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**Information technology — Test methods for
measuring conformance to POSIX**

*Technologies de l'information — Méthodes d'essai pour mesurer la
conformité à POSIX*

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Information technology—Test methods for measuring conformance to POSIX

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and by the
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Abstract: The general requirements and test methods for measuring conformance to POSIX standards are defined. This document is aimed primarily at working groups developing test methods for POSIX standards, developers of POSIX test methods, and users of POSIX test methods.

Keywords: assertion, assertion test, base assertion, conditional feature, extended assertions, POSIX, POSIX Conformance Document, POSIX Conformance Test Procedure, POSIX Conformance Test Suite, test method, test result code



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Annexes A and B form an integral part of this International Standard.



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Introduction

(This Introduction is not a normative part of ISO/IEC 13210 Information Technology— Test methods for measuring conformance to POSIX, but is included for information only.)

This standard defines the general requirements and test methods for measuring conformance to POSIX standards. This document is aimed primarily at working groups developing test methods for POSIX standards, developers of POSIX test methods, and users of POSIX test methods.

Organization of the Standard

This document is organized into sections and clauses. Some of these, such as 1.1, are mandated by the IEEE and other standards bodies.

The sections are:

- (1) General
- (2) Terminology and General Requirements
- (3) Test Methods Conformance to This Standard
- (4) Testing Levels and Complexity Levels
- (5) Classification of Assertions
- (6) Writing Assertions
- (7) Assertion Test Output
- (8) Statement of Conformance to a POSIX Standard

— A *Topical Index* points to the definition and/or usage of key words and phrases.

The foreword, introduction, any footnotes, and the informative annexes are not considered part of this International Standard.

Revisions and Supplements to This Standard

No activities to extend this International Standard to address additional requirements are in progress. Extension efforts may be anticipated in the future. This is an outline of how extensions can be incorporated.

Extensions are approved as “amendments” or “revisions” to this document, following the IEEE Standards Procedures.

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Information Technology— Test methods for measuring conformance to POSIX

Section 1: General

1.1 Scope

This International Standard is applicable to the development and use of conformance testing methodologies for POSIX standards. The generic test methods identified in this International Standard shall be used in conjunction with test methods identified for a specific standard.

This International Standard is intended for use by working groups developing test methods for POSIX standards, developers of POSIX test methods, and users of POSIX test methods.

The purpose of this International Standard is to define general rules for developing test assertions and related test methods for measuring conformance of an implementation to POSIX standards. Test methods may include POSIX Conformance Test Suites (PCTS), POSIX Conformance Test Procedures (PCTP), and audits of POSIX Conformance Documents (PCD).

Testing conformance of an implementation to a standard includes testing the claimed capabilities and behavior of the implementation with respect to the conformance requirements of the standard. Test methods are intended to provide a reasonable, practical assurance that the implementation conforms to the standard. Use of these test methods will not guarantee conformance of an implementation to the standard; that normally would require exhaustive testing (see 4.2.1), which is impractical for both technical and economic reasons.

21 **1.2 Normative References**

22 The following standards contain provisions which, through reference in this text,
23 constitute provisions of this International Standard. At the time of publication,
24 the editions indicated were valid. All standards are subject to revision, and par-
25 ties to agreements based on this International Standard are encouraged to inves-
26 tigate the possibility of applying the most recent editions of the standards indi-
27 cated below. Members of IEC and ISO maintain registers of currently valid Inter-
28 national Standards.

29 {1} IEEE Std 729-1983, *IEEE Glossary of Software Engineering Terminology*
30 (*ANSI*).

31 {2} ISO/IEC 9945-1: 1990 (ISO/IEC 9945-1: 1990), *Information technology—Portable*
32 *Operating System Interface (POSIX)—Part 1: System Application Program Inter-*
33 *face (API) [C Language]*.

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Section 2: Terminology and General Requirements

2.1 Conventions

This International Standard uses the following typographic conventions:

- (1) The *italic* font is used for:
 - The initial appearances of defined terms
 - Cross-references to defined terms within 2.2.1, 2.2.2, and 2.2.3
 - Parameters (option arguments and operands) that are generally substituted with real values by the application
 - C language data types and function names
 - Global external variable names
- (2) The **bold** font is used for:
 - Test result codes
 - Assertion type classification
- (3) The constant-width (Courier) font is used:
 - To illustrate examples of system input or output where exact usage is depicted
 - For references to utility names and C language headers
- (4) Symbolic *errno* names returned by functions are represented as [symbolic_name].
- (5) Symbolic constant limits are represented as {symbolic_constant_limit}.
- (6) Symbolic constant options are represented as {Option_name}.
- (7) Notes provided as parts of labeled tables and figures are integral parts of this International Standard (normative). Footnotes and Notes within the body of the text are for information only (informative).
- (8) Defined names that are usually in lowercase, particularly function names, are never used at the beginning of a sentence or anywhere else where regular English usage would require them to be capitalized.
- (9) Mathematical symbols such as <, ≤, etc. are only used in formulas, assertion classification assignments, and conditional clauses preceding conditional assertions.

(10) In some cases tabular information is presented “inline”; in others it is presented in a separately labeled table. This arrangement was employed purely for ease of typesetting and there is no normative difference between these two cases.

(11) The conventions listed above are for ease of reading only. Editorial inconsistencies in the use of typography are unintentional and have no normative meaning in this International Standard.

A summary of typographical conventions is shown in Table 2-1.

Table 2-1 – Typographical Conventions

Reference	Example
C Language Header	<sys/stat.h>
Command Name	awk
Command Option	-c
Command Option With Argument	-w <i>width</i>
Data Types	<i>long</i>
Defined Terms	<i>file</i>
Environment Variables	PATH
Error Number	[EINTR]
File Name	<i>filename</i>
Function Argument Declaration	extern unsigned long int
Function Argument	<i>arg1</i>
Function Declaration	int fstat(int <i>fildev</i> , struct stat * <i>buf</i>);
Function Name	<i>func()</i>
Global External	<i>errno</i>
Implementation-dependent Limit	{MAX_INPUT}
Metavariable	<+>
Operand	<i>file_name</i>
Output	foo
Parameters	< <i>directory pathname</i> >
Section Reference	(see Section 1)
Clause Reference	(see 1.m)
Subclause Reference	(see 1.n.m...)
Special Character	<newline>
Symbolic Constant Limit	{LINK_MAX}
Symbolic Constant Option	{_POSIX_JOB_CONTROL}
Table Reference	Table 6
Variable	<i>st_atime</i>

2.2 Definitions

2.2.1 Terminology

For the purposes of this International Standard, the following definitions apply:

2.2.1.1 may: an option for test methods.

In this International Standard, *need not* is used as the negative of *may*.

74 **2.2.1.2 shall:** A requirement for test methods.

75 **2.2.1.3 should:** A recommended practice for test methods.

76 **2.2.2 General Terms**

77 For the purposes of this International Standard, the following definitions apply:

78 **2.2.2.1 assertion:** A statement of functionality or behavior for a POSIX element
79 that is derived from the POSIX standard being tested and that is true for a con-
80 forming POSIX implementation.

81 **2.2.2.2 assertion number:** The numeric identifier assigned to an assertion.

82 The name of the element and the assertion number together uniquely identify an
83 assertion.

84 **2.2.2.3 assertion test:** The software or procedural methods that ascertain the
85 conformance of a POSIX implementation to an assertion.

86 **2.2.2.4 base assertion:** An assertion that is required to be tested for required
87 features and for implemented conditional features.

88 **2.2.2.5 conditional feature:** A feature or behavior referred to in a POSIX stan-
89 dard that need not be present on all conforming implementations.

90 **2.2.2.6 development system:** The computer system used to compile and
91 configure a PCTS.

92 **2.2.2.7 element:** A functional interface or a namespace allocation.

93 Examples of elements are C functions or utility programs. Examples of
94 namespace allocation include headers or error return value constants.

95 **2.2.2.8 extended assertion:** An assertion that is not required to be tested.

96 **2.2.2.9 POSIX Conformance Document (PCD):** The conformance document
97 required by a POSIX standard.

98 **2.2.2.10 POSIX Conformance Test Procedure (PCTP):** The nonsoftware pro-
99 cedures possibly used in conjunction with other test methods to measure
100 conformance.

101 **2.2.2.11 POSIX Conformance Test Suite (PCTS):** The collection of software
102 possibly used in conjunction with other test methods to measure conformance.

103 **2.2.2.12 required feature:** Either a single facility or behavior, or one of a pair
104 of alternative facilities or behaviors, required by a POSIX standard that is always
105 present on a conforming implementation.

106 **2.2.2.13 target system:** The combination of the computer system on which the
107 PCTS is executed and the parts of the development system that are used to gen-
108 erate the executable code of a PCTS.

