

ISO/IEC 14776-346:2024-09 (E)

Information technology - Small computer system interface (SCSI) - Part 346: Zoned Block Commands - 2 (ZBC-2)

Contents	Page
FOREWORD.....	xii
INTRODUCTION	xiii
General	xiii
SCSI standards family	xiii
1 Scope	1
2 Normative references	1
3 Definitions, symbols, abbreviations, and conventions	2
3.1 Definitions	2
3.2 Symbols and abbreviations	8
3.2.1 Abbreviations	8
3.2.2 Mathematical operators	8
3.3 Keywords	8
3.4 Editorial conventions	10
3.5 Numeric and character conventions	10
3.5.1 Numeric conventions	10
3.5.2 Units of measure	11
3.6 Bit and byte ordering	12
3.7 Notation for state diagrams	14
4 Zoned Block Device Model	15
4.1 Zoned Block Device model overview	15
4.1.1 Established SCSI concepts	15
4.1.2 Peripheral device type and supported commands	16
4.2 Zoned Block Device models	17
4.2.1 Zoned Block Device models introduction	17
4.2.2 Host aware zoned block device model	19
4.2.3 Host managed zoned block device model	19
4.2.4 Domains and realms zoned block device model	21
4.2.4.1 Domains and realms zoned block device model overview	21
4.2.4.2 Zone domains	22
4.2.4.3 Zone domain 0	23
4.2.4.4 Zone domains other than zone domain 0	24
4.2.4.5 Zone activation	24
4.2.4.6 Realms	25
4.2.4.7 Realm boundary considerations	26
4.3 Zone attributes	27
4.3.1 Zone attributes summary	27
4.3.2 Zone Type zone attribute	28
4.3.3 Zone Condition zone attribute	29
4.3.4 WPointer zone attribute	29
4.3.5 RWP Recommended zone attribute	29
4.3.6 Non-Sequential Write Resources Active zone attribute	30
4.3.7 Predicted Unrecovered Errors Present zone attribute	30
4.4 Realm attributes	31
4.4.1 Realm attributes overview	31
4.4.2 Restrict Write Pointer Reset realm attribute	31
4.4.3 Restrict Zone Activate realm attribute	31
4.5 Zone type models	32
4.5.1 Zone type models overview	32
4.5.2 Conventional zone model	32
4.5.2.1 Conventional zone model overview	32

