

ISO/IEC/IEEE 9945:2026-03 (E)

Information technology - Portable Operating System Interface (POSIX™) Base Specifications, Issue 8

Contents		Page
Volume	1	Base Definitions, Issue 8..... 1
Chapter	1	Introduction..... 3
	1.1	Scope 3
	1.2	Word Usage..... 4
	1.3	Conformance..... 4
	1.4	Normative References 5
	1.5	Change History 5
	1.6	Terminology 5
	1.7	Definitions and Concepts..... 6
	1.8	Portability 7
	1.8.1	Codes 7
	1.8.2	Margin Code Notation 12
Chapter	2	Conformance..... 15
	2.1	Implementation Conformance 15
	2.1.1	Requirements..... 15
	2.1.2	Documentation 16
	2.1.3	POSIX Conformance..... 17
	2.1.4	XSI Conformance 19
	2.1.5	Option Groups..... 20
	2.1.6	Options 25
	2.2	Application Conformance..... 27
	2.2.1	Strictly Conforming POSIX Application..... 27
	2.2.2	Conforming POSIX Application 28
	2.2.3	Conforming POSIX Application Using Extensions..... 28
	2.2.4	Strictly Conforming XSI Application 29
	2.2.5	Conforming XSI Application Using Extensions 29
	2.3	Language-Dependent Services for the C Programming Language 29
	2.4	Other Language-Related Specifications..... 29
Chapter	3	Definitions..... 31
	3.1	Abortive Release..... 31
	3.2	Absolute Pathname..... 31
	3.3	Access Mode 31
	3.4	Additional File Access Control Mechanism..... 31
	3.5	Address Space..... 31
	3.6	Advisory Information..... 31
	3.7	Affirmative Response 32
	3.8	Alert 32
	3.9	Alert Character (<alert>)..... 32
	3.10	Alias Name..... 32
	3.11	Alignment 32

3.12	Alternate File Access Control Mechanism	32
3.13	Alternate Signal Stack.....	33
3.14	Ancillary Data.....	33
3.15	Angle Brackets.....	33
3.16	Anonymous Memory Object	33
3.17	Apostrophe Character (<apostrophe>).....	33
3.18	Application.....	33
3.19	Application Address.....	33
3.20	Application Program Interface (API)	33
3.21	Appropriate Privileges	34
3.22	Argument	34
3.23	Arm (a Timer)	34
3.24	Asterisk Character (<asterisk>)	34
3.25	Async-Cancel-Safe Function.....	34
3.26	Asynchronous Events.....	34
3.27	Asynchronous Input and Output	34
3.28	Async-Signal-Safe Function.....	35
3.29	Asynchronously-Generated Signal.....	35
3.30	Asynchronous I/O Completion.....	35
3.31	Asynchronous I/O Operation.....	35
3.32	Atomic Operation	35
3.33	Authentication	35
3.34	Authorization	36
3.35	Background Job	36
3.36	Background Process.....	36
3.37	Background Process Group	36
3.38	Backquote Character.....	36
3.39	Backslash Character (<backslash>)	36
3.40	Backspace Character (<backspace>)	37
3.41	Barrier	37
3.42	Basename.....	37
3.43	Basic Regular Expression (BRE).....	37
3.44	Bind	37
3.45	Blank Character (<blank>).....	37
3.46	Blank Line.....	37
3.47	Blocked Process (or Thread)	37
3.48	Blocking	38
3.49	Block-Mode Terminal	38
3.50	Block Special File.....	38
3.51	Braces	38
3.52	Brackets.....	38
3.53	Broadcast	38
3.54	Built-In Utility (or Built-In).....	39
3.55	Byte.....	39
3.56	Byte Input/Output Functions	39
3.57	Carriage-Return Character (<carriage-return>)	39
3.58	Character	39
3.59	Character Array.....	40
3.60	Character Class.....	40
3.61	Character Set.....	40
3.62	Character Special File	40
3.63	Character String.....	40

3.64	Child Process	40
3.65	Circumflex Character (<circumflex>).....	40
3.66	Clock	41
3.67	Clock Jump.....	41
3.68	Clock Tick.....	41
3.69	Code Block	41
3.70	Coded Character Set	41
3.71	Codeset	41
3.72	Collating Element.....	41
3.73	Collation	42
3.74	Collation Sequence.....	42
3.75	Column Position.....	42
3.76	Command.....	42
3.77	Command Language Interpreter	42
3.78	Composite Graphic Symbol.....	43
3.79	Condition Variable	43
3.80	Connected Socket	43
3.81	Connection	43
3.82	Connection Mode	43
3.83	Connectionless Mode	43
3.84	Control Character.....	43
3.85	Control Operator	44
3.86	Controlling Process	44
3.87	Controlling Terminal	44
3.88	Conversion Descriptor	44
3.89	Core Image	44
3.90	CPU Time (Execution Time)	44
3.91	CPU-Time Clock.....	44
3.92	CPU-Time Timer.....	45
3.93	Current Job	45
3.94	Current Working Directory.....	45
3.95	Cursor Position.....	45
3.96	Datagram	45
3.97	Data Race.....	45
3.98	Data Segment.....	45
3.99	Decimal-Point Character	45
3.100	Declaration Utility.....	45
3.101	Device	46
3.102	Device ID	46
3.103	Directory	46
3.104	Directory Entry (or Hard Link).....	46
3.105	Directory Stream	46
3.106	Disarm (a Timer)	46
3.107	Display.....	46
3.108	Display Line	46
3.109	Dollar-Sign Character (<dollar-sign>)	46
3.110	Dot	47
3.111	Dot-Dot.....	47
3.112	Dot-Po File.....	47
3.113	Double-Quote Character	47
3.114	Downshifting	47
3.115	Driver	47