109 **2.2.2.14 test method:** The software, procedures, or other means specified by a
110 POSIX standard to measure conformance.

111 Test methods may include a PCTS, PCTP, or an audit of a PCD.

112 **2.2.2.15 test result code:** A value that describes the result of an assertion test.

113 2.2.3 Abbreviations

114 For the purposes of this International Standard, the following abbreviations
115 apply:

116 **2.2.3.1 IEEE:** The Institute of Electrical and Electronics Engineers.

117 **2.2.3.2 PCD:** POSIX Conformance Document.

118 **2.2.3.3 PCTP:** POSIX Conformance Test Procedures.

119 **2.2.3.4 PCTS:** POSIX Conformance Test Suite.

120 **2.2.3.5 POSIX:**¹⁾ Colloquial name for the collection of IEEE 1003 standards, draft
121 standards, and projects.

122 **2.2.3.6 POSIX.n:** Term used to refer to a specific IEEE P1003.n project or its pro-
123 ducts. For example, POSIX.1 represents the P1003.1 project and its associated
124 products, IEEE Std 1003.1-1990, ISO/IEC 9945-1: 1990, and IEEE Std 1003.1c-
125 1993.

126 **2.2.3.7 POSIX.3:** This standard.

127 1) The name POSIX was suggested by Richard Stallman. It is expected to be pronounced *pahz-icks*,
128 as in *positive*, not *poh-six*, or other variations. The pronunciation has been published in an
129 attempt to promulgate a standardized way of referring to a standard operating system interface.

Section 3: Test Methods Conformance to This Standard

3.1 Conformance Criteria

Test methods that conform to POSIX.3 shall meet all of the following criteria:

- The test methods shall document the POSIX.n test method specifications to which they conform.
- The test methods shall test base assertions for required features and implemented conditional features of the POSIX standard for which conformance is being measured. If an assertion lists a set of instances (often separated by the word *or*), the assertion test shall test each specified instance.
- The PCTS shall consist of automated assertion tests to the extent possible.
- The documentation of the PCTS shall include all the information necessary to install, configure, and execute the PCTS.
- The documentation of the test methods shall include, if needed, instructions for performing the PCTP and an audit of the PCD.
- The documentation of the test methods shall describe how to gather and interpret the results.
- Additional criteria shall be specified in applicable POSIX.n standards.

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Section 4: Testing Levels and Complexity Levels

4.1 Introduction

In principle, the objective of conformance testing is to establish whether the implementation being tested conforms to the specification in the relevant standard. Practical limitations make it impossible to be exhaustive, and economic considerations may restrict testing still further.

Due to these limitations, during the design and development of test methods the complexity level of an element will dictate the level of testing that satisfies conformance requirements.

Therefore, this International Standard distinguishes three major levels of testing, according to the extent to which they provide an indication of conformance, and three major levels of element complexity.

The three major levels of testing are:

- Exhaustive Testing
- Thorough Testing
- Identification Testing

The three major levels of element complexity are:

- Simple
- Intermediate
- Complex

4.2 Testing Levels

4.2.1 Exhaustive Testing

Exhaustive testing seeks to verify the behavior of every aspect of an element, including all permutations. For example, exhaustive testing of a given user command would require testing the command with no options, with each option, with each pair of options, and so on, up to every permutation of options.

The various command options and permutations rapidly approach numbers too large to reach execution completion in any realistic time frame. As an example, there are approximately 37 unique error conditions in POSIX.1. The occurrence of one error can (and often does) affect the proper detection of another error. An exhaustive test of the 37 errors would require not just one test per error, but one

30 test per possible permutation of errors. Thus, instead of 37 tests, billions of tests
31 would be needed (2 to the 37th power).

32 Exhaustive testing is normally infeasible.

33 **4.2.2 Thorough Testing**

34 Thorough testing is a useful alternative to exhaustive testing. Thorough testing
35 seeks to verify the behavior of every aspect of an element, but does not include all
36 permutations. For example, to perform thorough testing of a given command, the
37 command shall be tested with no options, then with each option individually.
38 Possible combinations of options may also be tested.

39 Given the above example concerning the 37 error conditions, thorough testing
40 would require 38 tests, a much more manageable number.

41 Thorough testing is a feasible solution. During testing of a multitude of indivi-
42 dual elements, certain combinations of subelements are coincidentally tested.

43 In this discussion, it is helpful to consider the number of assertions that can be
44 derived from the specification of each software element. Thorough testing aims to
45 verify each individual aspect in isolation and is thus much more feasible than
46 exhaustive testing. However, even thorough testing approaches infeasibility
47 when the sheer number of aspects of an element is very large. Therefore, a third
48 level of testing is defined.

49 **4.2.3 Identification Testing**

50 Identification testing seeks to verify some distinguishing characteristic of the ele-
51 ment in question. It consists of a cursory examination of the element, invoking it
52 with the minimal command syntax and verifying its minimal function.

53 For example, identification testing of a C compiler would distinguish it from a
54 compiler for another language on the system, but not necessarily from any other C
55 compiler on this or another system. It would not require a verification of all the
56 syntax or functions specified in the C compiler manual. Proper identification test-
57 ing of a C compiler would be to verify the minimal program constructs necessary
58 to establish its distinguishing characteristic as a C compiler.

59 **4.3 Complexity Levels**

60 **4.3.1 Simple**

61 Simple elements are those that are wholly defined in the description for that ele-
62 ment. Simple elements are those that have a few assertions to test and whose
63 functionality does not depend on other elements defined within the POSIX stan-
64 dard in which they are defined. Examples of simple elements include the `cat`
65 utility specified in POSIX.2 or the `close()` function specified in POSIX.1. Simple ele-
66 ments should be thoroughly tested.

67 4.3.2 Intermediate

68 Intermediate elements are those that have a moderate number of assertions and
69 may depend upon the functionality of other elements defined within the POSIX
70 standard in which they are defined. Examples of intermediate elements are the
71 `grep` and `sed` utilities specified in POSIX.2, which support their own functionality
72 in addition to regular expressions. Thorough testing should be a goal for inter-
73 mediate elements, but it may not be feasible in some cases.

74 4.3.3 Complex

75 Complex elements are those that implement a language, depend upon the func-
76 tion of intermediate elements, or have effects on hardware devices. Typically,
77 complex elements need a large number of assertion tests to test them thoroughly.
78 Examples of complex elements are the `sh` and `awk` utilities as specified in
79 POSIX.2, which implement a language in addition to regular expressions. For
80 complex elements, thorough testing may be limited to specific areas of the
81 element.

82 4.4 Conclusion

83 It follows from the definitions of testing levels and of element complexity levels
84 that the functionality of each element must be analyzed and evaluated. Since the
85 number of possible combinations of options, events, and timing of events is unrea-
86 sonably large, testing normally cannot be exhaustive.

87 It follows from the informal nature of the definition of thorough testing that
88 thoroughness of testing will vary from one PCTS to another and, within a PCTS,
89 from one assertion to another. These are choices the PCTS implementor must
90 make. It is not within the scope of this International Standard to define the
91 recommended testing level so precisely as to preclude this degree of freedom.

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Section 5: Classification of Assertions

5.1 Method of Classification

Each assertion falls into one of four categories represented by the two-by-two matrix as shown in Table 5-1.

Table 5-1 – Classification of Assertions

	Base Assertion	Extended Assertion
Required Feature	A	B
Conditional Feature	C	D

The rows of the assertion matrix correspond to whether the POSIX feature is required or conditional (see 2.2.2). The columns of the assertion matrix correspond to whether or not a test for the assertion is required. Those assertions not required to be tested are known as extended assertions. Whenever possible, the development of assertion tests for extended assertions is encouraged.

In some cases it may be appropriate to develop an assertion test that partially, but not fully, tests an extended assertion. For example, it is sometimes possible to detect failure to conform in certain instances, but not possible to detect all failures. Any assertion test that detects such failures shall produce a test result code of **FAIL** (see Section 7) for that assertion. Any assertion test that does not adequately test the assertion and that completes correctly on the system under test without detecting a failure in that system shall return a test result code of **UNTESTED**. The following is a list of reasons to classify assertions as extended:

Reason: 1 There is no known portable test method for this assertion.

Reason: 2 The corresponding statement in the POSIX standard to which conformance is being measured is not specific enough to write a portable test.

Reason: 3 There is no known reliable test method for this assertion.

Reason: 4 The assertion test requires setup procedures that involve an unreasonable amount of effort by the user of a test method.

Reason: 5 The assertion test would require an unreasonable amount of time or resources on most systems.

Reason: 6 Creating an assertion test would require an unreasonable amount of test development time.

34 Reason: 7 The assertion test could have an adverse effect on completion of a
35 test method.

36 Those assertions that are not extended are known as base assertions. Base asser-
37 tions for required features and implemented conditional features shall be tested.