4.5.2.2 Write access pattern requirements for conventional zones	32
4.5.2.3 Read access pattern requirements for conventional zones	32
4.5.3 Write pointer zone models	32
4.5.3.1 Features common to all write pointer zones	32
4.5.3.1.1 Write pointer features	32
4.5.3.1.2 Resetting the write pointer	35
4.5.3.1.3 Open zone resources	35
4.5.3.1.4 Initialization pattern	35
4.5.3.1.5 Write access pattern requirements common to all write pointer zones	35
4.5.3.1.6 Read access pattern requirements common to all write pointer zones	36
4.5.3.2 Write pointer zone operations	37
4.5.3.2.1 Write pointer zone operations overview	37
4.5.3.2.2 Open zone operation	37
4.5.3.2.3 Close zone operation	38
4.5.3.2.4 Finish zone operation	38
4.5.3.2.5 Reset write pointer operation	38
4.5.3.2.6 Sequentialize zone operation	39
4.5.3.2.7 Zone activation operation	39
4.5.3.2.7.1 Zone activation operation overview	39
4.5.3.2.7.2 Verify activations operation	39
4.5.3.2.7.3 Change activations operation	40
4.5.3.2.8 Manage open zone resources operation	41
4.5.3.2.8.1 Manage open zone resources operation overview	41
4.5.3.2.8.2 Select a sequential write preferred zone	42
4.5.3.2.8.3 Select a sequential write required zone	42
4.5.3.2.9 Read operations, verify operations, and write operations	43
4.5.3.3 Sequential write preferred zone model	44
4.5.3.3.1 Sequential write preferred zone model overview	44
4.5.3.3.2 Write access pattern requirements for sequential write preferred zones	44
4.5.3.3.3 Read access pattern requirements for sequential write preferred zones	46
4.5.3.4 Sequential write required zone model	46
4.5.3.4.1 Sequential write required zone model overview	46
4.5.3.4.2 Write access pattern requirements for sequential write required zones	46
4.5.3.4.3 Read access pattern requirements for sequential write required zones	47
4.5.3.4.4 Opening Sequential Write Required zones	48
4.5.3.5 Sequential or before required zone model	48
4.5.3.5.1 Sequential or before required zone model overview	48
4.5.3.5.2 Write access pattern requirements for sequential or before required zones	48
4.5.3.5.3 Read access pattern requirements for sequential or before required zones	49
4.5.3.6 Zone condition state machine	50
4.5.3.6.1 Zone condition state machine overview	50
4.5.3.6.2 ZC1:Empty state	53
4.5.3.6.2.1 ZC1:Empty state overview	53
4.5.3.6.2.2 Transition ZC1:Empty to ZC2:Implicit_Open	53
4.5.3.6.2.3 Transition ZC1:Empty to ZC3:Explicit_Open	53
4.5.3.6.2.4 Transition ZC1:Empty to ZC6:Read_Only	53
4.5.3.6.2.5 Transition ZC1:Empty to ZC7:Offline	53
4.5.3.6.2.6 Transition ZC1:Empty to ZC8:Inactive	54
4.5.3.6.3 ZC2:Implicit_Open state	54
4.5.3.6.3.1 ZC2:Implicit_Open state overview	54
4.5.3.6.3.2 Transition ZC2:Implicit_Open to ZC1:Empty	54
4.5.3.6.3.3 Transition ZC2:Implicit_Open to ZC3:Explicit_Open	54
4.5.3.6.3.4 Transition ZC2:Implicit_Open to ZC4:Closed	54
4.5.3.6.3.5 Transition ZC2:Implicit_Open to ZC5:Full	55
4.5.3.6.3.6 Transition ZC2:Implicit_Open to ZC6:Read_Only	55
4.5.3.6.3.7 Transition ZC2:Implicit_Open to ZC7:Offline	55
4.5.3.6.4 ZC3:Explicit_Open state	55
4.5.3.6.4.1 ZC3:Explicit_Open state overview	55

