

RA90/RA92 Disk Drive Service Manual

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Contents

About This Manual	xiii
--------------------------	-------------

1 Introduction

1.1 RA90 and RA92 Disk Drive Descriptions	1-1
1.1.1 Physical and Logical Media Layout	1-3
1.2 Maintenance Strategy	1-3
1.2.1 Service Delivery Strategy	1-4
1.2.1.1 Six-Step Maintenance Strategy	1-4
1.2.2 Tools Required for Maintenance	1-5
1.2.3 Preventative Maintenance	1-5
1.3 RA90/RA92 Disk Drive Specifications	1-5
1.4 Electrostatic Protection	1-8

2 Installation

2.1 Introduction	2-1
2.2 Site Preparation and Planning	2-1
2.2.1 Power and Safety Precautions	2-1
2.2.2 Three-Phase Power Requirements	2-1
2.2.3 AC Power Wiring	2-3
2.2.4 Thermal Stabilization	2-3
2.2.5 Floor Loading	2-3
2.2.6 Operating Temperature and Humidity	2-3
2.3 Unpacking the Cabinet	2-3
2.3.1 Deskidding the Cabinet	2-5
2.4 Installing SDI Cables and Power Cords	2-7
2.4.1 Removing the Front and Rear Access Panels	2-7
2.4.1.1 Front Access Panel Removal	2-7
2.4.1.2 Removing the Rear Access Panel	2-9
2.4.2 SDI Cable Connections and Routing	2-10
2.4.3 Power Cord Connections and Routing	2-11
2.5 Locating the RA90/RA92 Disk Drive Power Supply	2-12

2.5.1	Plugging in the Power Cord	2-12
2.6	International Operator Control Panel Labeling	2-13
2.7	RA90/RA92 Disk Drive Acceptance Testing Procedures	2-13
2.7.1	Voltage Selection	2-13
2.7.2	Applying Power to the Drive	2-14
2.8	Power-Up Resident Diagnostics	2-16
2.8.1	OCP Lamp Testing	2-16
2.8.2	Test Selection from the OCP	2-16
2.8.3	RA90/RA92 Idle Loop Acceptance Testing	2-16
2.8.4	Testing Spun-Down Drive	2-18
2.8.5	Testing Spun-Up Drive	2-19
2.9	Placing the Drive On Line	2-20
2.9.1	Programming the Drive Unit Address	2-20
2.10	Installing RA90/RA92 Add-On Disk Drives in 60-Inch Cabinets	2-22

3 Operating Instructions

3.1	Introduction	3-1
3.2	RA90/RA92 Disk Drive Components	3-1
3.2.1	Electronic Control Module (ECM)	3-3
3.2.1.1	I/O-R/W Module	3-3
3.2.1.2	Servo Module	3-5
3.2.2	Preamplifier Control Module (PCM)	3-7
3.2.3	Head Disk Assembly and Carrier Assembly	3-10
3.2.4	Dual Outlet Blower Motor	3-12
3.2.5	Power Supply	3-12
3.2.6	Drive Functional Microcode	3-13
3.2.7	OCP Functions	3-14
3.3	RA90/RA92 Operating Modes	3-15
3.3.1	Normal Mode Setup	3-15
3.3.2	Fault Display Mode Setup	3-16
3.3.3	Test Mode Setup	3-18
3.4	Programming the Drive Unit Address	3-19
3.4.1	Alternate Unit Address Display Mode	3-21

4 Drive-Resident Diagnostics and Utilities

4.1	Introduction	4-1
4.2	Power-Up and Idle Loop Diagnostics	4-1
4.2.1	Power-Up (Hardcore) Diagnostics	4-1
4.2.2	Idle Loop Tests (Drive Spun Down)	4-2
4.2.3	Idle Loop Tests (Drive Spun Up)	4-2
4.3	Sequence Diagnostics	4-2

4.4	Standard OCP Displays Indicating Procedural Problems	4-3
4.5	Software Jumper	4-4
4.6	Temperature's Affect on Drive Performance	4-5
4.7	Diagnostics Descriptions	4-5
4.7.1	Seek Timing Tests	4-14
4.7.2	Time, Seeks, and Spinups Display Interpretation	4-17

5 Troubleshooting and Error Codes

5.1	Troubleshooting Reference Material	5-1
5.1.1	Customer Support Training for the RA90/RA92 Disk Drive	5-1
5.2	RA90/RA92 Troubleshooting Aids	5-1
5.2.1	VAXsimPLUS	5-2
5.2.2	Host Error Logs	5-2
5.2.3	Extended Status Bytes	5-2
5.2.3.1	Response Opcode (Byte 1)	5-3
5.2.3.2	Unit Number Low Byte (Byte 2) and Subunit Mask (Byte 3)	5-3
5.2.3.3	Request Byte (Byte 4)	5-3
5.2.3.4	Mode Byte (Byte 5)	5-4
5.2.3.5	Error Byte (Byte 6)	5-4
5.2.3.6	Controller Byte (Byte 7)	5-5
5.2.3.7	Retry Count (Byte 8)	5-5
5.2.3.8	Previous Command Opcode (Byte 9)	5-6
5.2.3.9	HDA Revision Bits (Byte 10)	5-6
5.2.3.10	Cylinder Address (Bytes 11 and 12)	5-6
5.2.3.11	Error Recovery Level (Selected Group) (Byte 13)	5-9
5.2.3.12	Error Code (Byte 14)	5-9
5.2.3.13	Manufacturing Fault Code (Byte 15)	5-9
5.2.4	Drive Internal Error Log	5-9
5.2.4.1	Running DKUTIL From the HSC Console or KDM70 Controller	5-12
5.2.4.2	Running the Drive-Resident Utility Dump (T41) From the OCP	5-14
5.2.5	OCP Fault Indicator/Error Codes	5-14
5.2.6	Drive Power Supply Indicator	5-14
5.2.7	Drive Error Reporting Mechanisms	5-15
5.2.7.1	Detailed Description of Error Reporting Mechanisms	5-15
5.2.8	Host-Level Diagnostics and Utilities	5-16
5.3	General Troubleshooting Information	5-16
5.3.1	Drive-Resident Diagnostics Limitations	5-16
5.4	Step-by-Step Troubleshooting Procedure	5-16
5.4.1	Troubleshooting Worksheet	5-23
5.5	Identifying the Problem Drive 	5-23
5.5.1	Talking to the System Operator/Checking the OCP Fault Indicator 1.1	5-23
5.5.2	Using VAXsimPLUS to Identify the Problem Drive 1.2	5-23
5.5.3	Using the Host Error Log to Identify the Problem Drive 1.3	5-23

5.5.4	Using the HSC Console Log to Identify the Problem Drive 1.4	5-24
5.5.5	Using the Host Console/User Terminal Trails to Identify the Problem Drive 1.5	5-24
5.5.6	Using Other Means to Identify the Problem Drive 1.6	5-24
5.6	Identifying the Problem FRU 2	5-24
5.6.1	Pre-Verifying Drive Symptoms 2.1	5-25
5.6.2	Using OCP Error Codes to Identify the Problem FRU 2.2	5-25
5.6.3	Using VAXsimPLUS to Identify the Problem FRU 2.3	5-25
5.6.4	Using the Host Error Log to Identify the Problem FRU 2.4	5-25
5.6.5	Using the HSC Console Log to Identify the Problem FRU 2.5	5-26
5.6.6	Using the Drive Internal Error Log to Identify the Problem FRU 2.6	5-27
5.7	Priority Order of Troubleshooting DSA Errors 3	5-27
5.7.1	Drive-Detected Drive Errors and Diagnostic Faults 3.1	5-27
5.7.1.1	Drive-Detected Protocol Errors Without Communication Errors 3.2	5-27
5.7.1.2	Drive-Detected Pulse or State Parity Errors 3.3	5-27
5.7.2	Controller-Detected EDC Error 3.4	5-28
5.7.2.1	Controller-Detected Protocol and Transmission Errors Without Communication Errors (Status/Event Codes 14B or 4B) 3.5	5-29
5.7.2.2	Controller-Detected Pulse or State Parity Errors (Status/Event Code 10B) 3.6	5-29
5.7.3	Controller-Detected Communication Events and Faults 3.7	5-30
5.7.3.1	Controller-Detected: LOSS OF READ/WRITE READY (Status/Event Code: 8B) 3.8	5-30
5.7.3.2	Controller-Detected: LOST RECEIVER READY (Status/Event Code: CB) 3.9	5-30
5.7.3.3	Controller-Detected: RECEIVER READY COLLISION (Status/Event Code: 1AB) 3.10	5-31
5.7.3.4	Controller-Detected: DRIVE CLOCK DROPOUT (Status/Event Code: AB) 3.11	5-31
5.7.3.5	Controller-Detected: DRIVE FAILED INITIALIZATION (Status/Event Code: 16B) 3.12	5-31
5.7.3.6	Controller-Detected: DRIVE IGNORED INITIALIZATION (Status/Event Code: 18B) 3.13	5-31
5.7.3.7	Controller-Detected: SERDES OVERRUN ERROR (Status/Event Code: 2A) 3.14	5-32
5.7.3.8	SDI Drive Command Timeout (Status/Event Code: 2B) 3.15	5-32
5.8	Media-Related Errors 4	5-32
5.8.1	Repeating LBNs/RBNs 4.1	5-33
5.8.2	Excessive Number of Blocks Replaced Because of R/W Path Problems 4.2	5-33
5.8.3	LBN Correlation to Single Group/Track 4.3	5-33
5.8.4	LBN Correlation to Head Groups 4.4	5-34
5.8.4.1	LBNs Correlated to Zone Write Boundaries 4.5	5-34
5.8.4.2	LBN Correlation to a Physical Cylinder 4.6	5-34
5.8.5	Multiple Controllers Report Same Error Types 4.7	5-35
5.8.6	Only Single Controller Port Affected 4.8	5-35
5.8.7	Isolating Random R/W Transfer Errors 4.9	5-35
5.8.7.1	Not Defined to a Specific Drive/Controller Port	5-35

