construct*	R739	R215				
39	*where-construct-stmt*	R740	R739				
40	*where-stmt*	R738	R216				
41	*write-stmt*	R910	R216				
42	*array-name*		R525	R526	R616		
43	*array-variable-name*		R601	R613			
44	*block-data-name*		R1111	R1112			
45	*case-construct-name*		R809	R810	R811		
46	*common-block-name*		R524	R548			
47	*component-name*		R429	R612			
48	*digit*		R302	R313	R402	R408	R409
49			R411				
50	*do-construct-name*		R819	R820	R825	R834	R835
51	*dummy-arg-name*		R519	R520	R1212	R1216	R1221
52			R1226				
53	*entry-name*		R1223				
54	*external-name*		R1207				
55	*function-name*		R504	R1209	R1216	R1218	R1226

	Symbol	Defined in	Referenced in				
1	*generic-name*		R1206				
2	*if-construct-name*		R803	R804	R805	R806	
3	*int-constant-name*		R405				
4	*intrinsic-procedure-name*		R1208				
5	*letter*		R302	R304	R542	R704	R724
6	*local-name*		R1108	R1109			
7	*module-name*		R1105	R1106	R1107		
8	*namelist-group-name*		R543	R912			
9	*object-name*		R504	R524	R527	R528	
10	*procedure-name*		R1205	R1213			
11	*program-name*		R1102	R1103			
12	*rep-char*		R420	R1016			
13	*result-name*		R1216	R1223			
14	*special-character*		R301				
15	*subroutine-name*		R1210	R1220	R1222		
16	*type-name*		R424	R425	R430	R502	
17	*use-name*		R522	R1108	R1109		
18	*variable-name*		R544	R547	R549	R601	R610
19			R613				
20	%		R612				
21	'		R408	R409	R410	R420	
22	(		R417	R427	R429	R430	R433
23			R502	R503	R504	R505	R506
24			R507	R508	R519	R525	R526
25			R527	R528	R535	R538	R541
26			R546	R549	R609	R614	R615
27			R622	R624	R626	R628	R701
28			R738	R740	R803	R804	R807
29			R809	R813	R821	R837	R839
30			R840	R904	R907	R909	R910
31			R916	R919	R920	R921	R923
32			R1002	R1003	R1206	R1209	R1210
33			R1216	R1220	R1223	R1226	
34	(/		R431				
35	)		R417	R427	R429	R430	R433
36			R502	R503	R504	R505	R506
37			R507	R508	R519	R525	R526
38			R527	R528	R535	R538	R541
39			R546	R549	R609	R614	R615
40			R622	R624	R626	R628	R701
41			R738	R740	R803	R804	R807
42			R809	R813	R821	R837	R839
43			R840	R904	R907	R909	R910
44			R916	R919	R920	R921	R923
45			R1002	R1003	R1206	R1209	R1210
46			R1216	R1220	R1223	R1226	
47	*		R429	R504	R507	R509	R518
48			R532	R709	R901	R913	R1214
49			R1221				
50	**		R708				
51	+		R406	R710			
52	,		R417	R424	R426	R433	R434
53			R501	R506	R507	R518	R525
54			R526	R527	R528	R529	R535
55			R543	R546	R548	R622	R628

	Symbol	Defined in	Referenced in				
1			R821	R837	R839	R840	R909
2			R911	R916	R918	R1107	
3	-		R406	R542	R710		
4	.		R414	R704	R724	R1005	
5	.AND.		R720				
6	.EQ.		R714				
7	.EQV.		R722				
8	.FALSE.		R421				
9	.GE.		R714				
10	.GT.		R714				
11	.LE.		R714				
12	.LT.		R714				
13	.NE.		R714				
14	.NEQV.		R722				
15	.NOT.		R719				
16	.OR.		R721				
17	.TRUE.		R421				
18	/		R524	R530	R543	R548	R709
19			R1010				
20	/)		R431				
21	//		R712				
22	/=		R714				
23	:		R513	R516	R517	R518	R611
24			R619	R803	R809	R814	R819
25			R820				
26	::		R424	R426	R501	R519	R520
27			R521	R523	R525	R526	R527
28			R528				
29	<		R714				
30	<=		R714				
31	=		R434	R504	R505	R507	R535
32			R539	R622	R628	R735	R821
33			R918	R922	R923	R924	R1206
34			R1211				
35	==		R714				
36	=>		R736	R1108	R1109		
37	>		R714				
38	>=		R714				
39	A		R411	R1005			
40	ACCESS		R924				
41	ACCESS=		R905				
42	ACTION		R924				
43	ACTION=		R905				
44	ADVANCE=		R912				
45	ALLOCATABLE		R503	R526			
46	ALLOCATE		R622				
47	ASSIGN		R838				
48	ASSIGNMENT		R1206				
49	B		R408	R411	R1005		
50	BACKSPACE		R919				
51	BLANK		R924				
52	BLANK=		R905				
53	BLOCK		R1111	R1112			
54	BN		R1015				
55	BZ		R1015				
56	C		R411				

