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 *awk* 2608
3-2 Escape Sequences in *awk* 2616
3-3 Operators in *bc* 2656
3-4 Programming Environments: Type Sizes 2675
3-5 Programming Environments: *c17* Arguments 2676
3-6 Threaded Programming Environment: *c17* Arguments 2677
3-7 Compression algorithms, –**m** 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 *lex* 3040
3-12 Escape Sequences in *lex* 3042
3-13 ERE Precedence in *lex* 3042
3-14 Named Characters in *od* 3229
3-15 ustar Header Block 3268
3-16 ustar *mode* Field 3269
3-17 Octet-Oriented cpio Archive Entry 3272

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