5.9	Miscellaneous Checks 5	5-36
5.10	Are You Lost? 6	5-36
5.11	Using Host-Level Diagnostics as a Last Resort 7	5-37
5.11.1	HSC-Based Diagnostics	5-37
5.11.2	KDM-Based Diagnostics	5-37
5.11.2.1	On Line from VMS	5-37
5.11.2.2	Running Standalone Programs from the VAX Diagnostic Supervisor	5-38
5.11.3	xDA Controller-Based Diagnostics	5-38
5.12	Exiting Data Collection: Action Item List Process 8	5-39
5.13	FRU Replacement 9	5-40
5.13.1	Multiple Error Codes 9.1	5-40
5.13.2	Service Post-Verification 9.2	5-40
5.13.3	Return Disk Drive to User 9.3	5-41
5.14	Performance Issues When No Errors Are Being Logged	5-41
5.15	Troubleshooting VMS Mount Verification	5-42
5.15.1	VMS Mount Verification	5-42
5.15.2	VMS Problems Surrounding Diagnosis of "Why a Drive Mount-Verifies"	5-42
5.15.3	Non-VMS Mount Verification	5-44
5.16	Troubleshooting ECC Errors on RA90/RA92 Disk Drives	5-44
5.16.1	Uncorrectable ECC Errors—MSCP Status/Event E8	5-44
5.16.1.1	Hard Uncorrectable ECC Errors	5-44
5.16.1.2	Soft Uncorrectable ECC Errors	5-46
5.16.2	Correctable ECC Errors—MSCP Status/Event Codes 1A8, 1C8, 1E8	5-48
5.16.2.1	BBR Packet	5-48
5.17	Troubleshooting Controller-Detected Positioner Errors—MSCP Status/Event 6B	5-49
5.17.1	RA92 Disk Drive With MSCP Status/Event 6B	5-49
5.17.2	Evaluating MSCP 6B Events	5-52
5.18	Conclusion	5-52
5.19	Error Codes and Descriptions	5-53

6 Removal and Replacement Procedures

6.1	Introduction	6-1
6.2	Sequence for FRU Removal	6-3
6.3	Electrostatic Sensitivity	6-3
6.4	Power Precautions	6-3
6.5	Tools Checklist	6-3
6.6	Removing/Replacing Cabinet Front and Rear Access Panels	6-4
6.6.1	Removing/Replacing the Front Access Panel	6-4
6.6.2	Removing/Replacing the Rear Access Panel	6-4
6.7	Removing the Operator Control Panel	6-6

6.8	Removing the Blower/Bezel Motor Assembly	6-7
6.8.1	Separating the Bezel and Blower Motor Assembly	6-9
6.9	Removing the Electronic Control Module	6-10
6.10	Removing the Preamp Control Module	6-11
6.11	Removing/Replacing the Head Disk Assembly	6-12
6.11.1	Removing the HDA	6-12
6.11.2	HDA Thermal Stabilization Procedure	6-13
6.11.3	Replacing the HDA	6-14
6.11.4	Separating the HDA and Carrier	6-14
6.11.5	Removing the Spindle Ground Brush	6-16
6.11.6	Removing the Brake Assembly	6-17
6.11.7	Spindle Lock Solenoid Failure	6-20
6.12	Removing the Power Supply	6-22
6.13	Removing/Replacing the Rear Flex Cable Assembly	6-23
6.14	Media Removal Service for Customers	6-25

7 Microcode Update Procedure

7.1	Introduction	7-1
7.2	Microcode Update Cartridge Description	7-1
7.3	Microcode Update Port Description	7-2
7.4	Running Test 40 (T40)	7-3
7.5	Updating the Microcode	7-3
7.5.1	Error Codes/Common Problems During Microcode Update	7-3

A Capturing Information for LARS and CHAMPS

B RA90/RA92 Error Recovery Levels

C Customer Equipment Maintenance

C.1	Customer Responsibilities	C-1
C.1.1	Cleaning Supplies	C-1
C.1.2	Ongoing Equipment Care	C-1
C.1.3	Monthly Equipment Maintenance	C-2
C.1.4	Maintenance Records	C-2

D Customer Services' Preventative Maintenance

D.1	PM Checklist for RA90/RA92 Disk Drives	D-1
-----	--	-----

Index

Examples

5-1	RA90 Cylinder Address and Group (Head)	5-7
5-2	RA92 Cylinder Address and Group (Head)	5-8
5-3	VMS Uncorrectable ECC Error Log—Hard	5-45
5-4	VMS Uncorrectable ECC Error Log—Soft	5-47
5-5	VMS BBR Packet	5-50
5-6	Positioner Mis-Seek MSCP Status/Event 6B	5-51

Figures

1-1	Example of Sector Format	1-2
1-2	RA90 Physical and Logical Media Layout	1-3
1-3	RA92 Physical and Logical Media Layout	1-4
1-4	ESD Wrist Strap	1-9
2-1	Electrical Plug Configurations	2-2
2-2	Unpacking the 60-Inch Cabinet	2-4
2-3	Cabinet Deskidding	2-5
2-4	Ramp Installation of Shipping Pallet	2-6
2-5	Leveler Adjustment	2-7
2-6	Front Panel Removal	2-8
2-7	Rear Access Panel Removal	2-9
2-8	SDI Cable Connections and Routing—SA600 Example	2-10
2-9	Power Cord Connections and Routing—SA600 Example	2-11
2-10	RA90/RA92 Power Supply Controls and Indicators	2-12
2-11	RA90/RA92 Operator Control Panel	2-13
2-12	Location of Voltage Selector Switch	2-14
2-13	Location of Power Controller Controls—881 Example	2-15
2-14	Test Selection Flowchart	2-17
2-15	OCP Displays During Testing	2-19
2-16	Unit Selection Flowchart	2-21
3-1	RA90/RA92 Disk Drive Block Diagram	3-2
3-2	I/O-R/W Module Block Diagram	3-4
3-3	Servo Module Block Diagram	3-6
3-4	PCM Block Diagram	3-8
3-5	PCM Switch Pack Location	3-10
3-6	HDA Block Diagram	3-11
3-7	Power Supply OK LED	3-13
3-8	RA90/RA92 OCP	3-15
3-9	OCP Fault Display Error Code Example	3-17
3-10	Fault Display Mode Flowchart	3-17

3-11	OCP Display After Test Selection	3-18
3-12	OCP Display While Running Test	3-18
3-13	Unit Address Selection Flowchart	3-20
3-14	Alternate Unit Address Display Mode Flowchart	3-22
4-1	Using Loopback Connectors	4-10
4-2	Hardware Revision Switches	4-19
4-3	Hardware Revision Byte	4-20
4-4	T65 FCY OCP Display	4-23
4-5	T65 LCY OCP Display	4-24
4-6	T65 INC OCP Display	4-24
4-7	T65 DLY OCP Display	4-24
5-1	RA90/RA92 Extended Drive Status Bytes	5-2
5-2	RA90/RA92 Drive Internal Error Log Memory Layout	5-10
5-3	RA90/RA92 Drive Internal Error Log Header Format	5-11
5-4	RA90/RA92 Drive Internal Error Log Descriptor Format	5-12
5-5	Drive Internal Error Log	5-13
5-6	Power Supply Indicators	5-14
5-7	Step-by-Step Troubleshooting Flowchart	5-17
5-8	Power Supply Cover Removal	5-59
5-9	WRT/CMD Data Format	5-65
6-1	RA90/RA92 Disk Drive — Exploded View	6-2
6-2	FRU Removal Sequence	6-3
6-3	Front Access Panel Removal	6-5
6-4	Rear Access Panel Removal	6-6
6-5	OCP Removal	6-7
6-6	Blower Motor Assembly Removal Sequence	6-8
6-7	Bezel and Blower Motor Assembly Separation	6-9
6-8	ECM Removal	6-10
6-9	PCM Removal	6-11
6-10	HDA Removal	6-13
6-11	HDA Carrier Separation	6-15
6-12	Spindle Ground Brush Removal	6-16
6-13	Contact Extraction Tool	6-18
6-14	RA90/RA92 Brake Assembly Removal/Replacement	6-19
6-15	Disabling the Solenoid for In-Field Data Recovery	6-21
6-16	Power Supply Removal	6-23
6-17	Rear Flex Cable Assembly Removal	6-24
6-18	HDA Media Removal — Top View	6-27
6-19	HDA Media Removal — Bottom View	6-28
7-1	Microcode Update Cartridge	7-1
7-2	Microcode Update Port	7-2
A-1	LARS Example	A-2
C-1	Customer Equipment Maintenance Log for Storage Array Cabinets	C-3

Tables

1-1	Specifications for RA90 and RA92 Disk Drives	1-5
1-2	Additional Electrical Specifications by Model for RA90 and RA92 Disk Drives ..	1-7
1-3	RA90/RA92 Environmental Limits	1-7
2-1	OCP Error Codes	2-18
3-1	ECM Module Types — Compatibility Matrix	3-3
3-2	I/O-R/W Module — Hardware Revision Matrix	3-5
3-3	Servo Module — Hardware Revision Matrix	3-7
3-4	PCM Switch Pack Setup	3-9
3-5	PCM Module — Hardware Revision Matrix	3-9
3-6	RA90/RA92 HDA Hardware Compatibility Matrix	3-12
3-7	RA90/RA92 Microcode Compatibility With Drive FRUs	3-14
3-8	Power-Up: Normal Mode Operations	3-16
5-1	Reference Material for Troubleshooting	5-1
5-2	Two-Board Controller Diagnostics	5-9
5-3	Summary of Controller-Detected Communication Errors	5-29
5-4	RA90/RA92 Write Zones	5-34
5-5	VDS-Based Off-Line Diagnostics	5-39
5-6	MDM-Based Off-Line Diagnostics	5-39
5-7	XXDP-Based Off-Line Diagnostics	5-39
5-8	Serial Number	5-55
5-9	Power Supply Voltage Measurements	5-60
5-10	HDA Connector Pin Designations	5-61
5-11	HDA Resistance Measurements	5-61
6-1	Digital Part Numbers for Recommended Tools	6-26
7-1	Common Error Codes/Problems During Microcode Update	7-4
B-1	RA90/RA92 Hardware Error Recovery Circuits	B-1
B-2	RA90/RA92 Error Recovery Levels	B-2

About This Manual

The information contained in this manual is intended for Digital Customer Services personnel responsible for RA90/RA92 disk drive maintenance and service calls.