38 Thus, each assertion falls into one of four categories:

- 39 (A) Base assertion of a required feature.
- 40 (B) Extended assertion of a required feature.
- 41 (C) Base assertion of a conditional feature.
- 42 (D) Extended assertion of a conditional feature.

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Section 6: Writing Assertions

1 This section describes how test assertions in POSIX standards shall be written.

2 6.1 Assertion Determination

3 An assertion is written for each definitive statement in a POSIX standard that
4 pertains to an implementation. A corresponding assertion test is designed to
5 determine whether the statement is true or false for the implementation.

6 Since POSIX standards usually are written in prose style, it usually does not
7 suffice to copy a statement directly from the POSIX standard. Each assertion
8 shall be a stand-alone statement. Assertions shall be worded so that **PASS**
9 (see Section 7) is the result code for a conforming implementation.

10 A definitive statement is a statement in a standard that contains or implies a
11 *shall*, *should*, or *may*. This section, unless superseded by a POSIX.n standard,
12 describes how statements in a POSIX standard using *shall*, *should*, and *may*
13 are interpreted to arrive at the assertions.

14 A statement in the POSIX standard that applies to the implementation and
15 either includes the word *shall* or is a declarative sentence that implies the
16 verb *shall* is interpreted as a requirement for the implementation. Such a
17 statement by itself, or in conjunction with other definitive statements,
18 corresponds to an assertion.

19 A statement that applies to a conditional feature for the implementation, that
20 uses the verbs *should* or *may*, or is a statement that implies the verbs *should*
21 or *may*, is interpreted as a requirement on the implementation, if the imple-
22 mentation supports the option. Such a statement by itself or in conjunction
23 with other definitive statements corresponds to an assertion.

24 No assertions shall be written for a statement that applies only to usage of an
25 implementation rather than to an implementation itself.

26 No assertion shall be written for a statement that uses the verbs *should* or
27 *may* when that statement is either a warning to programmers or an implemen-
28 tation recommendation.

29 6.2 Assertion Constructs

30 6.2.1 Assertion Parts

31 There are three parts to an assertion: the assertion number, the assertion
32 classification, and the actual text for the assertion.

33 6.2.1.1 Assertion Number

34 Each assertion is assigned an assertion number that is unique within the set of
35 assertions for a particular element. The assertions should appear in the same
36 order as the corresponding statement in the POSIX standard. They should be
37 numbered sequentially beginning with one (1) in each element.

38 New or modified assertions shall be numbered sequentially beginning with the
39 next available number. If changes to the assertion list result in unused assertion
40 numbers, those numbers are indicated at the end of the assertion list for each ele-
41 ment preceded by the phrase Unused Assertion Numbers:.

42 6.2.1.2 Assertion Classification

43 If an assertion corresponds to a statement that is based on a conditional feature,
44 it is classified as an assertion with type **C** or **D**, and it is written as an 'If' state-
45 ment. Otherwise, it is classified as an assertion with type **A** or **B**.

46 If an assertion corresponds to a statement that can be tested by a portable PCTS
47 in a reasonable amount of time and effort, it is classified as a base assertion (type
48 **A** or **C**). Otherwise, it is classified as an extended assertion (type **B** or **D**). The
49 reason why it is an extended assertion is provided as a number that corresponds
50 to at least one of the reasons listed in Section 5.

51 For most assertions, the assertion classification is simply **A**, **B**, **C**, or **D** (see the
52 matrix in Section 5). Sometimes the classification of base or extended is depen-
53 dent on whether or not a qualifier is true for the implementation under test. In
54 these cases, the assertion classification is written as either (**QUALIFIER?A:B**) or
55 (**QUALIFIER?C:D**). In the first case, if **QUALIFIER** is true, the required asser-
56 tion is classified as **A** (base); otherwise, the required assertion is classified as **B**
57 (extended). In the second case, if **QUALIFIER** is true, the assertion for the condi-
58 tional feature is classified as **C** (base); otherwise, the conditional assertion is
59 classified as **D** (extended).

60 6.2.1.3 Assertion Text and Examples

61 The actual text for each assertion follows one of the constructs described in this
62 subclause.

63 In the simplest case, the assertion is a simple statement.

64 Example:

65 01(A) The sky is blue.

66 If the assertion requires the environment to be in a particular state, a 'When'
67 clause is included, followed by the word 'then'.

68 Example:

69 02(A) When there are no clouds, then the sky is blue.

70 If the assertion is for a conditional feature, an 'If' clause containing the condi-
71 tional POSIX behavior is included, followed by a colon (':').

72 Example:

73 03(C) If the implementation provides C Standard Language-
74 Dependent system support:
75 The sky is blue.

76 In the case where an assertion for a conditional feature requires the environment
77 to be in a particular state, the above two constructs are combined.

78 Example:

79 04(C) If the implementation provides C Standard Language-
80 Dependent system support:
81 When there are no clouds, then the sky is blue.

82 If an assertion is for a required feature that has different behavior depending on
83 whether or not a particular condition is true on the implementation, an 'If ...
84 Otherwise ...' construct is used, and its classification is either **A** or **B**.

85 Example:

86 05(A) If the behavior associated with { _POSIX_JOB_CONTROL } is
87 supported:
88 The sky is blue.
89 Otherwise:
90 The sky is gray.

91 A qualifier is used when the classification of the assertion depends upon a feature
92 of the implementation. The following is an example of a conditional assertion
93 that has a qualifier to determine whether or not it is base or extended:

94 Example:

95 06({ _POSIX_JOB_CONTROL }?C:D) If the implementation provides C Standard
96 Language-Dependent system support:
97 The sky is blue.

98 If a feature or behavior is similar across multiple functions defined in the same
99 section, the 'For' construct is allowed as a method of maintaining consistent asser-
100 tion numbers among functions.

101 Example:

102 07(C) For earth():

103 If the implementation provides C Standard Language-
104 Dependent system support:

105 When there are no clouds, then the sky is blue.

106 For moon():

107 If the implementation provides C Standard Language-
108 Dependent system support:

109 When there are no clouds, then the sky is black.

110 When an aspect of an implementation depends on two or more conditional
111 features, the assertions are written as multiple assertions that cover the applica-
112 ble combinations of these conditional features.

113 Example:

114 08(C) If the general terminal interface and the behavior associated with
115 {_POSIX_JOB_CONTROL} are supported:

116 The sky is blue.

117 09(C) If the general terminal interface and the behavior associated with
118 {_POSIX_JOB_CONTROL} are not supported:

119 The sky is gray.

120 10(C) If the general terminal interface is supported and the behavior
121 associated with {_POSIX_JOB_CONTROL} is not supported:

122 The sky is black.

123 If an assertion is based on a value that is too large to test or is indeterminate
124 according to a POSIX standard, a symbol beginning with the characters "PCTS"
125 and representing the testing limit for that value is used in the assertion. The
126 assertion describes the expected behavior of the feature based on the value of the
127 "PCTS_" symbol. This symbol is used by a PCTS to determine the expected results
128 for the assertion.

129 Example:

130 11(A) If {OPEN_MAX} is defined and {OPEN_MAX} < {PCTS_OPEN_MAX}:

131 The sky is blue.

132 Otherwise:

133 The sky is gray.

134 When an assertion requires many tests in order to test the assertion thoroughly, a
135 list or table is provided that contains the minimum required tests.

136 Example:

137 12(A) The sky has the colors black, white, aqua blue, and slate blue.

138 Or:

139 12(A) The sky changes colors during the day as shown in Table 6-1.

140 **Table 6-1 – Changing Sky**

141

142	Time of Day	Color
143	Dawn	black
144	Midday	white
145	Sunset	aqua blue
146	Evening	slate blue
147		

148 Two assertions are written when a statement in a POSIX standard specifies a set
149 of independent alternative setup conditions, some of which cannot be set. A base
150 assertion is written for the conditions that can be set. An extended assertion is
151 written for the conditions that cannot be set.

152 Example:

153 13(B) When it is noon, or the earth is struck by an asteriod, the system
154 prints "Hello there."

155 Splits into the following two assertions:

156 13(A) When it is noon, the system prints "Hello there."

157 14(B) When the earth is struck by an asteroid, the system prints "Hello
158 there."

159 6.2.1.3.1 General Assertions

160 General assertions are statements of behavior or functionality derived from a
161 POSIX standard that apply to more than one element and expand into one asser-
162 tion specific to each applicable element. General assertions are written as GA#,
163 where # is an integer beginning with one (1) and the value of # is unique within
164 each POSIX standard. General assertions are not assigned a classification. Each
165 assertion that is derived from a general assertion contains a reference to the gen-
166 eral assertion from which it was derived.