4.5.3.6.4.2 Transition ZC3:Explicit_Open to ZC1:Empty	55
4.5.3.6.4.3 Transition ZC3:Explicit_Open to ZC4:Closed	56
4.5.3.6.4.4 Transition ZC3:Explicit_Open to ZC5:Full	56
4.5.3.6.4.5 Transition ZC3:Explicit_Open to ZC6:Read_Only	56
4.5.3.6.4.6 Transition ZC3:Explicit_Open to ZC7:Offline	56
4.5.3.6.5 ZC4:Closed state	56
4.5.3.6.5.1 ZC4:Closed state overview	56
4.5.3.6.5.2 Transition ZC4:Closed to ZC1:Empty	57
4.5.3.6.5.3 Transition ZC4:Closed to ZC2:Implicit_Open	57
4.5.3.6.5.4 Transition ZC4:Closed to ZC3:Explicit_Open	57
4.5.3.6.5.5 Transition ZC4:Closed to ZC6:Read_Only	57
4.5.3.6.5.6 Transition ZC4:Closed to ZC7:Offline	57
4.5.3.6.6 ZC5:Full state	57
4.5.3.6.6.1 ZC5:Full state overview	57
4.5.3.6.6.2 Transition ZC5:Full to ZC1:Empty	58
4.5.3.6.6.3 Transition ZC5:Full to ZC6:Read_Only	58
4.5.3.6.6.4 Transition ZC5:Full to ZC7:Offline	58
4.5.3.6.7 ZC6:Read_Only state	58
4.5.3.6.7.1 ZC6:Read_Only state overview	58
4.5.3.6.7.2 Transition ZC6:Read_Only to ZC7:Offline	58
4.5.3.6.8 ZC7:Offline state	59
4.5.3.6.9 ZC8:Inactive state	59
4.5.3.6.9.1 ZC8:Inactive state overview	59
4.5.3.6.9.2 Transition ZC8:Inactive to ZC1:Empty state	59
4.5.4 Gap zone model	59
4.6 Zoned block device extensions to block device model	60
4.6.1 Overview	60
4.6.2 Zoned block device internal resource management	60
4.6.3 Unexpected power removal	60
4.6.4 Media failure	61
4.7 Interactions involving mode parameter block descriptors	61
4.8 Capacity reporting and LBAs out of range	62
4.9 Constant zone starting LBA offsets	62
4.10 Format operations	63
4.11 Sanitize operations	64
4.12 Reservations	64
4.13 Caches	65
4.13.1 Caches overview	65
4.13.2 Write caching	66
4.13.3 Command interactions with caches	66
4.13.4 Write operation and write medium operation interactions with caches	66
4.13.5 Close zone and finish zone operation interactions with cache	66
4.14 Interactions with WRITE LONG commands	66
4.15 Interactions with storage element depopulation and restoration	67
4.15.1 Interactions with storage element depopulation and restoration operations that modify data	67
4.15.2 Storage element depopulation with zone modifications	67
4.15.2.1 Depopulation with zone modifications overview	67
4.15.2.2 Depopulation with zone modifications processing	67
4.15.2.3 Handling unrecoverable errors	68
4.15.2.3.1 Handling unrecoverable errors overview	68
4.15.2.3.2 Predicted unrecovered read errors in Conventional zones	69
4.15.2.3.3 Predicted unrecovered write errors in Conventional zones	69
4.15.2.4 Allowed commands during depopulation with zone modifications processing	70
4.15.2.5 Event handling actions	70
5 Commands for zoned block devices	71
5.1 Commands for zoned block devices overview	71

5.1.1 Summary of commands for zoned block devices	71
5.1.2 Zoned block device 16-byte CDB format with no data transfer	71
5.2 CLOSE ZONE command	74
5.3 FINISH ZONE command	76
5.4 OPEN ZONE command	78
5.5 REMOVE ELEMENT AND MODIFY ZONES command	79
5.6 REPORT REALMS command	81
5.6.1 REPORT REALMS command overview	81
5.6.2 REPORT REALMS parameter data	83
5.6.2.1 REPORT REALMS parameter data overview	83
5.6.2.2 Realm descriptor	85
5.6.2.2.1 Realm descriptor overview	85
5.6.2.2.2 Realm Start/End descriptor	86
5.7 REPORT ZONE DOMAINS command	87
5.7.1 REPORT ZONE DOMAINS command overview	87
5.7.2 REPORT ZONE DOMAINS parameter data	89
5.8 REPORT ZONES command	92
5.8.1 REPORT ZONES command overview	92
5.8.2 REPORT ZONES parameter data	94
5.9 RESET WRITE POINTER command	98
5.10 SEQUENTIALIZE ZONE command	100
5.11 ZONE ACTIVATE command	102
5.11.1 ZONE ACTIVATE command overview	102
5.11.2 Identifying the candidate zones to activate and the candidate zones to deactivate	103
5.11.3 ZONE ACTIVATE parameter data and ZONE QUERY parameter data	105
5.11.3.1 ZONE ACTIVATE parameter data and ZONE QUERY parameter data overview	105
5.11.3.2 Zone activation descriptors	107
5.12 ZONE QUERY command	109
6 Parameters for zoned block devices	110
6.1 Parameters for zoned block devices overview	110
6.2 Diagnostic parameters	110
6.3 Log parameters	111
6.3.1 Log parameters overview	111
6.3.2 Zoned Block Device Statistics log page	112
6.3.2.1 Zoned Block Device Statistics log page overview	112
6.3.2.2 Maximum Open Zones	114
6.3.2.3 Maximum Explicitly Open Zones	115
6.3.2.4 Maximum Implicitly Open Zones	116
6.3.2.5 Minimum Empty Zones	117
6.3.2.6 Maximum Non-sequential Zones	118
6.3.2.7 Zones Emptied	119
6.3.2.8 Suboptimal Write Commands	120
6.3.2.9 Commands Exceeding Optimal Limit	121
6.3.2.10 Failed Explicit Opens	122
6.3.2.11 Read Rule Violations	123
6.3.2.12 Write Rule Violations	124
6.3.2.13 Maximum Implicitly Open Sequential Or Before Required Zones	125
6.4 Mode parameters	126
6.4.1 Mode parameters overview	126
6.4.2 Zoned Block Device Control mode page	127
6.5 Vital product data (VPD) parameters	128
6.5.1 VPD parameters overview	128
6.5.2 Zoned Block Device Characteristics VPD page	129
Annex A (normative) ZBC Feature Sets	132
A.1 ZBC feature sets overview	132