This manual contains checkout, servicing, and troubleshooting information for RA90 and RA92 disk drives. Procedures for unpacking, deskidding, and cabling 60-inch cabinets are also included.

Procedures for installing RA90 and RA92 add-on disk drives in 60-inch cabinets are not included in this manual. Refer to product-specific documentation.

Related documentation is listed below, in alphabetical order:

Document Title	Order Number
DSA Controller Documentation Kit	QP906-GZ
DSA Drive Documentation Kit	QP907-GZ
<i>DSA Error Log Manual</i>	EK-DSAEL-MN
<i>DSA Error Log Pocket Service Guide</i>	EK-DSAEL-PG
<i>Getting Started With VAXsimPLUS</i>	AA-KN79A-TE
<i>HSC Service Manual</i>	EK-HSCMA-SV
<i>RA90 Disk Drive Illustrated Parts Breakdown</i>	EK-ORA90-IP
<i>RA90 Disk Drive Technical Description Manual</i>	EK-ORA90-TD
RA90 Field Maintenance Print Set	MP-01424-01
<i>RA90/6000 Cabinet Series Upgrade Installation Guide</i>	EK-RA9CK-IN
<i>RA90/H9643 Cabinet Installation Guide</i>	EK-RA90H-IN
<i>RA90/RA92 Disk Drive Pocket Service Card</i>	EK-ORA90-PS
<i>RA90/RA92 Disk Drive User Guide</i>	EK-ORA90-UG
<i>SA600/SA800 Storage Array Family Configuration Guide</i>	EK-SA600-CG
<i>SA650/SA850 Storage Array Family Configuration Guide</i>	EK-SA650-CG
<i>VAXsimPLUS Field Service Manual</i>	AA-KN82A-RE
<i>VAXsimPLUS User Guide</i>	AA-KN80A-TE

1.1 RA90 and RA92 Disk Drive Descriptions

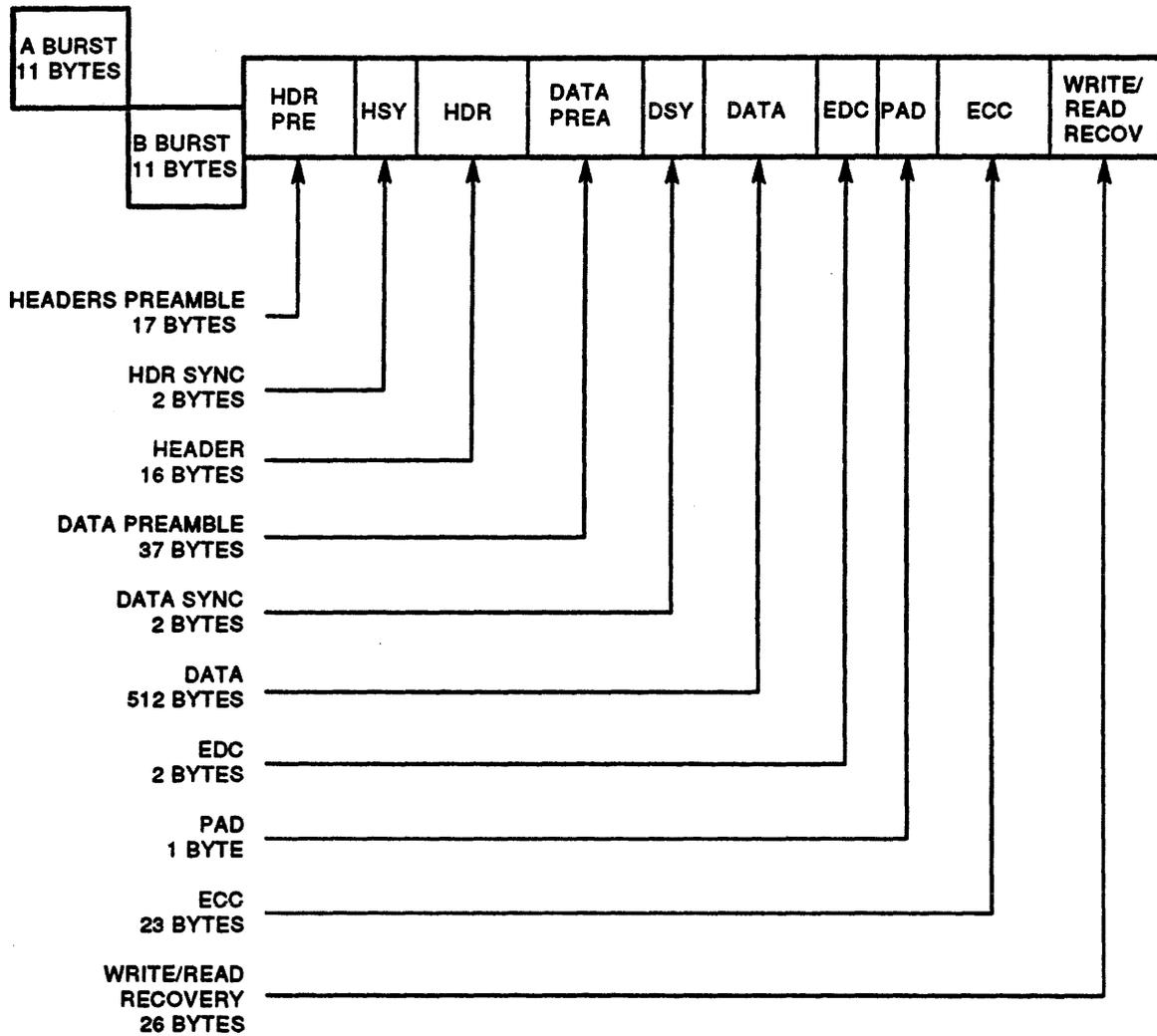
The RA90 and RA92 disk drives are high density, fixed-media disk drives which use nonremoveable, thin film media and thin film heads. The RA90/RA92 heads, disks, rotary actuator, and filtering system are encased in a single unit called the Head Disk Assembly (HDA).

The RA90 disk drive has a formatted data storage capacity of 1.216 gigabytes and an unformatted data storage capacity of 1.604 gigabytes in a 16-bit word format. The RA92 disk drive has a formatted data storage capacity of 1.506 gigabytes and an unformatted data storage capacity of 1.987 gigabytes in a 16-bit word format.

Thirteen surfaces contain data and embedded servo information. The embedded servo information is within the intersector gaps. The embedded servo information accomplishes fine positioning of read/write heads over the data tracks. Figure 1-1 is an example of the sector format used for RA90/RA92 disk drives.

The fourteenth surface is a dedicated servo surface that, when decoded by the drive electronics, provides information on:

- Coarse radial position
- Track crossing (velocity)
- Rotational index and sector position
- Generation of clock synch pulse
- Inner and outer guardband detection

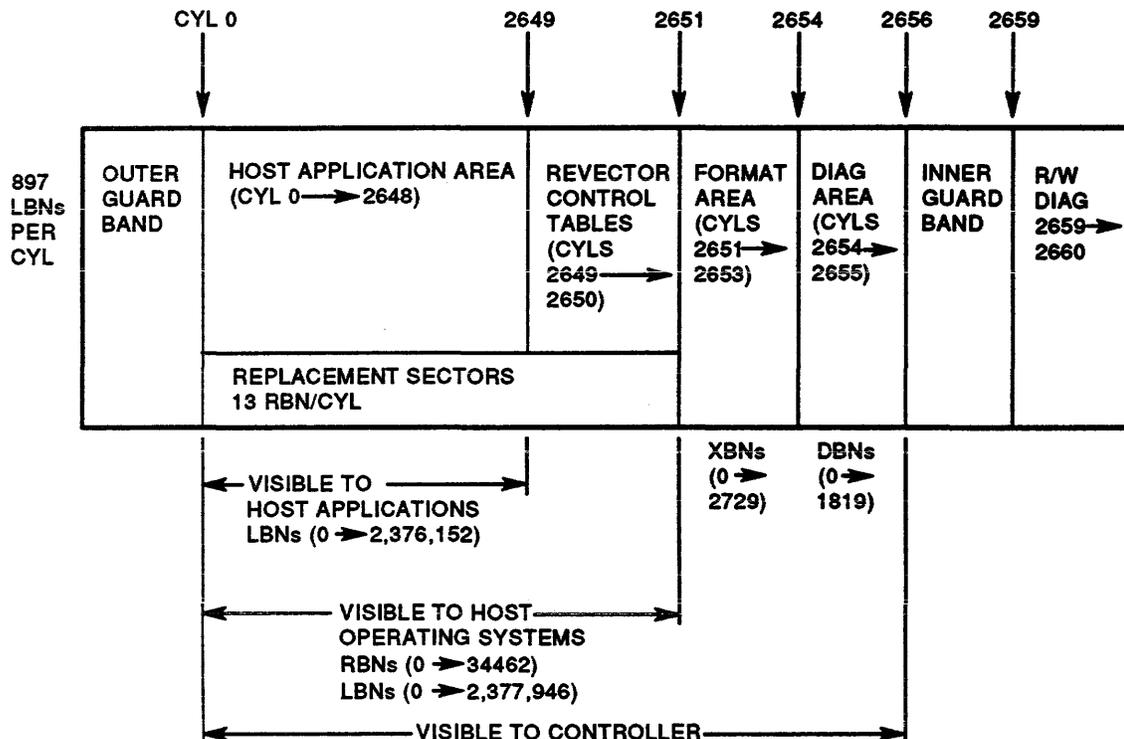


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Figure 1-1 Example of Sector Format

1.1.1 Physical and Logical Media Layout

The physical structure of the media is transparent to the user. Figures 1-2 and 1-3 represent the layout of logical information for the RA90 and RA92 media.