167 Example:

168 GA1 When a special key is pressed, the system stops.

169 This assertion becomes the following for the BREAK key element:

170 15(A) When the BREAK key is pressed, the system stops. (See GA1)

171 **6.2.1.3.2 Reference Assertions**

172 Reference assertions are written as R#, where # is an integer beginning with one
173 (1) and the value of # is unique within the description of each element. Reference
174 assertions are not assigned a classification. Reference assertions contain pointers
175 to the actual assertion(s).

176 Example:

177 R01 When there are no clouds overhead, then the sky is blue. (See
178 Assertion(s) 1,2 in 6.2.1.3)

179 **6.2.1.3.3 Testing Requirements**

180 When there is a possibility that an assertion may be ambiguous or subject to
181 misinterpretation, a clarification of the assertion is provided by adding a testing
182 requirement statement after the assertion. This is necessary when attempts to
183 provide additional precision to an assertion only results in increasing its ambi-
184 guity and “fog factor.”

185 Example:

186 16(A) When clouds cover the sky, the sky is gray.

187 Testing Requirement(s):

188 Test for initial sky colors of black, white, aqua blue, and
189 slate blue.

190 **6.2.1.3.4 Unused Assertion Numbers**

191 “Unused Assertion Numbers: # —” denotes that assertion number # is no longer
192 valid because the wording has been amended in the standard under test or the
193 original assertion was determined to be incorrect.

194 **6.2.2 Assertion Format**

195 This subclause formally defines the content of assertions using a formal
196 specification. This formal specification is used to assure a clarity and preciseness
197 in the definition of the assertion constructs that will facilitate a consistent
198 definition of assertions by future test methods working groups.

199 The following rules were used in developing the formal specification of the asser-
200 tion format:

- 201 (1) A variable name is a single word consisting of uppercase letters and
202 digits.
- 203 (2) Variables are defined by a variable name followed by the symbol ::= and
204 the definition.
- 205 (3) A definition consists of ordered sets of variables, literals, and variable
206 text.
- 207 (4) Quoted (“ ”) strings are literals that shall be used in assertions exactly as
specified.

208 (5) A variable may have more than one definition. The symbol || is used to
209 delineate alternatives.

210 (6) Variable text is specified by an unquoted phrase in uppercase and
211 lowercase.

212 All assertions shall be written in a form consistent with the grammar and rules
213 given in 6.2.2.1 and 6.2.2.2.

214 6.2.2.1 Assertion Format Grammar

215 ASSERTION::= Number "(" CLASS ")" STATEMENT || GENASSERT ||
216 REASSERT
217 CLASS::= CLASSLETTER || ICTEXT "?" CLASSPAIR
218 CLASSLETTER::= "A" || "B" || "C" || "D"
219 CLASSPAIR::= "A:B" || "C:D" || CLASSLETTER ":UNUSED"
220 STATEMENT::= MAINSTATEMENT || FORSTATEMENT
221 MAINSTATEMENT::= ATEXT || A1 ATEXT || A1 ATEXT "Otherwise" A4 ATEXT ||
222 A2 ATEXT
223 A1::= A3 || A3 "when" SCTEXT NEXTSTATE "then"
224 A2::= "when" SCTEXT NEXTSTATE "then"
225 A3::= "If" ICTEXT NEXTCONDITION ":"
226 A4::= NULL || STATE "then"
227 STATE::= "when" SCTEXT NEXTSTATE
228 NEXTSTATE::= NULL || "and" SCTEXT NEXTSTATE ||
229 "or" SCTEXT NEXTSTATE
230 NEXTCONDITION::= NULL || "and" ICTEXT NEXTCONDITION
231 ATEXT::= Assertion text
232 ICTEXT::= Implementation Condition text
233 SCTEXT::= State Condition text
234 GENASSERT::= "GA" Number STATEMENT
235 REASSERT::= "R" Number STATEMENT
236 FORSTATEMENT::= "For" ELEMENTLIST ":" MAINSTATEMENT ||
237 FORSTATEMENT blankline "For" ELEMENTLIST ":"
238 MAINSTATEMENT
239 ELEMENTLIST::= Element name || Element name "," ELEMENTLIST

240 6.2.2.2 Assertion Format Rules

241 (1) For type A and B assertions, an 'If' must always be followed by an
242 'Otherwise'.

243 (2) Type C and D assertions must start with an 'If'.

244 (3) For type C and D assertions, an 'Otherwise' shall not be used.

245 (4) Assertions derived from a general assertion (GENASSERT) must include a
246 reference to the general assertion in the form (see GA# in x.y.z) following
247 the MAINSTATEMENT (see 6.2.1.3.1).

- 248 (5) A reference assertion (REFASSERT) must include a pointer in the form
249 (see Assertion(s) # in x.y.z) following the MAINSTATEMENT (see
250 6.2.1.3.2).
- 251 (6) Testing requirements shall follow the MAINSTATEMENT and be preceded
252 by a blank line (see 6.2.1.3.3).

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Section 7: Assertion Test Output

7.1 Test Result Codes

After execution of assertion tests, there shall be sufficient output to derive the following information:

- The element name tested,
- The number of the assertion tested,
- Whether the corresponding assertion is base or extended, and
- The test result code.

There are two types of test result codes: final and intermediate.

The final test result codes are:

- **PASS** - The assertion was found to be true based on the execution of its assertion test.
- **FAIL** - The assertion was found to be false based on the execution of its assertion test.
- **UNTESTED** - Either there is no assertion test or the implemented test(s) for the extended assertion is not complete enough to result in a test result code of **PASS** or **FAIL**.
- **UNSUPPORTED** - An assertion test could not be performed because the conditional feature was not implemented. Additional final test result codes shall only be used in situations for which none of the above final test result codes apply. Any additional final test result codes used by a test method shall be documented in the test method documentation.

The intermediate test result code is:

- **UNRESOLVED** - At least one of the following conditions is true:
 - (1) The assertion test requires manual inspection in order to determine its result.
 - (2) The setup for the assertion test did not complete in the manner expected.
 - (3) The test program containing the assertion test was unexpectedly interrupted.
 - (4) The assertion test could not be executed because a previous assertion test on which it depended failed.
 - (5) The test program containing the assertion was not initiated.

- 33 (6) Compilation or execution of the test program produced unexpected
34 errors or warnings.
- 35 (7) The assertion test did not resolve to a final test result code for any
36 other reason.

37 All occurrences of **UNRESOLVED** test result codes shall resolve to one of the final
38 test result codes before a statement of conformance (see Section 8) is made.

39 The permissible test result codes for each class of assertions as explained in
40 Classification of Assertions (see Section 5) are shown in Table 7-1.

41 **Table 7-1 – Test Result Codes**
42

	Base Assertion	Extended Assertion
Required Feature	PASS	PASS
	FAIL	FAIL
	UNRESOLVED	UNTESTED UNRESOLVED
Conditional Feature	PASS	PASS
	FAIL	FAIL
	UNSUPPORTED	UNSUPPORTED
	UNRESOLVED	UNTESTED UNRESOLVED

54 Test methods shall not attach any other meaning to the test result codes
55 described above.

56 For each element, there is a largest assertion number that is actually used. For
57 each number less than that maximum and for which there is no valid assertion, a
58 test method shall output **UNUSED** in place of a valid test result code.

59 When the test result code is **FAIL** or **UNRESOLVED**, the test method shall pro-
60 vide, to the extent possible, sufficient information to determine the cause of the
61 result.

62 If an unexpected event occurs while determining the result of an assertion test
63 that could invalidate the test result, the test method shall identify it to the extent
64 possible and report such an occurrence. If the assertion test cannot be completed
65 after such an occurrence, the test result code shall be **UNRESOLVED**. If the test
66 method is a PCTS, it should strive to continue to execute test programs, but shall
67 report any assertion test that could not be executed as **UNRESOLVED**. A PCTS
68 should attempt to recover from the unexpected event in a manner that maximizes
69 the execution of assertion tests while ensuring the validity and correctness of sub-
70 sequent test results.

Section 8: Statement of Conformance to a POSIX Standard

8.1 Conformance Statement Contents

The results of the execution of the test methods against a specific target system may be summarized in a statement of conformance concerning that target system. If a statement of conformance is made, the following information shall be provided in the conformance statement:

- The name and edition of the POSIX.n standard to which conformance is being measured;
- The names and version numbers of the test methods used;
- The POSIX.n test method specifications to which the test methods conforms;
- The name, model, and configuration of the computer systems tested and the name, version, and release level of the implementation stated in terms of the identification scheme of the implementor;
- The name and version of the audited PCD (if a PCD is required by the POSIX.n standard);
- The date the test methods were applied; and
- The language bindings that have been tested.

In addition, the following information shall be available:

- The final result code for each assertion test, and
- A description of any modifications made to the test methods.