3.116	Effective Group ID	47
3.117	Effective User ID	47
3.118	Eight-Bit Transparency	48
3.119	Empty Directory	48
3.120	Empty Line	48
3.121	Empty String (or Null String)	48
3.122	Empty Wide-Character String	48
3.123	Encoding Rule	48
3.124	Entire Regular Expression	48
3.125	Epoch	48
3.126	Equivalence Class	49
3.127	Era	49
3.128	Event Management	49
3.129	Executable File	49
3.130	Execute	49
3.131	Execution Time	49
3.132	Execution Time Monitoring	49
3.133	Expand	50
3.134	Extended Regular Expression (ERE)	50
3.135	Extended Security Controls	50
3.136	Feature Test Macro	50
3.137	Field	50
3.138	FIFO Special File (or FIFO)	51
3.139	File	51
3.140	File Description	51
3.141	File Descriptor	51
3.142	File Group Class	51
3.143	File Lock	51
3.144	File Mode	52
3.145	File Mode Bits	52
3.146	Filename	52
3.147	Filename String	52
3.148	File Offset	52
3.149	File Other Class	52
3.150	File Owner Class	52
3.151	File Permission Bits	53
3.152	File Serial Number	53
3.153	File System	53
3.154	File Type	53
3.155	Filter	53
3.156	First Open (of a File)	53
3.157	Flow Control	53
3.158	Foreground Job	54
3.159	Foreground Process	54
3.160	Foreground Process Group	54
3.161	Foreground Process Group ID	54
3.162	Form-Feed Character (<form-feed>)	54
3.163	Graphic Character	54
3.164	Group Database	55
3.165	Group ID	55
3.166	Group Name	55
3.167	Hard Limit	55

3.168	Hard Link	55
3.169	Hole	55
3.170	Home Directory	56
3.171	Host Byte Order.....	56
3.172	Incomplete Line.....	56
3.173	Inf.....	56
3.174	Interactive Device.....	56
3.175	Interactive Shell	56
3.176	Internationalization	56
3.177	Interprocess Communication	56
3.178	Intrinsic Utility	57
3.179	Invoke	57
3.180	Job.....	57
3.181	Job Control	57
3.182	Job ID	57
3.183	Joinable Thread.....	58
3.184	Last Close (of a File).....	58
3.185	Line.....	58
3.186	Linger	58
3.187	Link	58
3.188	Link Count	58
3.189	Live Process.....	59
3.190	Live Thread	59
3.191	Local Customs	59
3.192	Local Interprocess Communication (Local IPC).....	59
3.193	Locale	59
3.194	Localization.....	59
3.195	Lock-Free Operation	59
3.196	Login	60
3.197	Login Name	60
3.198	Map	60
3.199	Matched	60
3.200	Memory Mapped Files	60
3.201	Memory Object	60
3.202	Memory-Resident.....	60
3.203	Message	61
3.204	Message Catalog.....	61
3.205	Message Catalog Descriptor	61
3.206	Message Queue.....	61
3.207	Messages Object	61
3.208	Mode	61
3.209	Monotonic Clock	61
3.210	Mount Point	62
3.211	Multi-Character Collating Element	62
3.212	Multi-Threaded Library	62
3.213	Multi-Threaded Process	62
3.214	Multi-Threaded Program	62
3.215	Mutex	62
3.216	Name.....	63
3.217	NaN (Not a Number)	63
3.218	Native Language	63
3.219	Negative	63