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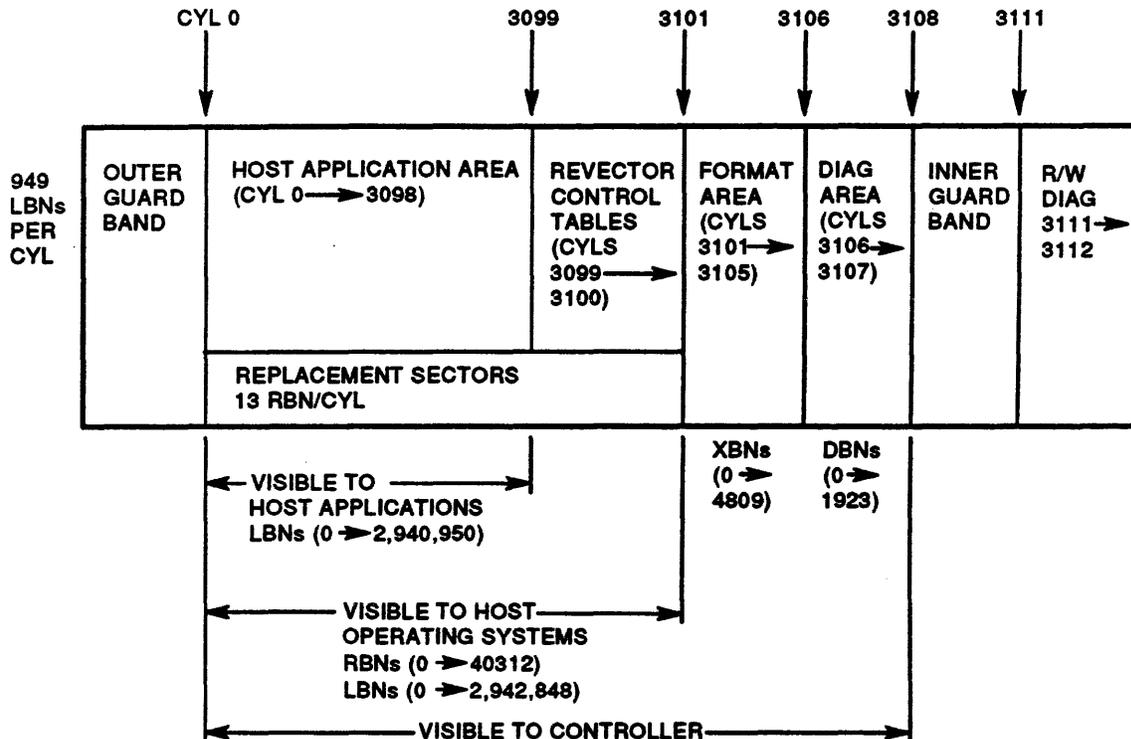
Figure 1-2 RA90 Physical and Logical Media Layout

1.2 Maintenance Strategy

The RA90 and RA92 disk drives introduce a new approach to repairing peripheral equipment. In most cases, RA90/RA92 disk drives afford easy access to field replaceable units (FRU) without the use of tools.

Additional drive maintenance features include the following:

- A microprocessor-controlled operator control panel (OCP) interface eliminating the need for external test equipment
- EEPROM where an internal error log is stored
- Twelve error recovery levels
- Extensive drive-resident diagnostics
- Drive microcode that can be updated by way of the microcode update port



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Figure 1-3 RA92 Physical and Logical Media Layout

1.2.1 Service Delivery Strategy

Real-time subsystem (drive) faults detected by the drive are recorded in the RA90/RA92 drive internal error log. Real-time faults detected in the disk subsystem are recorded in the supporting system host error log. Controller-detected errors (such as ECC errors) are also logged to the host error log and not the RA90/RA92 drive-resident error log.

Use utility programs to obtain a print-out of the drive internal error log and isolate faults, provided the error was drive-detected. Additionally, you can run the RA90/RA92 drive-resident utility T41 to access the drive internal error log. This provides the drive LED error codes only. Use of other utility programs provides additional error information.

Use drive-resident diagnostics to validate repairs to RA90/RA92 disk drives. For more information on drive-resident diagnostics and utilities, refer to Chapter 4.

1.2.1.1 Six-Step Maintenance Strategy

This section describes the maintenance strategy for RA90 and RA92 disk drives. Become familiar with it as it determines the course of action necessary to successfully service RA90/RA92 disk drives.

Implement the following six-step maintenance strategy on each service call for a drive problem:

1. Examine and analyze VAXsimPLUS.
2. Examine and analyze system error logs.
3. Examine and analyze the drive internal error log.
4. Correlate failure symptoms to the probable failing FRU through service documentation.

5. Replace the FRU only after a prime FRU is identified from previous steps.
6. Verify device repair through drive-resident diagnostics. (Running host-level diagnostics to verify repairs is unnecessary and penalizes the customer by tying up the system.)

Use host-based diagnostics only as a last resort, to obtain symptomatic failure information, and only if system and drive error logs are unavailable.

Verify the drive is on line and operational through normal system-level commands that access the unit under repair.

1.2.2 Tools Required for Maintenance

Tools required for maintaining RA90/RA92 disk drives are identified in the procedures where they are needed and in Chapter 6.

1.2.3 Preventative Maintenance

Customer responsibilities for preventative maintenance (60-inch cabinets only) are described in Appendix C.

Digital Customer Services responsibilities for cabinet and RA90/RA92 disk drive maintenance are described in Appendix D.

1.3 RA90/RA92 Disk Drive Specifications

Table 1-1 lists important operating and nonoperating specifications for RA90 and RA92 disk drives.

Table 1-1 Specifications for RA90 and RA92 Disk Drives

Characteristic	RA90 Disk Drive	RA92 Disk Drive
Head Disk Assembly (HDA)		
Storage capacity, formatted	1.216 gigabytes	1.506 gigabytes
Storage capacity, unformatted	1.604 gigabytes	1.987 gigabytes
HDA word format	16-bit only	Same as RA90
Bits/square inch	40 megabits	49.4 megabits
Tracks/inch	1750	2045
Disk recording method	Rate 2/3 modulation code	Same as RA90
Number of disks	7	Same as RA90
Disk surfaces	14 (13 data and 1 servo)	Same as RA90
Number of heads	14	Same as RA90
Heads per surface	1	Same as RA90
Data tracks	34,437	40,287
Logical cylinders	2656	3101
User logical cylinders	2649	3099
Number of sectors	69 + 1 spare	73 + 1 spare
Number of logical blocks	2,376,153	2,942,849

Table 1-1 (Cont.) Specifications for RA90 and RA92 Disk Drives

Characteristic	RA90 Disk Drive	RA92 Disk Drive
Seek Times		
One cylinder	5.5 milliseconds	3.0 milliseconds
Average seek	18.5 milliseconds	16.0 milliseconds
Maximum cylinder seek	31.5 milliseconds	29.0 milliseconds
Latency		
Rotation speed	3600 r/min	3405 r/min
Average latency	8.33 milliseconds	8.81 milliseconds
Maximum latency	16.67 milliseconds	17.62 milliseconds
Single Start/Stop Time		
Start (maximum)	40 seconds	Same as RA90
Inhibit between stop and restart	40 seconds	Same as RA90
Data Rates		
Transfer rate	2.77 megabytes/sec	Same as RA90
Physical Characteristics		
Height	26.56 cm (10.42 inches)	Same as RA90
Width	22.19 cm (8.74 inches)	Same as RA90
Depth	68.47 cm (26.96 inches)	Same as RA90
Weight	31.8 kg (70 pounds)	Same as RA90
Inrush Current		
120 Vac	60 amperes peak @ 132 Vac	Same as RA90
220-240 Vac	70 amperes peak @ 264 Vac	Same as RA90
Running current for:		
120 Vac	4.6 amps	Same as RA90
220-240 Vac	2.4 amps	Same as RA90
Power factor:		
120 Vac	0.7	Same as RA90
220-240 Vac	0.58	Same as RA90
Line cord length (from the cabinet)	2.74 meters (9 feet)	Same as RA90

Table 1-2 contains additional electrical specifications by model for RA90 and RA92 disk drives.

NOTE

The RA90 and RA92 disk drives are not line-frequency dependent.

Table 1-2 Additional Electrical Specifications by Model for RA90 and RA92 Disk Drives

Model	Nominal Voltage	Input Current (Amps) ¹			Power Dissipation	BTUs/Hour [Kj/Hour] ²
		Start-Up Current	PH1	Neutral		
RA90-xx/RA92-xx	120 volts	5.0	3.4	3.4	281 Watts	960
RA90-xx/RA92-xx	240 volts	2.35	1.45	1.45	271 Watts	[976]

¹Currents are for nominal voltages of 120 Vac phase to neutral or for 240 Vac phase to neutral. For 101 Vac and 220 Vac nominal voltages, the drives will have proportionately higher phase currents by a ratio of 120/101 or 240/220 to the currents specified in this table.

²Bracketed figures indicate kilojoules per hour.

Table 1-3 shows the maximum environmental limits and the recommended environmental operating ranges to optimize equipment performance and reliability.