A statement of conformance to a POSIX standard is based on a completed test of the target system using a set of POSIX.3 conforming test methods, where for each POSIX.3 assertion for that standard, there is a correctly assigned test result code. A target system conforms to that standard if those test result codes are as in Table 8-1.

26
27
28
29
30
31
32
33
34

Table 8-1 – Conformance Test Result Codes

	Base Assertion	Extended Assertion
Required Feature	PASS	PASS UNTESTED
Conditional Feature	PASS UNSUPPORTED	PASS UNSUPPORTED UNTESTED

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Annex A (informative) Bibliography

1 This Annex contains lists of related open systems standards and suggested reading
2 on historical implementations and application programming.

3 A.1 Related Open Systems Standards

4 A.1.1 Networking Standards

- 5 [B1] ISO 7498: 1984, *Information processing systems—Open Systems Inter-*
6 *connection—Basic Reference Model.*¹⁾
- 7 [B2] ISO 8072: 1986, *Information processing systems—Open Systems Inter-*
8 *connection—Transport service definition.*
- 9 [B3] ISO/IEC 8073: 1988, *Information processing systems—Open Systems Inter-*
10 *connection—Connection oriented transport protocol specification.*²⁾
- 11 [B4] ISO 8326: 1987, *Information processing systems—Open Systems Inter-*
12 *connection—Basic connection oriented session service definition.*
- 13 [B5] ISO 8327: 1987, *Information processing systems—Open Systems Inter-*
14 *connection—Basic connection oriented session protocol definition.*
- 15 [B6] ISO 8348: 1987, *Information processing systems—Data communications—*
16 *Network service definition.*
- 17 [B7] ISO 8473: 1988, *Information processing systems—Data communications—*
18 *Protocol for providing the connectionless-mode network service.*
- 19 [B8] ISO 8571: 1988, *Information processing systems—Open Systems Inter-*
20 *connection—File Transfer, Access and Management.*
- 21 [B9] ISO 8649: 1988, *Information processing systems—Open Systems Inter-*
22 *connection—Service definition for the Association Control Service Element.*

23 1) ISO documents can be obtained from the ISO office, 1, rue de Varembe, Case Postale 56, CH-1211,
24 Genève 20, Switzerland/Suisse.

25 2) IEC documents can be obtained from the IEC office, 3, rue de Varembe, Case Postale 131, CH-
26 1211, Genève 20, Switzerland/Suisse.

- 27 {B10} ISO 8650: 1988, *Information processing systems—Open Systems Inter-*
28 *connection—Protocol specification for the Association Control Service*
29 *Element.*
- 30 {B11} ISO 8802-2: 1989 [IEEE Std 802.2-1989 (ANSI)], *Information processing*
31 *systems—Local area networks—Part 2: Logical link control.*
- 32 {B12} ISO 8802-3: 1989 [IEEE Std 802.3-1988 (ANSI)], *Information processing*
33 *systems—Local area networks—Part 3: Carrier sense multiple access with*
34 *collision detection (CSMA/CD) access method and physical layer*
35 *specifications.*
- 36 {B13} ISO/IEC 8802-4: 1990 [IEEE Std 802.4-1990 (ANSI)], *Information*
37 *technology—Local area networks—Part 4: Token-passing bus access method*
38 *and physical layer specifications.*
- 39 {B14} ISO 8802-5: ... (IEEE 802.5-1989), *Information technology—Local area*
40 *networks—Part 5: Token ring access method and physical layer*
41 *specifications.*
- 42 {B15} ISO 8822: 1988, *Information processing systems—Open Systems Inter-*
43 *connection—Connection oriented presentation service definition.*
- 44 {B16} ISO 8823: 1988, *Information processing systems—Open Systems Inter-*
45 *connection—Connection oriented presentation protocol specification.*
- 46 {B17} ISO 8831: 1989, *Information processing systems—Open Systems Inter-*
47 *connection—Job transfer and manipulation concepts and services.*
- 48 {B18} ISO 8832: 1989, *Information processing systems—Open Systems Inter-*
49 *connection—Specification of the basic class protocol for job transfer and*
50 *manipulation.*
- 51 {B19} CCITT Recommendation X.25, *Interface between data terminal equipment*
52 *(DTE) and data circuit-terminating equipment (DCT) for terminals operating*
53 *in the packet mode and connected to public data networks by dedicated*
54 *circuit.*³⁾
- 55 {B20} CCITT Recommendation X.212, *Information processing systems—Data*
56 *communication—Data link service definition for Open Systems*
57 *Interconnection.*

58 A.1.2 Language Standards

- 59 {B21} ISO 1539: 1980, *Programming languages—FORTRAN.*
- 60 {B22} ISO 1989: 1985, *Programming Languages—COBOL.*
- 61 {B23} ISO 8652: 1987, *Programming Languages—Ada.*

62 3) CCITT documents can be obtained from the CCITT General Secretariat, International
63 Telecommunications Union, Sales Section, Place des Nations, CH-1211, Genève 20,
64 Switzerland/Suisse.

- 65 {B24} ANSI X3.113-1987⁴⁾, *Information systems—Programming language—FULL*
66 *BASIC.*
- 67 {B25} ANSI/IEEE 770X3.97-1983, *Standard Pascal Computer Programming*
68 *Language.*
- 69 {B26} ANSI/MDC X11.1-1984, *Programming Language MUMPS.*

70 **A.1.3 Graphics Standards**

- 71 {B27} ISO 7942: 1985, *Information processing systems—Computer graphics—*
72 *Graphical Kernel System (GKS) functional description.*
- 73 {B28} ISO 8632: 1987, *Information processing systems—Computer graphics—*
74 *Metafile for the storage and transfer of picture description information.*
- 75 {B29} ISO/IEC 9592: 1989 (ANSI X3.144-1988), *Information processing systems—*
76 *Computer graphics—Programmer's hierarchical interactive graphics system*
77 *(PHIGS).*

78 **A.1.4 Database Standards**

- 79 {B30} ISO 8907: 1987, *Database Language—NDL.*
- 80 {B31} ISO 9075: 1987, *Database Language—SQL.*

81 **A.2 Other Standards**

- 82 {B32} ISO 639: 1988, *Code for the representation of names of languages.*
- 83 {B33} ISO 3166: 1988, *Code for the representation of names of countries.*
- 84 {B34} ISO 8859-1: 1987, *Information Processing—8-bit single-byte coded graphic*
85 *character sets—Part 1: Latin alphabet No. 1.*
- 86 {B35} ISO 9127: 1988, *Information processing systems—User documentation and*
87 *cover information for consumer software packages.*
- 88 {B36} ISO/IEC 9945-2: ..., ⁵⁾ *Information technology—Portable operating system*
89 *interface (POSIX)—Part 2: Shell and utilities.*
- 90 {B37} ISO/IEC 10646: ..., ⁶⁾ *Information processing—Multiple octet coded charac-*
91 *ter set.*
- 92 {B38} IEEE Std 100-1988, *IEEE Standard Dictionary of Electrical and Electronics*
93 *Terms.*

94 4) ANSI documents can be obtained from the Sales Department, American National Standards
95 Institute, 1430 Broadway, New York, NY 10018.

96 5) To be approved and published.

97 6) To be approved and published.

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Annex B (informative)

Rationale and Notes

1 **B.1 General**

2 The developers of this International Standard rejected any requirements on how
3 to create a test suite. It was recognized that target systems may range from small
4 embedded systems to a large mainframe. It was also recognized that some com-
5 pany might have a specific situation where they would like to conform to this
6 International Standard, but the situation required a nonportable test method.

7 Automatic testing versus interactive testing was discussed. It was concluded that
8 the test methods could include interactive testing, although the goal should be
9 automatic testing in a thorough manner. This conclusion was reached even
10 though it was recognized that this could put a requirement on having additional
11 hardware, such as having two asynchronous ports versus one, so that closed-loop
12 testing could be performed.

13 The meaning of a PCTS and whether it included a documentation audit of the
14 required documentation was discussed. The developers of this International Stan-
15 dard concluded that the documentation audit was separate from the PCTS.

16 **B.2 Terminology and General Requirements**

17 The terms defined in this section are unique to this International Standard and
18 apply to other POSIX.3.n standards.

19 **assertion**

20 The developers of this International Standard earlier defined an assertion
21 to be the essential functionality from a statement in an applicable POSIX
22 standard that would correspond to a single test result. This would permit a
23 PCTS developer to execute a specific software or procedure test and docu-
24 mentation audit on a conforming implementation to verify the functionality
25 of that assertion. Use of the phrase “software or procedure” is used in favor
26 of “software” to cover assertions that require a manual procedure to deter-
27 mine results.

28 The developers of this International Standard later decided to drop the con-
29 cept of correspondence of an assertion to a single test result from the
30 definition. This was primarily because the previous definition imposed an
31 unnecessary restriction on the implementation of a PCTS. Moreover, the
 definition disagreed with one in IEEE Std 729-1983, which is one of the
 referenced documents of this International Standard.