3.220	Negative Response.....	63
3.221	Network.....	63
3.222	Network Address.....	63
3.223	Network Byte Order	64
3.224	Newline Character (<newline>)	64
3.225	Nice Value	64
3.226	Non-Blocking.....	64
3.227	Non-Spacing Characters	64
3.228	NUL.....	64
3.229	Null Byte.....	65
3.230	Null Pointer.....	65
3.231	Null String.....	65
3.232	Null Terminator.....	65
3.233	Null Wide-Character Code	65
3.234	Number-Sign Character (<number-sign>).....	65
3.235	Object File.....	65
3.236	Octet	65
3.237	OFD-Owned File Lock	66
3.238	Offset Maximum	66
3.239	Opaque Address.....	66
3.240	Open File	66
3.241	Open File Description.....	66
3.242	Operand.....	66
3.243	Operator	66
3.244	Option.....	67
3.245	Option-Argument	67
3.246	Orientation	67
3.247	Orphaned Process Group.....	67
3.248	Page.....	67
3.249	Page Size.....	67
3.250	Parameter	68
3.251	Parent Directory	68
3.252	Parent Process.....	68
3.253	Parent Process ID	68
3.254	Pathname.....	68
3.255	Pathname Component.....	69
3.256	Path Prefix	69
3.257	Pattern.....	69
3.258	Period Character (<period>)	69
3.259	Permissions	69
3.260	Persistence.....	69
3.261	Pipe.....	70
3.262	Polling.....	70
3.263	Portable Character Set	70
3.264	Portable Filename.....	70
3.265	Portable Filename Character Set.....	70
3.266	Portable Messages Object Source File (or Dot-Po File).....	70
3.267	Positional Parameter.....	71
3.268	Positive	71
3.269	Preallocation	71
3.270	Preempted Process (or Thread).....	71

3.271	Previous Job	71
3.272	Printable Character	71
3.273	Printable File	71
3.274	Priority	72
3.275	Priority Inversion	72
3.276	Priority Scheduling	72
3.277	Priority-Based Scheduling	72
3.278	Privilege	72
3.279	Process	72
3.280	Process Group	72
3.281	Process Group ID	72
3.282	Process Group Leader	72
3.283	Process Group Lifetime	73
3.284	Process ID	73
3.285	Process Lifetime	73
3.286	Process Memory Locking	73
3.287	Process Termination	73
3.288	Process Virtual Time	74
3.289	Process-Owned File Lock	74
3.290	Process-To-Process Communication	74
3.291	Program	74
3.292	Protocol	74
3.293	Pseudo-Terminal	74
3.294	Radix Character (or Decimal-Point Character)	74
3.295	Read-Only File System	75
3.296	Read-Write Lock	75
3.297	Real Group ID	75
3.298	Real Time	75
3.299	Realtime Signal Extension	75
3.300	Real User ID	75
3.301	Record	75
3.302	Record Lock	76
3.303	Redirection	76
3.304	Redirection Operator	76
3.305	Referenced Shared Memory Object	76
3.306	Refresh	76
3.307	Regular Built-In Utility (or Regular Built-In)	76
3.308	Regular Expression	76
3.309	Region	76
3.310	Regular File	77
3.311	Relative Pathname	77
3.312	Relocatable File	77
3.313	Relocation	77
3.314	(Time) Resolution	77
3.315	Robust Mutex	77
3.316	Root Directory	77
3.317	Runnable Process (or Thread)	77
3.318	Running Process (or Thread)	77
3.319	Saved Resource Limits	78
3.320	Saved Set-Group-ID	78
3.321	Saved Set-User-ID	78
3.322	Scheduling	78

3.323	Scheduling Allocation Domain	78
3.324	Scheduling Contention Scope	78
3.325	Scheduling Policy	79
3.326	Screen	79
3.327	Scroll.....	79
3.328	Semaphore.....	79
3.329	Session	79
3.330	Session Leader	79
3.331	Session Lifetime.....	79
3.332	Shared Memory Object.....	80
3.333	Shell.....	80
3.334	Shell, the	80
3.335	Shell Script.....	80
3.336	Signal.....	80
3.337	Signal Stack	80
3.338	Single-Quote Character	80
3.339	Single-Threaded Process	80
3.340	Single-Threaded Program.....	81
3.341	Slash Character (<slash>).....	81
3.342	Socket	81
3.343	Socket Address	81
3.344	Soft Limit	81
3.345	Source Code	81
3.346	Space Character (<space>).....	82
3.347	Sparse File	82
3.348	Spawn	82
3.349	Special Built-In Utility (or Special Built-In).....	82
3.350	Special Parameter.....	82
3.351	Spin Lock.....	82
3.352	Sporadic Server.....	82
3.353	Standard Error	82
3.354	Standard Input.....	83
3.355	Standard Output	83
3.356	Standard Utilities	83
3.357	Stream	83
3.358	String	83
3.359	Subshell.....	84
3.360	Successfully Transferred	84
3.361	Supplementary Group ID	84
3.362	Suspended Job	84
3.363	Symbolic Constant	84
3.364	Symbolic Link.....	85
3.365	Synchronization Operation.....	85
3.366	Synchronized Input and Output.....	85
3.367	Synchronized I/O Completion	85
3.368	Synchronized I/O Data Integrity Completion.....	85
3.369	Synchronized I/O File Integrity Completion	85
3.370	Synchronized I/O Operation	86
3.371	Synchronous I/O Operation.....	86
3.372	Synchronously-Generated Signal	86
3.373	System.....	86
3.374	System Boot.....	86