Table 1-3 RA90/RA92 Environmental Limits

Characteristic	RA90/RA92 Disk Drive
Maximum Environmental Limits	
Temperature (Required)	
Operating	10°C to 40°C (50°F to 104°F) with a temperature gradient of 20°C/hour (36°F/hour)
Nonoperating	-40°C to +60°C (-40°F to +140°F)
Relative humidity	
Operating	10% to 90% (noncondensing) with a minimum wet bulb temperature of 28°C (82°F) and a minimum dew point of 2°C (36° F)
Nonoperating	10% to 90% with no condensation

Table 1-3 (Cont.) RA90/RA92 Environmental Limits

Characteristic	RA90/RA92 Disk Drive
Recommended Environmental Operating Ranges	
Temperature	18°C to 24°C (64.4°F to 75.2°F) with an average rate of change of 3°C/hour maximum and a step change of 3°C or less
Relative humidity	40% to 60% (noncondensing) with a step change of 10% or less (noncondensing)
Air quality (maximum particle count)	Not to exceed 500,000 particles per cubic foot of air at a size of 0.5 micron or larger
Air volume (at inlet)	50 cubic feet per minute (.026 cubic meters per second)
Altitude	
Operating	Sea level to 2400 meters (8000 feet); maximum allowable operating temperatures are reduced by a factor of 1.8°C/1000 meters (1°F/1000 feet) for operation above sea level
Nonoperating	300 meters (1000 feet) below sea level to 7500 meters (16,000 feet) above sea level (actual or effective by means of cabin pressurization)

1.4 Electrostatic Protection

Electrostatic discharge (ESD) is the result of electrostatic buildup and its subsequent release. The surface storage of an electrostatic charge from a person or object can damage hardware components and may result in premature device or option failure.

The basic concept of static protection for electronic components is the prevention of static buildup, where possible, and the safe release of existing electrostatic charge buildup. If the charged object is a conductor, such as an object or person, complete discharge can be achieved through grounding the person or object.

Use the following guidelines when handling static-sensitive components and modules:

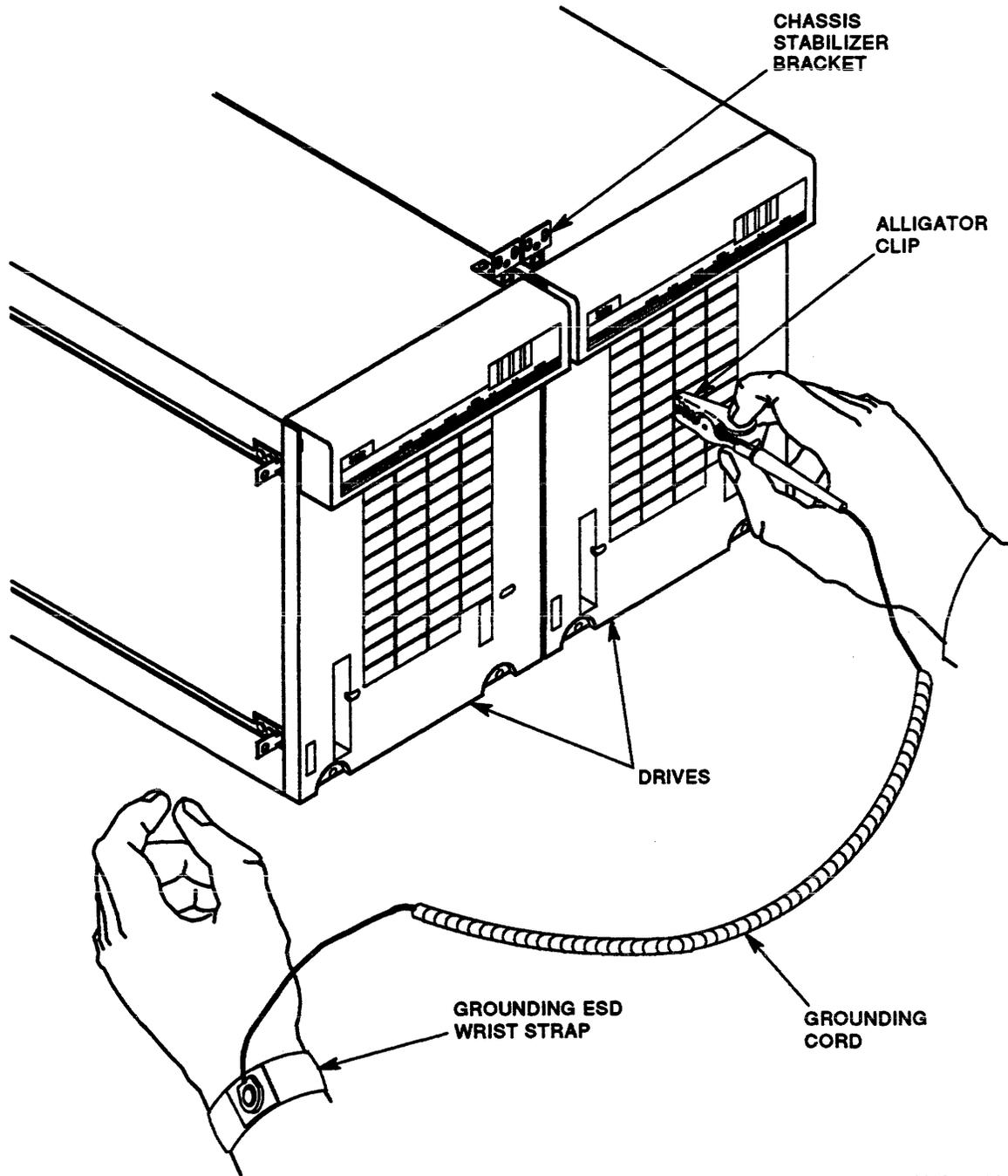
CAUTION

Always use grounding straps to avoid product damage when handling static-sensitive components and modules.

1. Read all instructions and installation procedures included with static control materials and kits.
2. Use static-protective containers to transfer modules and components (including bags and tote boxes).
3. Wear a properly grounded ESD wrist strap when handling components, modules, or other static-sensitive devices. Figure 1-4 shows the ESD wrist strap in use.

When using an ESD wrist strap:

- Ensure the wrist strap fits snugly for proper conductivity.
- Attach the alligator clip securely to a clean, unpainted, grounded metal surface such as the drive chassis or cabinet frame.
- Do not overextend the grounding cord.



CXO-2168C

Figure 1-4 ESD Wrist Strap

2.1 Introduction

The SA600 and SA650 cabinets are the most commonly used cabinets for RA90 and RA92 disk drives. Procedures for unpacking, deskidding, and cabling 60-inch† cabinets are contained in this chapter. This chapter also covers site preparation and planning considerations, drive acceptance testing procedures, and power-up diagnostics.

Information on unpacking and installing add-on RA90 and RA92 disk drives in 60-inch cabinets can be found in product-specific documentation and is not covered here.

2.2 Site Preparation and Planning

Site preparation and planning are necessary before installing an RA90 or RA92 disk drive subsystem. Chapter 1 contains a full range of recommended environmental specifications. In addition, consider the following items before attempting installation.

2.2.1 Power and Safety Precautions

The RA90/RA92 disk drives do not present any unusual fire or safety hazards. It is recommended, however, that you check ac power wiring for the computer system to determine adequate capacity for expansion.

2.2.2 Three-Phase Power Requirements

The RA90 and RA92 disk drives use a single-phase power supply; however, the 881 power controller uses three phases. It is very important that the correct phase requirements for this product be met. Refer to Chapter 1 for power specifications.

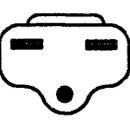
WARNING

Hazardous voltages are present in this equipment. Installation and service must be performed by trained service personnel. Bodily injury or equipment damage may result from incorrect servicing.

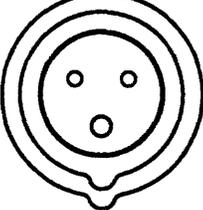
To prevent damage to equipment and personnel, ensure power sources meet the specifications required for this equipment.

† The SA600 and the SA650 are both 60-inch cabinets.

POWER CORDS GOING TO POWER CONTROLLER

<p>120V 60HZ POWER CORD DEC NO. A-PS-1700083-23 PLUG - POWER CONTROLLER END</p>	
<p>240V 50HZ POWER CORD DEC NO. A-PS-1700083-24 PLUG - POWER CONTROLLER END</p>	
<p>120/240V 47-63HZ 10A/6A POWER CORD DEC NO. A-PS-1700442-18 OR A-PS-1700442-19 PLUG - DRIVE END</p>	

PLUGS GOING TO WALL OUTLET (FROM CONTROLLER)

<p>40-INCH CABINET</p>	<p>120V 60HZ 24A 1-PHASE</p>		<p>NEMA NO. L5-30P DEC NO. 12-11193 (874-D)</p>
	<p>220/240V 50-60HZ 16A 1-PHASE</p>		<p>IEC 309 320-P6W DEC NO. 12-14379-03 (874-F)</p>
<p>60-INCH CABINET</p>	<p>120/208V AC 60HZ 30A 3-PHASE WYE USED WITH 881-A AND 881-C POWER CONTROLLERS</p>		<p>5-WIRE NEMA NO. L21-30P</p>
	<p>220-240/380-415V AC 50HZ 20A OR 16A 3-PHASE WYE USED WITH 881-B POWER CONTROLLER</p>		<p>5-WIRE, 4-POLE, IEC 309</p>

CXO-1872D

Figure 2-1 Electrical Plug Configurations

2.2.3 AC Power Wiring

The wiring used by Digital Equipment Corporation conforms to UL, CSA, and ISE standards. Figure 2-1 shows the ac plug configurations for RA90 and RA92 disk drives and 881 and 874 power controllers.

2.2.4 Thermal Stabilization

Thermal stabilization prevents temperature differences between the equipment and its environment from damaging disk drive components.

Prior to installation, a 60-inch cabinet subsystem and the RA90/RA92 add-on drive must be stored at a temperature of 60°F (16°C) or higher for a minimum of 24 hours. These units may be stored either in the computer room or in another storage room under controlled temperature conditions. If stored in another storage room, each unit must sit for an additional hour in the computer room in which it is to be installed.

CAUTION

The thermal stabilization procedure is *mandatory*. Do not open the moisture barrier bag until after the thermal stabilization period. Failure to thermally stabilize the equipment may cause premature equipment failure.

After the thermal stabilization criteria has been met, carefully cut the moisture barrier bag and proceed with the installation.