32 **assertion test**

33 This is defined to be the software or procedure that determines confor-
34 mance of a POSIX implementation to an assertion. This would include, for
35 example, an executable software test, the manual verification inspection of
36 output, or the auditing of required implementation-defined documentation
37 required by a POSIX standard.

38 **base assertion**

39 This is an assertion that is required to be tested because a POSIX standard
40 required it as a feature with a shall statement or through an implied shall
41 statement in a declarative sentence. Another class of base assertion is
42 where a conditional feature (see 2.2.2.5) has been implemented and there-
43 fore must be tested.

44 **conditional feature**

45 In POSIX.3, the term *conditional*, which has a broader meaning, is used in
46 favor of the POSIX.1 term *optional*. The term optional may be defined in
47 other POSIX standards, but their definitions will always be subsets of the
48 POSIX.3 term conditional. The term optional, in a POSIX standard, implies
49 a feature or behavior that the developers of the applicable POSIX standard
50 have deliberately specified as an option, as opposed to a requirement. The
51 issue is raised when a statement in the standard states that a feature is
52 only required if it is actually implemented by the conforming POSIX system,
53 which means that within a PCTS a condition is raised as to whether the test
54 should proceed if the relative POSIX feature has been implemented. Exam-
55 ples of this are asynchronous communications, file types, and privileged
56 mode in POSIX.1.

57 **development system**

58 It is not necessary for the development system to be POSIX conforming.
59 However, it shall have all the software necessary to generate the configured
60 PCTS for the specified target system. In such a case, the compilation
61 environment used to generate the configured PCTS will be considered part
62 of the target system configuration.

63 **extended assertion**

64 This is an assertion that is not a base assertion, hence it is not required to
65 be tested. The reason the developers of this International Standard created
66 this class of assertion is because there will be features specified in the
67 POSIX standards that will be untestable (see B.5).

68 **PCTP**

69 This standard defines PCTS to be software. To test an assertion requires
70 executing the assertion test software. However, the result produced by the
71 assertion test software may not resolve to the final result code of the asser-
72 tion test. A procedure may have to be manually executed to resolve the
73 assertion test to a final **PASS** or **FAIL** test result code. In other words, it
74 takes both a piece of software and human executed procedures to produce a
75 final result for some assertion tests.

76 For example, an element such as the `lp` command may have an assertion
77 defined that requires the printing of some specific characters on a printer.
78 The assertion test software can send the characters to the printer, but it
cannot verify that the printer printed the correct characters. In this

79 example, the test result code of the assertion test software would be an
80 intermediate test result code such as **UNRESOLVED**. The test result mes-
81 sage would indicate that someone must follow a procedure to verify that the
82 printer printed the correct characters. In this example, both software and
83 manual procedures are required to resolve the assertion test to a test result
84 code of **PASS** or **FAIL**.

85 In conclusion, the final results needed to produce the conformance state-
86 ment might require software testing and human executed procedures.

87 required feature

88 This is a feature that is required by a conforming implementation as
89 specified by the applicable POSIX standard. A required feature is deter-
90 mined by a specific shall statement or an implied shall statement in the
91 POSIX standard. A required feature usually generates a base assertion, but
92 it may become an extended assertion if the feature is determined to be
93 untestable by a PCTS with supporting rationale as discussed in B.5.

94 This definition of required feature handles the ‘If . . . Otherwise . . .’ asser-
95 tion construct. The alternative to this would have been to require that ‘If
96 . . . Otherwise . . .’ assertions would have to be split up into two “C” type
97 assertions, where one of the two would result in an **UNSUPPORTED** test
98 result code. In order to avoid this and to preserve the concept that in the
99 absence of a conditional feature there is required behavior for a conforming
100 implementation, the definition of required feature was modified.

101 Some terms that were in previous drafts of this International Standard have been
102 removed. However, the rationale for these definitions has been preserved for his-
103 torical reasons.

104 closed-loop mode

105 A closed-loop mode of terminal I/O testing of a target system configuration
106 would be where two target system asynchronous ports are electrically con-
107 nected in such a way that data communications is performed between the
108 ports using modem control protocols.

109 compliance

110 The term *compliance* was introduced in POSIX.3 to provide an efficient way
111 to represent specific, acceptable levels of conformance of an implementation
112 to a POSIX standard (as measured by a POSIX.3 conforming test method).
113 Thus, “compliant with” a POSIX standard as measured by a test method
114 means “passing” that test method.

115 The standard dictionary meanings of *compliance* and *conformance* are very
116 similar. The developers of this International Standard chose to differen-
117 tiate the meanings of these words in the context of measuring conformance
118 to a POSIX standard in order to distinguish between the theoretical ideal of
119 complete conformance and the practical measurement of that conformance.

120 Based on the definitions of conformance in a specific POSIX standard, a sup-
121 plier may claim conformance of an implementation to that POSIX standard.
122 Similarly, based on the definition of conformance in the POSIX.3 standard, a
test methods supplier may claim conformance to the POSIX.3 standard. The
purpose of the test method specified in the POSIX.3 standard is to measure

123 the level of conformance of an implementation to a POSIX standard. Practi-
124 cal limitations, however, preclude the test method from guaranteeing com-
125 plete conformance. It follows that an implementation might be 100% com-
126 pliant with a POSIX standard, even though it is less than 100% conformant
127 to that standard.

128 To sum up, an implementation may conform to a POSIX standard to some
129 degree, but there is no way of guaranteeing complete conformance, and no
130 efficient way of describing acceptable degrees of conformance without intro-
131 ducing additional terms.

132 conformance

133 After the draft balloting of this International Standard, the developers of
134 this International Standard decided that the distinction between the terms
135 *compliance* and *conformance* should be eliminated as it was causing confu-
136 sion. The developers of this International Standard decided to treat both
137 terms synonymously as done by English dictionaries, and to use the term
138 *conformance* to ascertain the application portability of a computing
139 environment.

140 B.3 Test Methods Conformance to This Standard

141 The developers of this International Standard determined that it was necessary to
142 require the developers of a PCTS to document the nature of their test suite. The
143 developers of this International Standard did not specify the exact nature of the
144 required PCTS documentation, as the marketplace would determine the needs of
145 the user for understanding each PCTS to test conforming systems. The developers
146 of this International Standard did provide the requirement that a PCTS shall
147 include all the information to install, configure, and execute the PCTS. The other
148 requirement was that a user of the PCTS should be able to gather and interpret
149 the results of the PCTS. The developers of this International Standard also
150 specified that the documentation would meet the requirements of a Conforming
151 POSIX Application as specified in POSIX.1.

152 While the standard states that the documentation should provide information as
153 to how to execute the PCTS, it is implicit that any PCTS may only be able to exe-
154 cute on a subset of the totality of conforming implementations. PCTS implementa-
155 tions are likely to have dependencies on facilities outside the POSIX standard
156 under test, and the documentation only needs to describe installation and execu-
157 tion methods on an environment for which the PCTS was designed.

158 As an example for items to consider, the developers of this International Standard
159 provided what they felt would be a sample of information that a PCTS documenta-
160 tion package could supply with the PCTS product.

161 The documentation for the test methods may contain the following information:

- 162 — The edition of the standard being tested;
- 163 — An overview of the PCTS, including the extended assertions and the
164 optional POSIX features tested by the PCTS;
- 165 — A specification of any deviance from the recommendations defined
within this International Standard;

- 166 — A specification of any known limitations of the PCTS;
- 167 — A specification of any release-specific change;
- 168 — A specification of any configuration-specific parameters;
- 169 — A specification of development system hardware requirements such as
- 170 memory, disk space, terminal, and printer needs;
- 171 — A specification of development system software requirements;
- 172 — A specification of the hardware and software requirements necessary to
- 173 execute the PCTS;
- 174 — A definition of the user interface syntax;
- 175 — A description of the procedures for transferring the PCTS to a target sys-
- 176 tem, if the PCTS requires such a transfer;
- 177 — A specification of the format of the PCTS output;
- 178 — Examples of sample PCTS output;
- 179 — A description of the procedures for obtaining the PCTS output;
- 180 — Examples of the procedures for obtaining PCTS output;
- 181 — A list of any known assertion tests that may severely impact PCTS exe-
- 182 cution; and
- 183 — A description of any PCTS trouble-clearing procedures.

184 **B.4 Testing Levels and Complexity Levels**

185 **B.4.1 Introduction**

186 There is no additional rationale provided for this subclause.

187 **B.4.2 Testing Levels**

188 The developers of this International Standard determined it was necessary to
189 define what the testing levels were when developing a PCTS. This was put into
190 the actual standard to provide a guideline for those entities developing PCTSs for
191 the POSIX standards. The degrees of testing were *exhaustive*, *thorough*, and
192 *identification*, with discussion of each methodology contained in the standard.