A.2 Host Aware 2020 feature set	132
A.3 Host Managed 2020 feature set	134
A.4 Domains and Realms 2020 feature set	135
Annex B (informative) Application Client Considerations for Zoned Block Devices	137
B.1 Application client considerations for zoned block devices overview	137
B.2 Writing to write pointer zones	137
B.3 Open zone considerations	137
B.3.1 Open zone considerations overview	137
B.3.2 Explicitly opened zones and implicitly opened zones	138
B.3.3 Opening and closing zones	138
B.3.4 Finish zone operation considerations	139
B.4 Open zone resources considerations based on zone type	139
B.4.1 Sequential write preferred zones	139
B.4.2 Sequential write required zones	140
B.5 Partial failures	140
B.5.1 Partial failures overview	140
B.5.2 Sanitize considerations	140
Annex C (Informative) Bibliography	141

Tables

	Page
Table 1 – Numbering conventions	11
Table 2 – Comparison of decimal prefixes and binary prefixes	12
Table 3 – Example of ordering of bits and bytes within a data dword	13
Table 4 – Example of ordering of bits and bytes within an element dword	13
Table 5 – Zoned block device model concepts	15
Table 6 – Requirements of zoned block devices	18
Table 7 – Commands for host managed zoned block devices	20
Table 8 – Zone domain ID values	23
Table 9 – Summary of zone attributes	27
Table 10 – Zone Type zone attribute	28
Table 11 – Relationships between zone attributes	28
Table 12 – Zone Condition zone attribute	29
Table 13 – Summary of realm attributes	31
Table 14 – Summary of write pointer zone operations	37
Table 15 – Characteristics associated with zone state	51
Table 16 – READ CAPACITY (16) parameter data as modified for zoned block devices	62
Table 17 – RC BASIS field	62
Table 18 – ZBC-2 commands that are allowed in the presence of various reservations	65
Table 19 – Summary of commands that are unique to zoned block devices	71
Table 20 – Typical 16-byte zoned block device CDB format with no data transfer	72
Table 21 – CLOSE ZONE command	74
Table 22 – CLOSE ZONE command processing	75
Table 23 – FINISH ZONE command	76
Table 24 – FINISH ZONE command processing	77
Table 25 – OPEN ZONE command	78
Table 26 – OPEN ZONE command processing	79
Table 27 – REMOVE ELEMENT AND MODIFY ZONES command	79
Table 28 – REPORT REALMS command	81
Table 29 – REPORT REALMS REPORTING OPTIONS field	82
Table 30 – REPORT REALMS parameter data	83
Table 31 – Realm descriptor	85
Table 32 – REALM RESTRICTIONS field	86