3.375	System Clock.....	86
3.376	System Console	86
3.377	System Crash	86
3.378	System Databases.....	87
3.379	System Documentation	87
3.380	System Process.....	87
3.381	System Reboot	87
3.382	System-Wide	87
3.383	Tab Character (<tab>).....	87
3.384	Terminal (or Terminal Device)	87
3.385	Text Column.....	87
3.386	Text Domain.....	88
3.387	Text File.....	88
3.388	Thread	88
3.389	Thread ID	88
3.390	Thread Lifetime	89
3.391	Thread List	89
3.392	Thread Termination	89
3.393	Thread-Safe	89
3.394	Thread-Specific Data Key.....	89
3.395	Tilde Character (<tilde>).....	90
3.396	Timeouts	90
3.397	Timer	90
3.398	Timer Overrun.....	90
3.399	Token.....	90
3.400	Typed Memory Name Space	90
3.401	Typed Memory Object.....	90
3.402	Typed Memory Pool	90
3.403	Typed Memory Port.....	91
3.404	Unbind	91
3.405	Unit Data	91
3.406	Upshifting	91
3.407	User Database	91
3.408	User ID.....	91
3.409	User Name	91
3.410	Utility	92
3.411	Variable.....	92
3.412	Vertical-Tab Character (<vertical-tab>).....	92
3.413	White Space.....	92
3.414	White-Space Byte	92
3.415	White-Space Character	92
3.416	White-Space Wide Character.....	92
3.417	Wide-Character Code (C Language)	93
3.418	Wide-Character Input/Output Functions	93
3.419	Wide-Character String.....	93
3.420	Word.....	93
3.421	Working Directory (or Current Working Directory)	93
3.422	Worldwide Portability Interface	93
3.423	Write.....	93
3.424	XSI	93
3.425	XSI-Conformant	94
3.426	Zombie Process.....	94

	3.427	Zombie Thread	94
	3.428	±0	94
Chapter	4	General Concepts	95
	4.1	Case Insensitive Comparisons	95
	4.2	Concurrent Execution	95
	4.3	Default Initialization	95
	4.4	Directory Operations	96
	4.5	Directory Protection	96
	4.6	Extended Security Controls	96
	4.7	File Access Permissions	97
	4.8	File Hierarchy	97
	4.9	Filenames	97
	4.10	Filename Portability	98
	4.11	File System Cache	98
	4.12	File Times Update	98
	4.13	Host and Network Byte Orders	99
	4.14	Measurement of Execution Time	99
	4.15	Memory Ordering and Synchronization	100
	4.15.1	Memory Ordering	100
	4.15.2	Memory Synchronization	104
	4.16	Pathname Resolution	105
	4.17	Process ID Reuse	106
	4.18	Scheduling Policy	107
	4.19	Seconds Since the Epoch	107
	4.20	Semaphore	108
	4.21	Special Device Drivers	108
	4.22	Thread-Safety	108
	4.23	Treatment of Error Conditions for Mathematical Functions	109
	4.23.1	Domain Error	109
	4.23.2	Pole Error	109
	4.23.3	Range Error	110
	4.24	Treatment of NaN Arguments for the Mathematical Functions	110
	4.25	Utility	111
	4.26	Variable Assignment	111
Chapter	5	File Format Notation	113
Chapter	6	Character Set	117
	6.1	Portable Character Set	117
	6.2	Character Encoding	120
	6.3	C Language Wide-Character Codes	120
	6.4	Character Set Description File	121
	6.4.1	State-Dependent Character Encodings	125
Chapter	7	Locale	127
	7.1	General	127
	7.2	POSIX Locale	128
	7.3	Locale Definition	128
	7.3.1	LC_CTYPE	131