193 The conclusion of the developers of this International Standard was that each
194 PCTS would vary and each level of testing for each assertion would also vary.

195 **B.4.3 Complexity Levels**

196 A software problem exists within the context of what exactly are the ramifications
197 of an element that should be tested. What are the practical and economic con-
198 siderations? The components of an element and the interrelationships of that ele-
199 ment to other elements are what can create the complexity, from a design point of
200 view, within a PCTS.

201 Each element has at least two realms of complexity. One realm deals with the
202 complexity of the functionality of the element itself. The other realm is how hard
203 it is to test the functionality of the element. An element may have much func-
204 tionality and many hundreds of assertions must be defined to test all aspects of
205 the element, but the testing of the element is rather simple, while another ele-
206 ment may be simple in functionality, but the testing is not simple.

207 The developers of this International Standard chose to only deal with the one
208 realm. This is the realm that deals with the complexity of the functionality of the
209 element.

210 **B.4.4 Conclusion**

211 The developers of this International Standard considered, and rejected, a proposal
212 to remove this clause from the standard. The objection raised was, "this section
213 has no measurable requirement on a PCTS and the terms are subjective." This is
214 true. However, while there is nothing measurable in this clause, much of POSIX.3
215 deals with the definition of general concepts, and other standards exist that
216 present such general concepts. For example, ISO/IEC DIS 9646-1: ..., *Information*
217 *technology—OSI conformance testing methodology and framework—Part 1: Gen-*
218 *eral concepts*,¹⁾ discusses general conformance testing concepts as they apply to
219 OSI interfaces. Because of these existing documents, this objection was rejected.

220 This section specifically deals with the concept of conformance testing and the
221 evaluations of elements that must be made by the assertion writers and PCTS
222 writers.

223 **B.5 Classification of Assertions**

224 It is highly recommended that extended assertions be tested whenever possible.
225 Development of assertion tests for extended assertions is encouraged because it is
226 desired that test suites be made available that are as complete as possible in
227 regards to the assertions in POSIX.3.n.

228 Seven reasons exist for extended assertions.

229 (1) There is no known portable test method for this assertion.

230 The first reason states that a portable test cannot be written for all con-
231 forming systems because the actual software may change for different

232 1) To be approved and published.

233 target systems that the PCTS supports. This is the case where exits into
234 the hosting operating system would have to be written for a POSIX con-
235 forming system and would most likely be different for each target system.
236 Reason 1 is used instead of reason 3 when there is a known test method
237 for the assertion for at least one POSIX implementation, but that method
238 is not portable to all POSIX implementations.

239 (2) The corresponding statement in the POSIX standard to which confor-
240 mance is being measured is not specific enough to write a portable test.

241 The second reason stated is that the POSIX standard was not clear in the
242 specification of a feature from a software testing viewpoint. An example
243 of this is in POSIX.1, where it is stated that the *stat.h* data items shall
244 have meaningful values. A PCTS would have great difficulty in determin-
245 ing the test software to verify that a *stat* structure contains meaningful
246 values. It may be that supplements developed for the POSIX standards
247 can address these statements in the applicable POSIX standard.

248 (3) There is no known reliable test method for this assertion.

249 The third reason stated is the result of the developers of this Interna-
250 tional Standard being unable to determine a software or procedure test to
251 determine if the assertion did what was stated in the applicable POSIX
252 standard. An example of this case can be seen when trying to determine
253 elapsed clock time for a particular function in a POSIX standard.

254 (4) Testing the assertion requires setup procedures that involve an unrea-
255 sonable amount of effort by the user of a PCTS.

256 (5) Testing the assertion would require an unreasonable amount of time or
257 resources on most systems.

258 (6) Creating an assertion test would require an unreasonable amount of test
259 development time.

260 The fourth, fifth, and sixth reasons were a judgment call on the part of
261 the developers of this International Standard trying to perceive the sys-
262 tem, engineering, and business costs of testing assertions on a conform-
263 ing POSIX system. The developers of this International Standard
264 achieved consensus on the aspects of what the word "reasonable" denotes
265 in POSIX.3 regarding testing assertions. The working group also realized
266 that the marketplace would drive the need for extended assertions to be
267 tested if they were critical within the respective industry.

268 (7) The assertion test could have an adverse effect on completion of a test
269 method.

270 The classification of assertions, the assertion matrix, and the extended assertion
271 rationale can be used to categorize an assertion in the POSIX.n standard.

272 This standard does not preclude a test suite from containing further tests beyond
273 those contained in the assertion list for the corresponding POSIX standard.
274 Where a test suite contains such assertions, the same test result codes may be
275 used as defined in Section 7, but the additional assertions must not be taken into
276 account in determining the conformance of an implementation to the POSIX
standard.

277 **B.6 Writing Assertions**

278 **B.6.1 Assertion Determination**

279 Certain statements containing the word *may* do not provide sufficient clarity. For
280 these cases no assertion can be written. For example, the statement

281 A call to *fopen()* may cause the *st_atime* field of the underlying file to be
282 marked for update.

283 does not declare whether the behavior is to be consistent for all file types or a
284 specific implementation.

285 The definition for *may* is the most difficult to deal with when writing a test suite.
286 Each *may* could indicate a branch in the flow of control of a function, the
287 definition of which is at the discretion of the supplier. From the perspective of a
288 test suite, a reliable test that exercises a *may* feature is difficult to create. The
289 test might attempt to use the feature and report the results, but it cannot report
290 an error if the feature acts in a nondeterministic way (from the point of view of
291 the standard). Unfortunately, an allowable side effect of a *may* feature could be
292 catastrophic.

293 **B.6.2 Assertion Constructs**

294 Very late in the development of this International Standard, it was recognized
295 that constructs must be provided for those times when a standard states that the
296 concept in question is implementation defined and nothing in the standard
297 requires that implementation to work, yet the concept is required to be imple-
298 mented in order to test that assertion. A case in point is read-only file systems.
299 The POSIX.1 standard does not tell how to create a read-only file system. The
300 POSIX.1 standard does not require them, but allows for them. How is a file
301 created on a read-only file system if the implementation does not support it?
302 This, then, is an implementation condition as opposed to a condition defined by
303 the standard.

304 Because of this problem, a new definition of a condition was introduced.

305 The developers of this International Standard now recognized that *conditions*
306 have two realms.

307 — Conditions defined by a standard.

308 — Conditions not defined by a standard, but defined by the
309 implementation.

310 Assertion constructs have been defined to handle all known conditions. We be-
311 lieve that these constructs can be used when writing assertions for any standard.

312 The POSIX standards define functionality based on qualifiers or prerequisites or,
313 for lack of another word, conditions. If the condition is not a required feature,
314 this International Standard (POSIX.3) uses the notation of conditional feature. If
315 the condition is a statement where an implementation must choose between two
316 or more qualifiers this International Standard calls this a *condition*. It is re-
quired that an implementation choose one of these conditions. These are condi-
tions defined by the POSIX standard.

317 The POSIX standards allow functionality that they do not explicitly define. They
318 state the concept as implementation defined. Some assertions may require that
319 the implementation support the condition in order to test the assertion.

320 **B.6.2.1 Assertion Parts**

321 **B.6.2.1.1 Assertion Number**

- 322 (1) Assertion numbers are identifiers, and do not imply a testing sequence or
323 location in the standard being tested.
- 324 (2) When an assertion is added, the next sequential unused number for the
325 element is assigned to the new assertion. The assertion will be placed as
326 close as possible to where it appears lexically in the standard for which
327 the assertions are being written.
- 328 (3) When an assertion is deleted, its assertion number is put on the
329 **UNUSED** list at the end of the assertion list for each element.
- 330 (4) If an assertion is changed substantially, it shall be deleted and a new
331 assertion shall be added.

332 **B.6.2.1.2 Assertion Classification**

333 There is no additional rationale for this subclause.

334 **B.6.2.1.3 Assertion Text and Examples**

335 This section shows examples of writing assertions. They are simplistic in scope,
336 but they accurately reflect the way assertions are expressed in POSIX.n standards.

337 The 'For' construct may be used within general assertions. For example:

338 GA1 For all elements, except *asteroids()* and *moons()*:
339 When a special key is pressed, the system stops.

340 This assertion becomes the following for the **BREAK** key element:

341 15(A) When the **BREAK** key is pressed, the system stops. (See GA1)

342 **B.7 Assertion Test Output**

343 To aid in the test result analysis process, it was decided that test output must
344 appear for each assertion, whether or not it is tested. The output for those test
345 assertions that are not tested because they are extended assertions for which no
346 tests are available show an **UNTESTED** test result code. The **UNTESTED** test
347 result code is intended to be used whenever an assertion test is not provided. If
348 an assertion test is provided but not attempted because of some environmental
349 failure, the **UNRESOLVED** test result code is used.