2.2.5 Floor Loading

Consider the placement of this equipment, especially if a fully loaded 60-inch configuration is used. A fully loaded 60-inch cabinet weighs approximately 390 kilograms (860 pounds). Each RA90 or RA92 disk drive weighs approximately 31.8 kilograms (70 pounds).

2.2.6 Operating Temperature and Humidity

The required relative humidity range is between 10 percent and 90 percent with a minimum wet bulb temperature of 28°C (82°F) and a minimum dew point of 2°C (36°F) (non-condensing) with a step change of 10 percent or less.

The RA90 and RA92 disk drives can be operated within temperatures of 10°C to 40°C (50°F to 104°F). However, it is highly recommended that RA90 and RA92 disk drives be operated in a temperature range below 25°C (77°F) to increase reliability and extend product life.

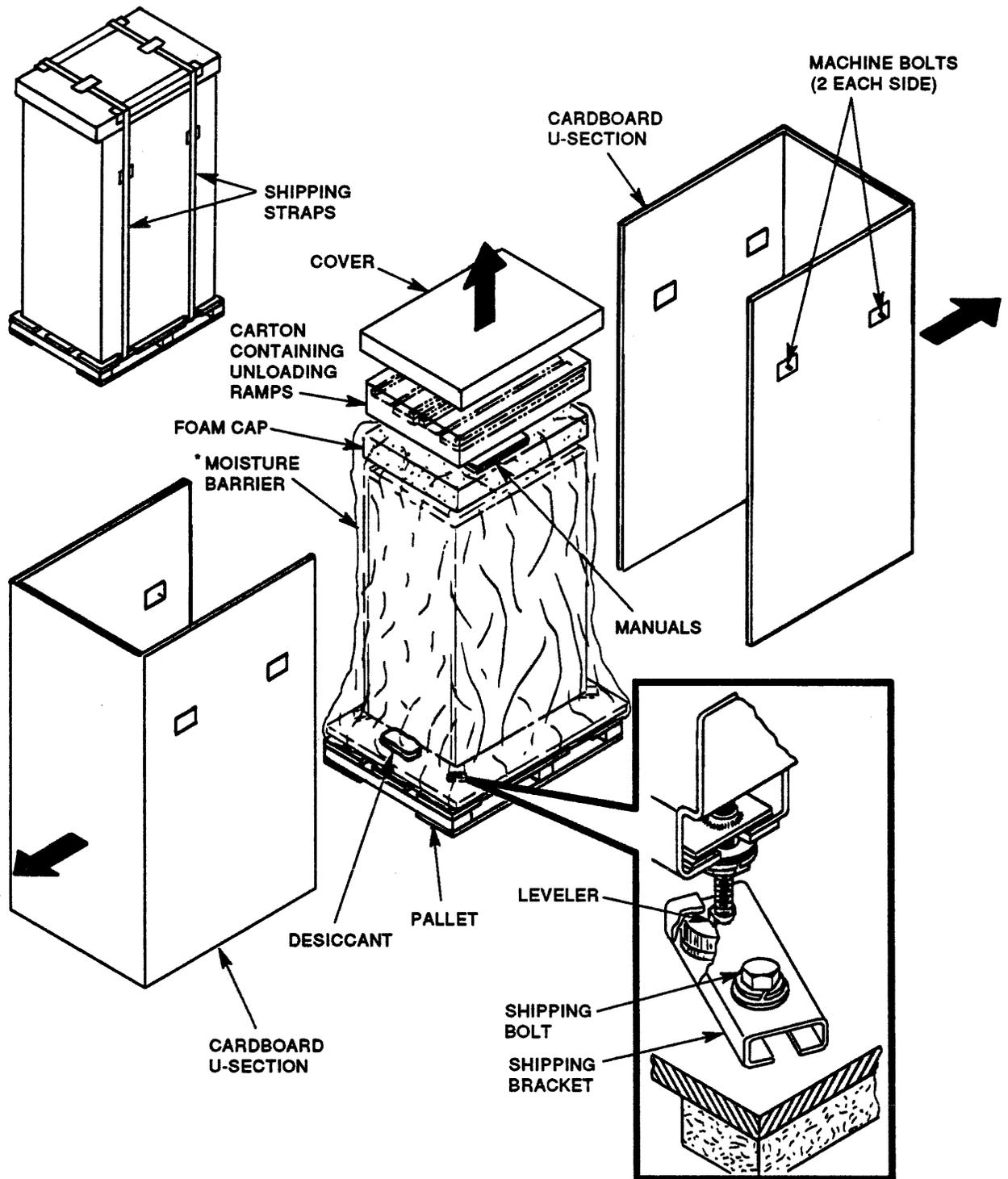
2.3 Unpacking the Cabinet

The 60-inch cabinet configuration is packed in a cardboard carton attached to a wooden shipping pallet. Refer to Figure 2-2 and use the following procedure to unpack the cabinet:

1. Inspect the shipping carton for any sign of external damage. Report any damage to the local carrier and to the Digital Customer Services or sales office.
2. Remove the two cardboard U-sections but leave the sealed moisture barrier with desiccant in place during thermal stabilization.

CAUTION

This equipment must be thermally stabilized in the site environment for at least 24 hours before operation.



*DO NOT OPEN UNTIL THE THERMAL STABILIZATION PROCEDURE IS COMPLETE.

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Figure 2-2 Unpacking the 60-Inch Cabinet

2.3.1 Deskidding the Cabinet

Three people are required to deskid the 60-inch cabinet. See Figure 2-3.

WARNING

Serious injury could result if the cabinet is improperly handled.



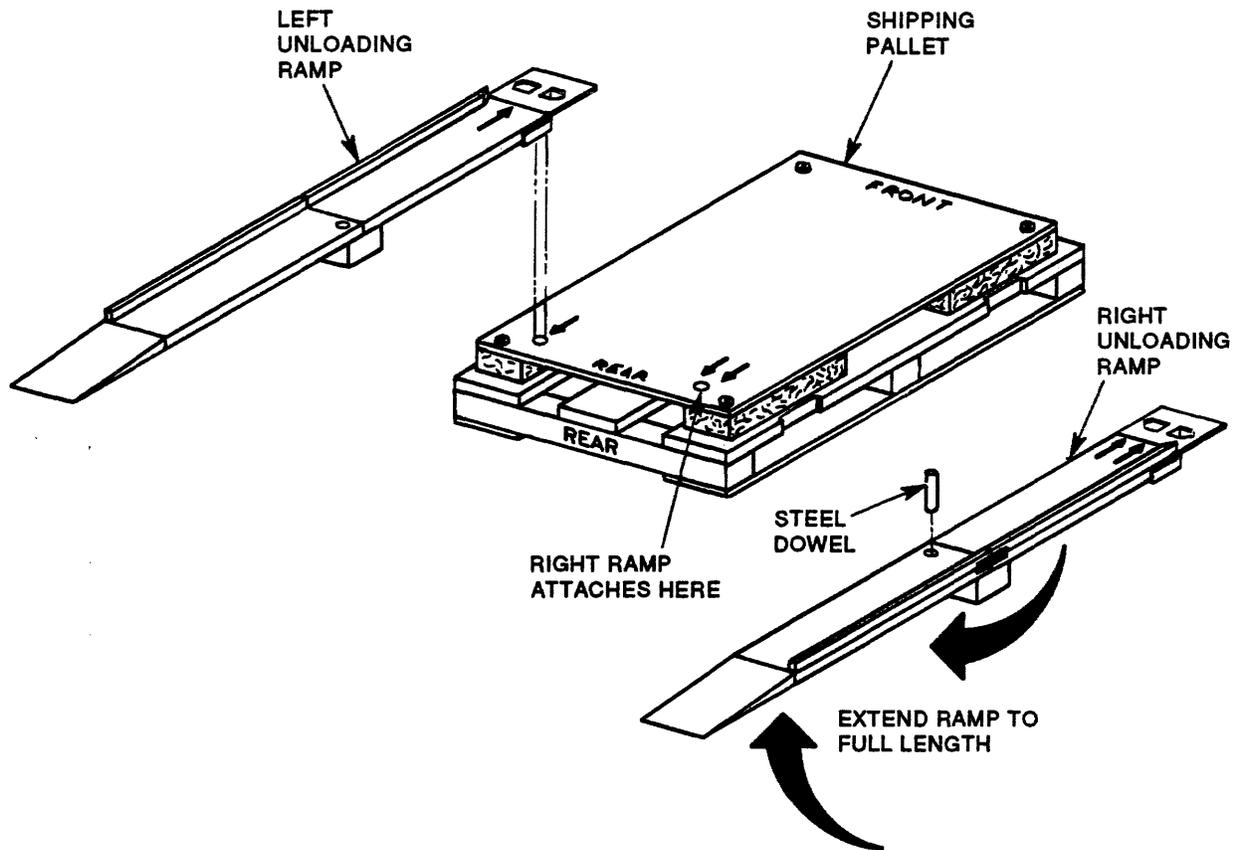
CXO-924A_S

Figure 2-3 Cabinet Deskidding

1. Remove the two unloading ramps from their carton located under the carton top cover.
2. Inspect the ramps, ramp side rails, and metal hardware for defects described in the following list:
 - Cracks more than 25 percent of the ramp depth, either across or lengthwise on the ramp.
 - Knots or knotholes going through the thickness of the ramp and greater than 50 percent of the ramp width.
 - Loose, missing, or broken ramp side rails.
 - Loose, missing, or bent metal hardware.

If any of these conditions exist, do not use that ramp. Investigate alternate means of removing the cabinet and/or order a new ramp. The part number for the left ramp is 99-07689-01; the part number for the right ramp is 99-07689-02.

3. Remove shipping bolts from the shipping brackets on each of the four levelers. See inset in Figure 2-2.
4. Remove shipping brackets from the four cabinet levelers.
5. Fasten unloading ramps onto the pallet by fitting the grooved end of each ramp over the metal mating strip on the pallet. See Figure 2-4.