	7.3.2	LC_COLLATE.....	139
	7.3.3	LC_MONETARY	147
	7.3.4	LC_NUMERIC.....	151
	7.3.5	LC_TIME	152
	7.3.6	LC_MESSAGES	159
	7.4	Locale Definition Grammar.....	160
	7.4.1	Locale Lexical Conventions.....	160
	7.4.2	Locale Grammar.....	161
Chapter	8	Environment Variables.....	167
	8.1	Environment Variable Definition.....	167
	8.2	Internationalization Variables	169
	8.3	Other Environment Variables.....	174
Chapter	9	Regular Expressions.....	179
	9.1	Regular Expression Definitions.....	179
	9.2	Regular Expression General Requirements.....	180
	9.3	Basic Regular Expressions	181
	9.3.1	BREs Matching a Single Character or Collating Element.....	181
	9.3.2	BRE Ordinary Characters.....	181
	9.3.3	BRE Special Characters	182
	9.3.4	Periods in BREs	182
	9.3.5	RE Bracket Expression.....	182
	9.3.6	BREs Matching Multiple Characters	185
	9.3.7	BRE Precedence	186
	9.3.8	BRE Expression Anchoring.....	186
	9.4	Extended Regular Expressions.....	187
	9.4.1	EREs Matching a Single Character or Collating Element.....	187
	9.4.2	ERE Ordinary Characters.....	187
	9.4.3	ERE Special Characters	188
	9.4.4	Periods in EREs	188
	9.4.5	ERE Bracket Expression	188
	9.4.6	EREs Matching Multiple Characters	189
	9.4.7	ERE Alternation.....	190
	9.4.8	ERE Precedence	190
	9.4.9	ERE Expression Anchoring.....	190
	9.5	Regular Expression Grammar.....	191
	9.5.1	BRE/ERE Grammar Lexical Conventions.....	191
	9.5.2	RE and Bracket Expression Grammar.....	192
	9.5.3	ERE Grammar.....	194
Chapter	10	Directory Structure and Devices	197
	10.1	Directory Structure and Files.....	197
	10.2	Output Devices and Terminal Types.....	197
Chapter	11	General Terminal Interface	199
	11.1	Interface Characteristics	199
	11.1.1	Opening a Terminal Device File.....	199
	11.1.2	Process Groups	199
	11.1.3	The Controlling Terminal.....	200

	11.1.4	Terminal Access Control	200
	11.1.5	Input Processing and Reading Data	201
	11.1.6	Canonical Mode Input Processing.....	202
	11.1.7	Non-Canonical Mode Input Processing.....	202
	11.1.8	Writing Data and Output Processing	203
	11.1.9	Special Characters	203
	11.1.10	Modem Disconnect	205
	11.1.11	Closing a Terminal Device File.....	205
	11.2	Parameters that Can be Set	205
	11.2.1	The termios Structure	205
	11.2.2	Input Modes.....	206
	11.2.3	Output Modes.....	207
	11.2.4	Control Modes	209
	11.2.5	Local Modes.....	210
	11.2.6	Special Control Characters.....	212
Chapter	12	Utility Conventions.....	213
	12.1	Utility Argument Syntax.....	213
	12.2	Utility Syntax Guidelines.....	215
Chapter	13	Namespace and Future Directions	219
Chapter	14	Headers	221
Volume	2	System Interfaces, Issue 8.....	491
Chapter	1	Introduction.....	493
	1.1	Relationship to Other Formal Standards	493
	1.2	Format of Entries.....	493
Chapter	2	General Information	495
	2.1	Use and Implementation of Interfaces	495
	2.1.1	Use and Implementation of Functions.....	495
	2.1.2	Use and Implementation of Macros	496
	2.2	The Compilation Environment	496
	2.2.1	POSIX.1 Symbols.....	496
	2.2.2	The Name Space.....	498
	2.3	Error Numbers.....	507
	2.3.1	Additional Error Numbers	513
	2.4	Signal Concepts	513
	2.4.1	Signal Generation and Delivery.....	513
	2.4.2	Realtime Signal Generation and Delivery	515
	2.4.3	Signal Actions	516
	2.4.4	Signal Effects on Other Functions.....	520
	2.5	Standard I/O Streams	521
	2.5.1	Interaction of File Descriptors and Standard I/O Streams	522
	2.5.2	Stream Orientation and Encoding Rules	524
	2.6	File Descriptor Allocation.....	525
	2.7	XSI Interprocess Communication	526
	2.7.1	IPC General Description	526

2.8	Realtime	527
2.8.1	Realtime Signals	528
2.8.2	Asynchronous I/O	528
2.8.3	Memory Management	529
2.8.4	Process Scheduling	531
2.8.5	Clocks and Timers	535
2.9	Threads	537
2.9.1	Thread-Safety	537
2.9.2	Thread IDs	538
2.9.3	Thread Mutexes	539
2.9.4	Thread Scheduling	540
2.9.5	Thread Cancellation	542
2.9.6	Thread Read-Write Locks	547
2.9.7	Thread Interactions with File Operations	547
2.9.8	Use of Application-Managed Thread Stacks	548
2.9.9	Synchronization Object Copies and Alternative Mappings	548
2.10	Sockets	549
2.10.1	Address Families	549
2.10.2	Addressing	549
2.10.3	Protocols	549
2.10.4	Routing	550
2.10.5	Interfaces	550
2.10.6	Socket Types	550
2.10.7	Socket I/O Mode	551
2.10.8	Socket Owner	551
2.10.9	Socket Queue Limits	551
2.10.10	Pending Error	551
2.10.11	Socket Receive Queue	552
2.10.12	Socket Out-of-Band Data State	552
2.10.13	Connection Indication Queue	553
2.10.14	Signals	553
2.10.15	Asynchronous Errors	553
2.10.16	Use of Options	554
2.10.17	Use of Sockets for Local UNIX Connections	557
2.10.18	Use of Sockets over Internet Protocols	558
2.10.19	Use of Sockets over Internet Protocols Based on IPv4	558
2.10.20	Use of Sockets over Internet Protocols Based on IPv6	558
2.11	Data Types	561
2.11.1	Defined Types	562
2.11.2	The char Type	563
2.12	Status Information	563
Chapter 3	System Interfaces	565
Volume 3	Shell and Utilities, Issue 8	2451
Chapter 1	Introduction	2453
1.1	Relationship to Other Documents	2453