350 In an earlier draft, **PASS** was defined as a successful test. This was changed
351 because in software testing, the term *successful* often means that a bug was found
352 in the feature. This is just the opposite of what was to be portrayed in the
definition of **PASS**.

353 For several drafts this chapter contained the **ALERT** test result code with the fol-
354 lowing definition:

355 — The extended assertion was found to be false on the target system based
356 on execution of its assertion test.

357 Also, **FAIL** was defined for base assertions only. But the developers of this Inter-
358 national Standard decided that **FAIL** should apply when the assertion is found to
359 be false, regardless of whether or not it is a base or an extended assertion. Some
360 desired the means to determine from the test output whether or not a **FAILED** test
361 was from a base or an extended assertion, now that this distinction had been
362 taken away from the test result code. So the decision was made to require an
363 indication as to whether or not the assertion is base or extended in the test output
364 for each assertion test.

365 Here is an example of how test output conforming to this International Standard
366 might look:

```
367 fork 3 BASE PASS Child ID different from parent ID  
368 fork 4 EXTEND FAIL Child ID matched an active ID
```

369 There was considerable debate about the ability to resolve a test result code of
370 **UNRESOLVED** to a test result code of **UNTESTED** in the case of an extended
371 assertion that relied upon a supporting facility. It was agreed by the developers
372 of this International Standard that a failure to supply such a support facility
373 would cause the final result code to be represented as **UNTESTED**, since the test
374 had not been performed (and possibly should not be performed) by the system
375 under test.

376 During this debate the question of reliance of assertions on implementation-
377 defined features was also considered. If a base assertion is incorrectly classified, it
378 can be reclassified following the standard IEEE process. It was suggested that
379 such features could be provided by an implementation in such a manner as to
380 prohibit a test from accessing these features. (The particular example cited was
381 that of obtaining a controlling terminal.) A review of the definition of “implemen-
382 tation defined” in POSIX led to the belief that the conformance document needed
383 to detail the “correct program construct and correct data” that was required when
384 using such a feature. This supported the view that all implementation-defined
385 features needed to be available to a test author in an accessible manner on all
386 conforming implementations.

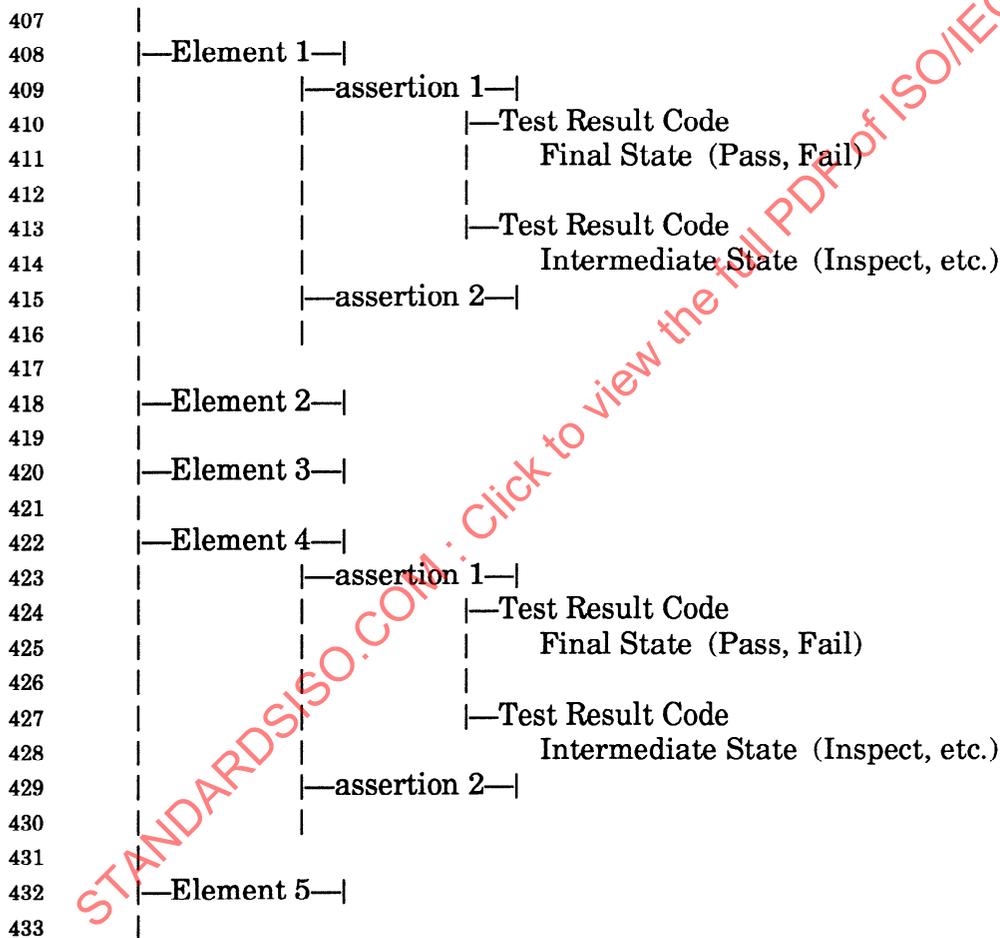
387 The paragraph on unexpected events is included in the standard because the
388 developers of this International Standard felt that a standard PCTS should have
389 the ability to recover from unexpected events such as signals. While it is true
390 that there are limitations to how well a piece of software can recover from such
391 events, the PCTS software is expected to recognize and report these events when-
392 ever possible.

393 The conformance testing reference model can be represented by two inverted trees
394 (see Figure B-1). One tree is the PCTS and the other tree is the procedures.

- 395 The forks in the tree are:
 396 — Element being tested
 397 — Assertions being tested
 398 — Test result codes (Final or Intermediate)

399 The lowest limb of the tree in most cases will result in an assertion test conclu-
 400 sion, and the test result code will be final. The test result code can be used as evi-
 401 dence in the preparation of a conformance statement. However, there are cases
 402 where the lowest limb cannot resolve to a final state. In this case, the lowest limb
 403 will represent an intermediate test result code. To determine the final test result
 404 one must return to the top of the element tree until one can resolve to a final
 405 state.

406 **Figure B-1 – Software Testing and Procedure Testing**



434 **B.8 Statement of Conformance to a POSIX Standard**

435 There was a concept of “Extended Compliance” in earlier drafts of this Interna-
436 tional Standard. It relied on calling FAILures of Extended Assertions an **ALERT**
437 test result code. Here is its previous definition:

438 **Extended Compliant:** A specific target system is extended compliant if it is base
439 compliant [where base compliant is the current definition of compliant] and
440 the following conditions are true:

- 441 — At least one extended assertion of a required feature or a conditional
442 feature resolved to a **PASS** test result code.
- 443 — For all extended assertions of required features that do not resolve to
444 **PASS**, The test result codes resolve to either **ALERT** or **UNTESTED**.
- 445 — The test result codes for extended assertions of conditional features
446 that do not resolve to **PASS**, resolve to **ALERT**, **UNTESTED**, or
447 **UNSUPPORTED**.

448 The extended compliance concept was removed because it allowed a level,
449 “extended,” that could be achieved by passing only one extended assertion. The
450 counter-case presented a challenge to credulity; The ability to have base compli-
451 ance with FAILed extended assertions is not within the spirit of POSIX.1.

452 The issue of “buggy” test methods was properly factored out of consideration.
453 Portability of test methods and specificity of the underlying standard (POSIX.1)
454 are the real concerns.

455 The discussion considered the POSIX implementor who would “shop around” for a
456 PCTS vendor who would have a suite that would not fail the implementation.

457 The following is a sample compliance statement as shown in an earlier draft of
458 this International Standard.

459 The XYZSYS Release 2.0 target system with conditional features, supplement-
460 ary groups, and job control supported, is **COMPLIANT** with ISO/IEC 9945-
461 1: 1990, C Language Binding (C Standard Language-Dependent System Sup-
462 port) as measured by the XSVS Release 1.0 PCTS, which conforms to POSIX.3
463 and POSIX.n.

464 The test methods were applied from Jan 2 to Jan 10, 1990.

465 Complete results are in “XSVS Release 1.0 Output for XYZSYS Release 2.0,
466 Report 060189-23,” XYZ Records Office, Vancouver, B.C., Canada.

467 A list of extended assertions that were tested is provided in the attached
468 report.

469 No changes were made to the target system or to the PCTS during execution
470 of the PCTS.

471 After initial balloting, the terms *conformance* and *compliance* were made
472 synonymous and the working group decided to use only the term *conformance* (see
473 B.2). Accordingly, the term *compliance* was consistently changed to *conformance*.

474 In addition, it was decided that the statement of conformance should include
identification of the configuration version and release level of the computer