Table 33 – Realm Start/End descriptor	86
Table 34 – REPORT ZONE DOMAINS command	87
Table 35 – REPORT ZONE DOMAINS REPORTING OPTIONS field	88
Table 36 – REPORT ZONE DOMAINS parameter data	89
Table 37 – Zone domain descriptor	90
Table 38 – REPORT ZONES command	92
Table 39 – REPORT ZONES REPORTING OPTIONS field	93
Table 40 – REPORT ZONES parameter data	94
Table 41 – SAME field description	95
Table 42 – Zone descriptor format	96
Table 43 – Zone descriptor ZONE TYPE field	96
Table 44 – Zone descriptor ZONE CONDITION field	97
Table 45 – RESET WRITE POINTER command	98
Table 46 – RESET WRITE POINTER command processing	99
Table 47 – SEQUENTIALIZE ZONE command	100
Table 48 – SEQUENTIALIZE ZONE command processing	101
Table 49 – ZONE ACTIVATE command	102
Table 50 – Selecting candidate zones to activate and deactivate with ALL bit set to zero	104
Table 51 – ZONE ACTIVATE parameter data and ZONE QUERY parameter data	105
Table 52 – Zone activation descriptor	108
Table 53 – ZONE QUERY command	109
Table 54 – Parameters for zoned block devices	110
Table 55 – Diagnostic page codes for host managed zoned block devices	110
Table 56 – Log page codes and subpage codes for host managed zoned block devices	111
Table 57 – Zoned Block Device Statistics log page parameter codes	112
Table 58 – Zoned Block Device Statistics log page	113
Table 59 – Maximum Open Zones log parameter	114
Table 60 – Maximum Explicitly Open Zones log parameter	115
Table 61 – Maximum Implicitly Open Zones log parameter	116
Table 62 – Minimum Empty Zones log parameter	117
Table 63 – Maximum Non-sequential Zones log parameter	118
Table 64 – Zones Emptied log parameter	119
Table 65 – Suboptimal Write Commands log parameter	120
Table 66 – Commands Exceeding Optimal Limit log parameter	121
Table 67 – Failed Explicit Opens log parameter	122
Table 68 – Read Rule Violations log parameter	123
Table 69 – Write Rule Violations log parameter	124
Table 70 – Maximum Implicitly Open Sequential Or Before Required Zones log parameter	125
Table 71 – Mode page codes and subpage codes for host managed zoned block devices	126
Table 72 – Zoned Block Device Control mode page	127
Table 73 – VPD page codes for zoned block devices	128
Table 74 – Zoned Block Device Characteristics VPD page	129
Table 75 – ZONED BLOCK DEVICE EXTENSION field	130
Table 76 – ZONE ALIGNMENT METHOD field	130
Table A.1 – Feature sets	132
Table A.2 – Commands mandatory for the Host Aware 2020 feature set	132
Table A.3 – Mode pages mandatory for the Host Aware 2020 feature set	133
Table A.4 – VPD pages mandatory for the Host Aware 2020 feature set	133
Table A.5 – Commands mandatory for the Host Managed 2020 feature set	134
Table A.6 – Mode pages mandatory for the Host Managed 2020 feature set	134
Table A.7 – VPD pages mandatory for the Host Managed 2020 feature set	134
Table A.8 – Commands mandatory for the Domains and Realms 2020 feature set	135
Table A.9 – Mode pages mandatory for the Domains And Realms 2020 feature set	135
Table A.10 – VPD pages mandatory for the Domains And Realms 2020 feature set	136

Figures

	Page
Figure 0 – SCSI document structure	xiv
Figure 1 – Example state diagram	14
Figure 2 – Zones in a zoned block device	17
Figure 3 – Zone domain	22
Figure 4 – Example of two zone domains	23
Figure 5 – Example of zone activation with the AAORB bit set to zero	24
Figure 6 – Realms model	25
Figure 7 – Example of conventional and shingled recording technologies using two zone domains	25
Figure 8 – Example of zone activation with the AAORB bit set to one	26
Figure 9 – Write pointer zone and write pointer after reset write pointer operation with no subsequent writes	33
Figure 10 – Write pointer zone and write pointer	33
Figure 11 – Write pointer zone example operations	34
Figure 12 – Example write command that starts at the write pointer	44
Figure 13 – Examples of write commands that do not start at the write pointer	45
Figure 14 – Zone condition state machine	52
Figure 15 – Example of paired sequential write required zones and gap zones	63