1.1.1	System Interfaces.....	2453
1.1.2	Concepts Derived from the ISO C Standard	2457
1.2	Utility Limits.....	2459
1.3	Grammar Conventions.....	2461
1.4	Utility Description Defaults.....	2462
1.5	Considerations for Utilities in Support of Files of Arbitrary Size.....	2469
1.6	Built-In Utilities	2470
1.7	Intrinsic Utilities.....	2470
Chapter 2	Shell Command Language	2472
2.1	Shell Introduction.....	2472
2.2	Quoting.....	2472
2.2.1	Escape Character (Backslash).....	2473
2.2.2	Single-Quotes.....	2473
2.2.3	Double-Quotes.....	2473
2.2.4	Dollar-Single-Quotes	2474
2.3	Token Recognition.....	2475
2.3.1	Alias Substitution.....	2477
2.4	Reserved Words.....	2478
2.5	Parameters and Variables.....	2478
2.5.1	Positional Parameters	2479
2.5.2	Special Parameters	2479
2.5.3	Shell Variables.....	2481
2.6	Word Expansions	2483
2.6.1	Tilde Expansion	2485
2.6.2	Parameter Expansion.....	2485
2.6.3	Command Substitution	2489
2.6.4	Arithmetic Expansion.....	2490
2.6.5	Field Splitting	2491
2.6.6	Pathname Expansion	2493
2.6.7	Quote Removal.....	2493
2.7	Redirection	2493
2.7.1	Redirecting Input	2494
2.7.2	Redirecting Output	2494
2.7.3	Appending Redirected Output	2495
2.7.4	Here-Document.....	2495
2.7.5	Duplicating an Input File Descriptor	2497
2.7.6	Duplicating an Output File Descriptor	2497
2.7.7	Open File Descriptors for Reading and Writing.....	2497
2.8	Exit Status and Errors	2497
2.8.1	Consequences of Shell Errors	2497
2.8.2	Exit Status for Commands	2499
2.9	Shell Commands	2499
2.9.1	Simple Commands.....	2500
2.9.2	Pipelines	2504
2.9.3	Lists	2505
2.9.4	Compound Commands.....	2508
2.9.5	Function Definition Command	2511
2.10	Shell Grammar.....	2512
2.10.1	Shell Grammar Lexical Conventions.....	2512
2.10.2	Shell Grammar Rules.....	2513

2.11	Job Control	2518
2.12	Signals and Error Handling	2521
2.13	Shell Execution Environment	2522
2.14	Pattern Matching Notation	2523
2.14.1	Patterns Matching a Single Character	2523
2.14.2	Patterns Matching Multiple Characters.....	2524
2.14.3	Patterns Used for Filename Expansion.....	2525
2.15	Special Built-In Utilities.....	2526
Chapter 3	Utilities.....	2573
Volume 4	Rationale (Informative), Issue 8.....	3633
Part A	Base Definitions	3635
Appendix A	Rationale for Base Definitions.....	3637
A.1	Introduction	3637
A.1.1	Scope	3637
A.1.2	Word Usage.....	3639
A.1.3	Conformance.....	3639
A.1.4	Normative References	3639
A.1.5	Change History	3639
A.1.6	Terminology	3639
A.1.7	Definitions and Concepts.....	3642
A.1.8	Portability.....	3642
A.2	Conformance.....	3643
A.2.1	Implementation Conformance	3643
A.2.2	Application Conformance.....	3647
A.2.3	Language-Dependent Services for the C Programming Language	3648
A.2.4	Other Language-Related Specifications.....	3648
A.3	Definitions	3648
A.4	General Concepts	3676
A.4.1	Case Insensitive Comparisons	3676
A.4.2	Concurrent Execution.....	3676
A.4.3	Default Initialization.....	3677
A.4.4	Directory Operations	3677
A.4.5	Directory Protection.....	3677
A.4.6	Extended Security Controls	3677
A.4.7	File Access Permissions.....	3677
A.4.8	File Hierarchy	3678
A.4.9	Filenames.....	3678
A.4.10	Filename Portability.....	3679
A.4.11	File System Cache	3680
A.4.12	File Times Update	3680
A.4.13	Host and Network Byte Order	3681
A.4.14	Measurement of Execution Time	3681
A.4.15	Memory Ordering and Synchronization	3681
A.4.16	Pathname Resolution.....	3683
A.4.17	Process ID Reuse	3685
A.4.18	Scheduling Policy.....	3685