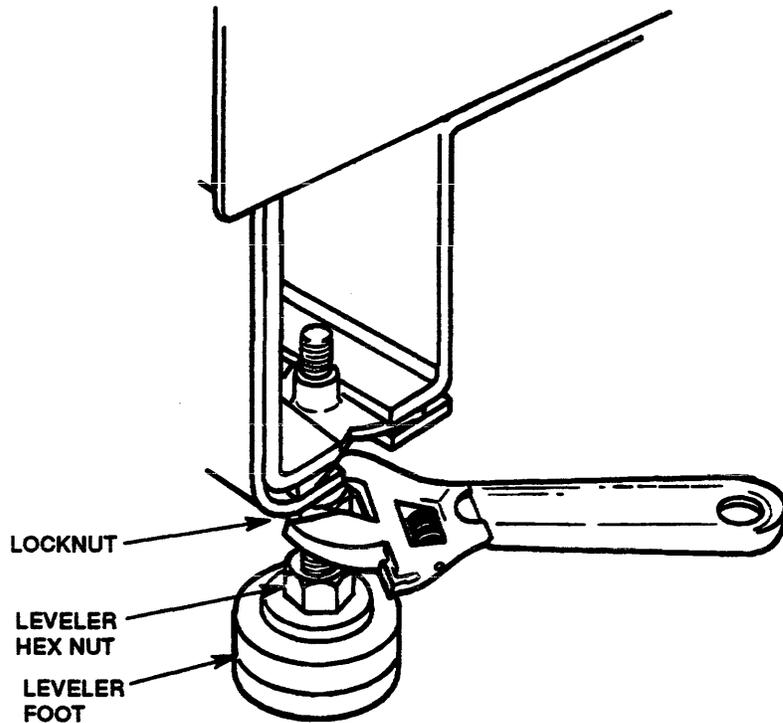
CXO-688C_S

Figure 2-4 Ramp Installation of Shipping Pallet

6. Screw the cabinet levelers (Figure 2-5) all the way up until the cabinet rests on its rollers on the pallet.
7. Carefully roll the cabinet down the ramps (three people are required).
8. Move the cabinet into its final position.
9. Turn each leveler hex nut clockwise until the leveler foot contacts the floor (no weight on the casters) and the cabinet is level.

2.4 Installing SDI Cables and Power Cords

Generally, SDI cables and power cords are installed in the 60-inch cabinet prior to shipping. Use this section as a reference should you need to remove or reinstall the power cords or SDI cables.



CXO-395C_S

Figure 2-5 Leveler Adjustment

2.4.1 Removing the Front and Rear Access Panels

Use the following procedure to remove front and rear cabinet access panels.

2.4.1.1 Front Access Panel Removal

Refer to Figure 2-6 while performing this procedure:

1. Use a hex wrench or flat-bladed screwdriver to unlock the two quarter-turn fasteners at the top of the panel. Turn the fasteners counterclockwise.
2. Grasp the panel by its edges, tilt it toward you, and lift it up about 2 inches. Remove the panel and store it in a safe place.

To reinstall the front panel, lift it into place and lower it straight down until the tabs on the panel's lower edge engage the slots in the cabinet support bracket. Hold the panel flush with the cabinet and use a hex wrench to lock the fasteners.

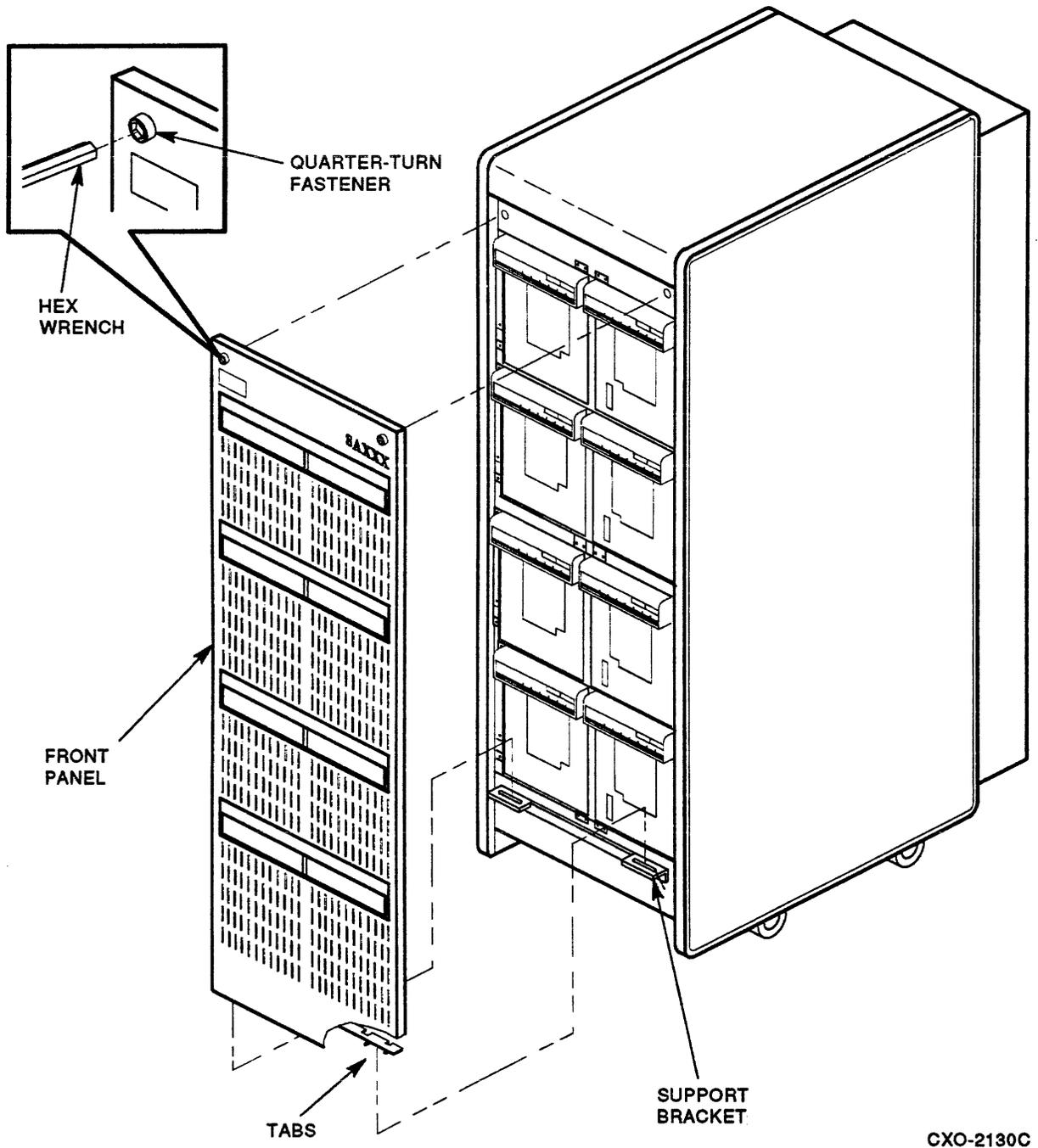


Figure 2-6 Front Panel Removal

2.4.1.2 Removing the Rear Access Panel

Refer to Figure 2-7 while performing this procedure:

1. Use a hex wrench or flat-bladed screwdriver to unlock the two quarter-turn fasteners at the top of the panel. Turn the fasteners counterclockwise.
2. Tilt the panel toward you and lift it up to disengage the pins at the bottom.
3. Lift the panel clear of the enclosure and store it in a safe place.

When replacing the rear panel, lift it into place and fit the pins into the holes at the top of the I/O bulkhead. Push the top of the panel into place and turn the quarter-turn fasteners clockwise.