	Symbol	Defined in	Referenced in
1	CALL		R1210
2	CASE		R809 R810
3	CHARACTER		R502
4	CLOSE		R907
5	COMMON		R548
6	COMPLEX		R502
7	CONTAINS		R1225
8	CONTINUE		R841
9	CYCLE		R834
10	D		R411 R415 R1005
11	DATA		R529 R1111 R1112
12	DEALLOCATE		R628
13	DEFAULT		R813
14	DELIM		R924
15	DELIM=		R905
16	DIMENSION		R427 R503 R525
17	DIRECT		R924
18	DO		R819 R820 R825
19	DOUBLE		R502
20	E		R411 R415 R1005
21	ELSE		R804 R805
22	ELSEWHERE		R742
23	EN		R1005
24	END		R425 R743 R806 R811 R825
25			R1103 R1106 R1112 R1203 R1218
26			R1222
27	END=		R912
28	ENDFILE		R920
29	ENTRY		R1223
30	EOR=		R912
31	EQUIVALENCE		R545
32	ERR		R922 R924
33	ERR=		R905 R908 R912
34	ES		R1005
35	EXIST		R924
36	EXIT		R835
37	EXTERNAL		R503 R1207
38	F		R411 R1005
39	FILE		R924
40	FILE=		R905
41	FMT=		R912
42	FORM		R924
43	FORM=		R905
44	FORMAT		R1001
45	FORMATTED		R924
46	FUNCTION		R1216 R1218
47	G		R1005
48	GO		R836 R837 R839
49	H		R1016
50	I		R1005
51	IF		R803 R804 R806 R807 R840
52	IMPLICIT		R540
53	IN		R511
54	INOUT		R511
55	INQUIRE		R923
56	INTEGER		R502

	Symbol	Defined in	Referenced in
1	INTENT		R503 R519
2	INTERFACE		R1202 R1203
3	INTRINSIC		R503 R1208
4	IOLENGTH		R923
5	IOSTAT		R922 R924
6	IOSTAT=		R905 R908 R912
7	KIND		R505
8	KIND=		R506
9	L		R1005
10	LEN		R507
11	LEN=		R506
12	LOGICAL		R502
13	MODULE		R1105 R1106 R1205
14	NAME		R924
15	NAMED		R924
16	NAMELIST		R543
17	NEXTREC		R924
18	NML=		R912
19	NONE		R540
20	NULLIFY		R626
21	NUMBER		R924
22	O		R409 R1005
23	ONLY		R1107
24	OPEN		R904
25	OPENED		R924
26	OPERATOR		R1206
27	OPTIONAL		R503 R520
28	OUT		R511
29	P		R1010
30	PAD		R924
31	PAD=		R905
32	PARAMETER		R503 R538
33	PAUSE		R844
34	POINTER		R427 R503 R527
35	POSITION		R924
36	POSITION=		R905
37	PRECISION		R502
38	PRINT		R911
39	PRIVATE		R423 R510
40	PROCEDURE		R1205
41	PROGRAM		R1102 R1103
42	PUBLIC		R510
43	READ		R909 R924
44	READWRITE		R924
45	REAL		R502
46	REC=		R912
47	RECL		R924
48	RECL=		R905
49	RECURSIVE		R1217 R1220
50	RESULT		R1216 R1223
51	RETURN		R1224
52	REWIND		R921
53	S		R1014
54	SAVE		R503 R523
55	SELECT		R809 R811
56	SEQUENCE		R423

	Symbol	Defined in	Referenced in				
1	SEQUENTIAL		R924				
2	SIZE=		R912				
3	SP		R1014				
4	SS		R1014				
5	STAT		R622	R628			
6	STATUS=		R905	R908			
7	STOP		R842				
8	SUBROUTINE		R1220	R1222			
9	T		R1012				
10	TARGET		R503	R528			
11	THEN		R803	R804			
12	TL		R1012				
13	TO		R836	R837	R838	R839	
14	TR		R1012				
15	TYPE		R424	R425	R502		
16	UNFORMATTED		R924				
17	UNIT		R922	R924			
18	UNIT=		R905	R908	R912		
19	USE		R1107				
20	WHERE		R738	R740	R743		
21	WHILE		R821				
22	WRITE		R910	R924			
23	X		R1012				
24	Z		R410	R1005			
25	_		R303	R404	R413	R420	R421

APPENDIX E. PERMUTED INDEX FOR HEADINGS

APPENDIX F. INDEX