A.4.19	Seconds Since the Epoch	3685
A.4.20	Semaphore.....	3686
A.4.21	Special Device Drivers.....	3686
A.4.22	Thread-Safety.....	3687
A.4.23	Treatment of Error Conditions for Mathematical Functions	3687
A.4.24	Treatment of NaN Arguments for Mathematical Functions	3687
A.4.25	Utility	3687
A.4.26	Variable Assignment.....	3687
A.5	File Format Notation	3688
A.6	Character Set.....	3688
A.6.1	Portable Character Set.....	3688
A.6.2	Character Encoding	3689
A.6.3	C Language Wide-Character Codes	3689
A.6.4	Character Set Description File.....	3690
A.7	Locale	3692
A.7.1	General.....	3692
A.7.2	POSIX Locale	3693
A.7.3	Locale Definition	3693
A.7.4	Locale Definition Grammar	3701
A.7.5	Locale Definition Example.....	3701
A.8	Environment Variables	3704
A.8.1	Environment Variable Definition.....	3704
A.8.2	Internationalization Variables	3705
A.8.3	Other Environment Variables.....	3706
A.9	Regular Expressions	3709
A.9.1	Regular Expression Definitions.....	3709
A.9.2	Regular Expression General Requirements.....	3710
A.9.3	Basic Regular Expressions	3711
A.9.4	Extended Regular Expressions.....	3715
A.9.5	Regular Expression Grammar	3716
A.10	Directory Structure and Devices.....	3717
A.10.1	Directory Structure and Files.....	3717
A.10.2	Output Devices and Terminal Types.....	3717
A.11	General Terminal Interface	3718
A.11.1	Interface Characteristics.....	3719
A.11.2	Parameters that Can be Set	3723
A.12	Utility Conventions.....	3724
A.12.1	Utility Argument Syntax.....	3724
A.12.2	Utility Syntax Guidelines.....	3725
A.13	Namespace and Future Directions	3728
A.14	Headers.....	3728
A.14.1	Format of Entries.....	3728
A.14.2	Removed Headers in Issue 8	3728

Part B System Interfaces..... 3729

Appendix B Rationale for System Interfaces..... 3731

B.1	Introduction	3731
B.1.1	Change History	3731

B.1.2	Relationship to Other Formal Standards	3735
B.1.3	Format of Entries	3735
B.2	General Information	3735
B.2.1	Use and Implementation of Interfaces	3735
B.2.2	The Compilation Environment	3737
B.2.3	Error Numbers.....	3742
B.2.4	Signal Concepts	3746
B.2.5	Standard I/O Streams	3757
B.2.6	File Descriptor Allocation	3758
B.2.7	XSI Interprocess Communication	3758
B.2.8	Realtime	3759
B.2.9	Threads	3806
B.2.10	Sockets	3835
B.2.11	Data Types.....	3837
B.2.12	Status Information	3840
B.3	System Interfaces.....	3840
B.3.1	System Interfaces Removed in this Version	3840
B.3.2	System Interfaces Removed in the Previous Version.....	3842
B.3.3	Examples for Spawn	3842
Part	C Shell and Utilities	3853
Appendix	C Rationale for Shell and Utilities.....	3855
C.1	Introduction	3855
C.1.1	Change History	3855
C.1.2	Relationship to Other Documents	3856
C.1.3	Utility Limits.....	3857
C.1.4	Grammar Conventions.....	3860
C.1.5	Utility Description Defaults.....	3860
C.1.6	Considerations for Utilities in Support of Files of Arbitrary Size	3864
C.1.7	Built-In Utilities	3864
C.1.8	Intrinsic Utilities.....	3865
C.2	Shell Command Language	3866
C.2.1	Shell Introduction.....	3866
C.2.2	Quoting.....	3866
C.2.3	Token Recognition.....	3871
C.2.4	Reserved Words.....	3873
C.2.5	Parameters and Variables.....	3874
C.2.6	Word Expansions	3880
C.2.7	Redirection	3890
C.2.8	Exit Status and Errors	3894
C.2.9	Shell Commands	3895
C.2.10	Shell Grammar.....	3905
C.2.11	Job Control	3906
C.2.12	Signals and Error Handling.....	3907
C.2.13	Shell Execution Environment.....	3907
C.2.14	Pattern Matching Notation	3908
C.2.15	Special Built-In Utilities.....	3912
C.3	Utilities.....	3912
C.3.1	Utilities Removed in this Version	3912

	C.3.2	Utilities Removed in the Previous Version.....	3912
	C.3.3	Exclusion of Utilities.....	3913
Part	D	Portability Considerations.....	3917
Appendix	D	Portability Considerations (Informative).....	3919
	D.1	User Requirements.....	3919
	D.1.1	Configuration Interrogation	3920
	D.1.2	Process Management.....	3920
	D.1.3	Access to Data.....	3920
	D.1.4	Access to the Environment	3920
	D.1.5	Access to Determinism and Performance Enhancements.....	3920
	D.1.6	Operating System-Dependent Profile	3921
	D.1.7	I/O Interaction	3921
	D.1.8	Internationalization Interaction	3921
	D.1.9	C-Language Extensions.....	3921
	D.1.10	Command Language	3921
	D.1.11	Interactive Facilities	3921
	D.1.12	Accomplish Multiple Tasks Simultaneously	3921
	D.1.13	Complex Data Manipulation.....	3922
	D.1.14	File Hierarchy Manipulation	3922
	D.1.15	Locale Configuration.....	3922
	D.1.16	Inter-User Communication.....	3922
	D.1.17	System Environment	3922
	D.1.18	Printing.....	3922
	D.1.19	Software Development.....	3922
	D.2	Portability Capabilities.....	3923
	D.2.1	Configuration Interrogation	3923
	D.2.2	Process Management.....	3924
	D.2.3	Access to Data.....	3924
	D.2.4	Access to the Environment	3925
	D.2.5	Bounded (Realtime) Response	3926
	D.2.6	Operating System-Dependent Profile	3926
	D.2.7	I/O Interaction	3926
	D.2.8	Internationalization Interaction	3927
	D.2.9	C-Language Extensions.....	3927
	D.2.10	Command Language	3927
	D.2.11	Interactive Facilities	3928
	D.2.12	Accomplish Multiple Tasks Simultaneously	3928
	D.2.13	Complex Data Manipulation.....	3928
	D.2.14	File Hierarchy Manipulation	3929
	D.2.15	Locale Configuration.....	3929
	D.2.16	Inter-User Communication.....	3929
	D.2.17	System Environment	3930
	D.2.18	Printing.....	3930
	D.2.19	Software Development.....	3930
	D.2.20	Future Growth.....	3930
	D.3	Profiling Considerations	3931
	D.3.1	Configuration Options	3931
	D.3.2	Configuration Options (Shell and Utilities)	3931

D.3.3	Configurable Limits	3932
D.3.4	Configuration Options (System Interfaces).....	3933
D.3.5	Configurable Limits	3937
D.3.6	Optional Behavior	3940
Part E	Subprofiling Considerations.....	3941
Appendix E	Subprofiling Considerations (Informative)	3943
E.1	Subprofiling Option Groups.....	3943
	Index.....	3951
List of Figures		
3-1	pax Format Archive Example.....	3263
B-1	Example of a System with Typed Memory	3777
List of Tables		
3-1	Job ID Formats.....	58
5-1	Escape Sequences and Associated Actions	113
6-1	Portable Character Set	117
6-2	Non-Portable Control Characters	122
7-1	Valid Character Class Combinations.....	135
10-1	Control Character Names	198
2-1	Value of Level for Socket Options.....	554
2-2	Socket-Level Options.....	555
1-1	Actions when Creating a File that Already Exists.....	2455
1-2	Selected ISO C Standard Operators and Control Flow Keywords	2458
1-3	Utility Limit Minimum Values	2459
1-4	Symbolic Utility Limits	2460
1-5	Intrinsic Utilities	2470
3-1	Expressions in Decreasing Precedence in <i>awk</i>	2608
3-2	Escape Sequences in <i>awk</i>	2616
3-3	Operators in <i>bc</i>	2656
3-4	Programming Environments: Type Sizes	2675
3-5	Programming Environments: <i>c17</i> Arguments	2676
3-6	Threaded Programming Environment: <i>c17</i> Arguments.....	2677
3-7	Compression algorithms, <i>-m</i> option-argument values, and suffixes	2737
3-8	ASCII to EBCDIC Conversion.....	2780
3-9	ASCII to IBM EBCDIC Conversion	2781
3-10	File Utility Output Strings	2933
3-11	Table Size Declarations in <i>lex</i>	3040
3-12	Escape Sequences in <i>lex</i>	3042
3-13	ERE Precedence in <i>lex</i>	3042
3-14	Named Characters in <i>od</i>	3229
3-15	ustar Header Block.....	3268
3-16	ustar <i>mode</i> Field	3269
3-17	Octet-Oriented <i>cpio</i> Archive Entry.....	3272

3-18	Values for <code>cpio c_mode</code> Field	3273
3-19	Variable Names and Default Headers in <i>ps</i>	3314
3-20	Control Character Names in <i>stty</i>	3409
3-21	Circumflex Control Characters in <i>stty</i>	3410
3-22	<code>uuencode</code> Base64 Values	3512
3-23	Internal Limits in <i>yacc</i>	3626
A-1	Historical Practice for Symbolic Links	3672