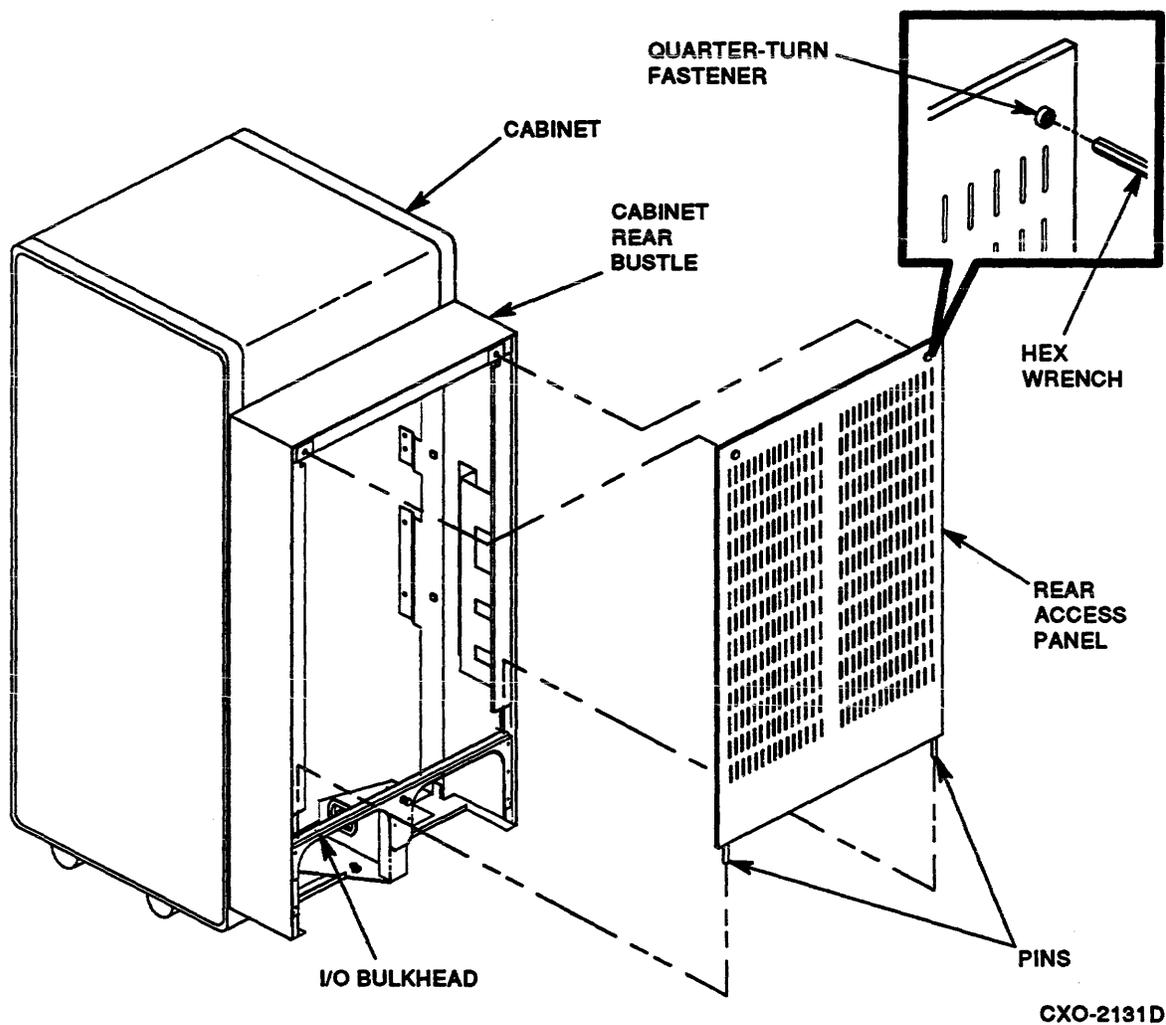
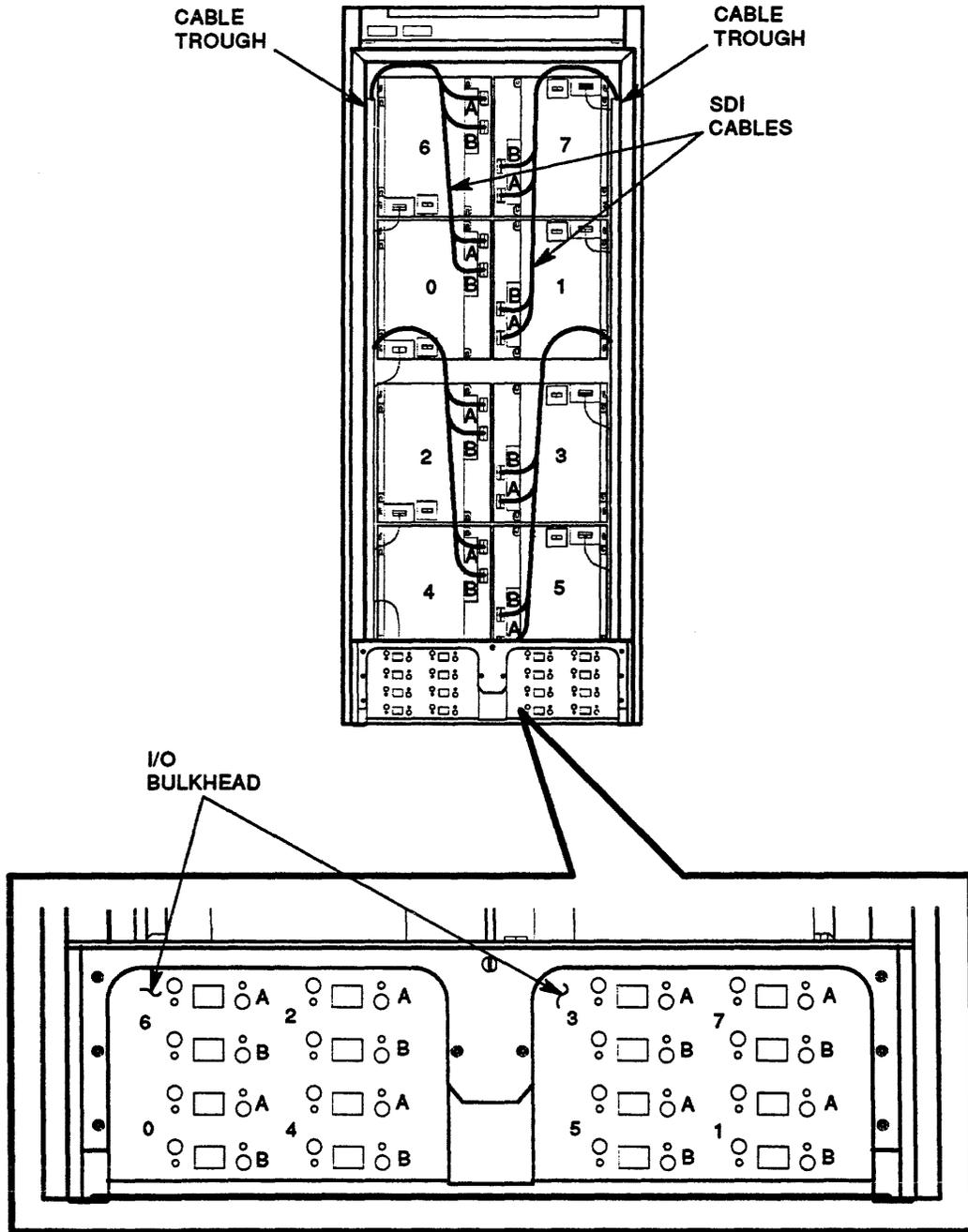


Figure 2-7 Rear Access Panel Removal

2.4.2 SDI Cable Connections and Routing

Both external and internal cables are connected to the I/O bulkhead located at the base of the drive cabinet. See Figure 2-8. Refer to product-specific documentation for more information.

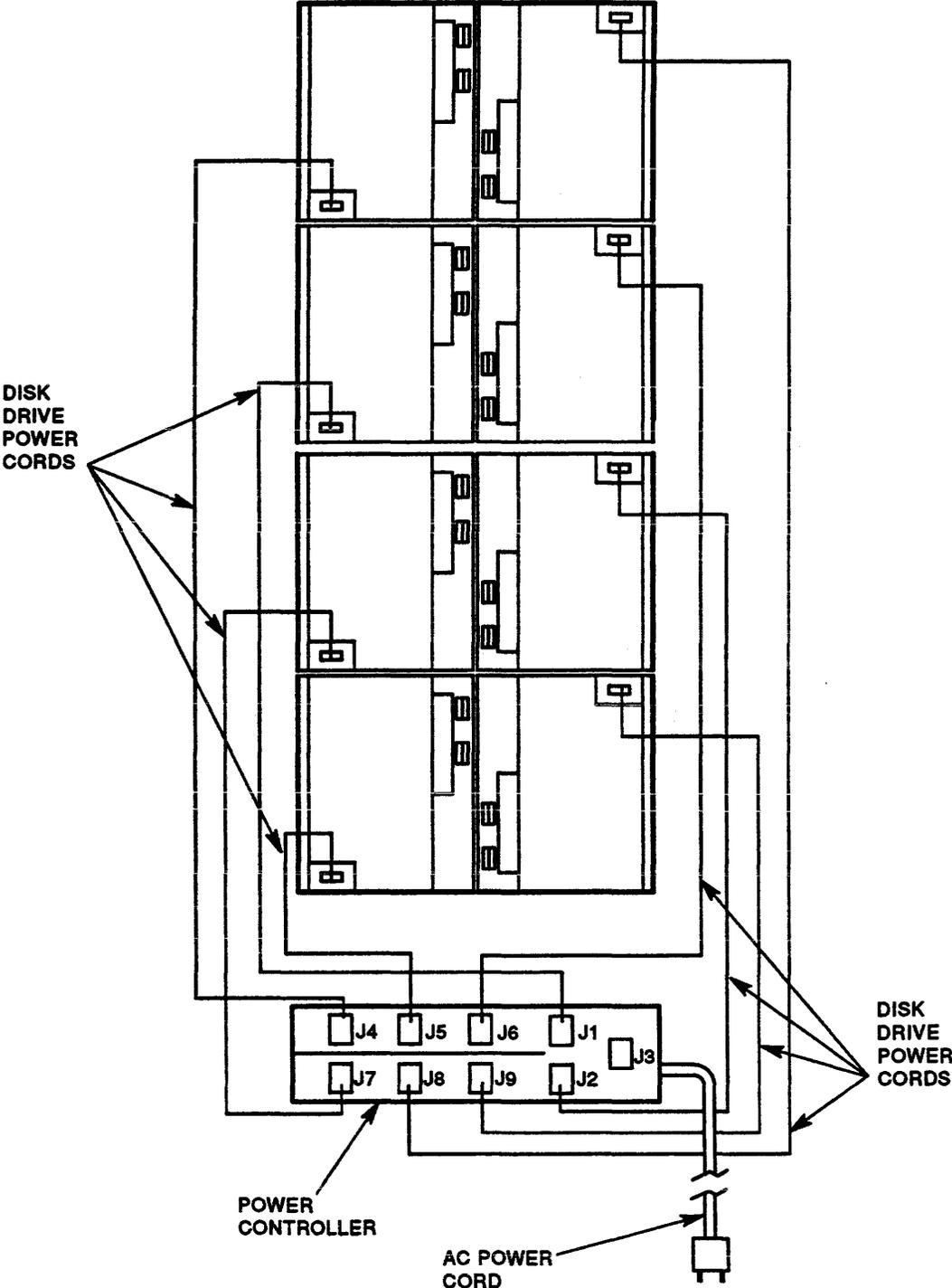


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Figure 2-8 SDI Cable Connections and Routing—SA600 Example

2.4.3 Power Cord Connections and Routing

Figure 2-9 shows drive power cord connections and the recommended power cord routing for an SA600 storage array cabinet. Refer to product-specific documentation for power cord connections and routing for other subsystems.



CXO-2133B

Figure 2-9 Power Cord Connections and Routing—SA600 Example

2.5 Locating the RA90/RA92 Disk Drive Power Supply

To access the RA90 or RA92 disk drive power supply, remove the cabinet rear access panel (Figure 2-7). Figure 2-10 shows the location of the RA90/RA92 disk drive power supply, circuit breaker, and the Power OK LED.

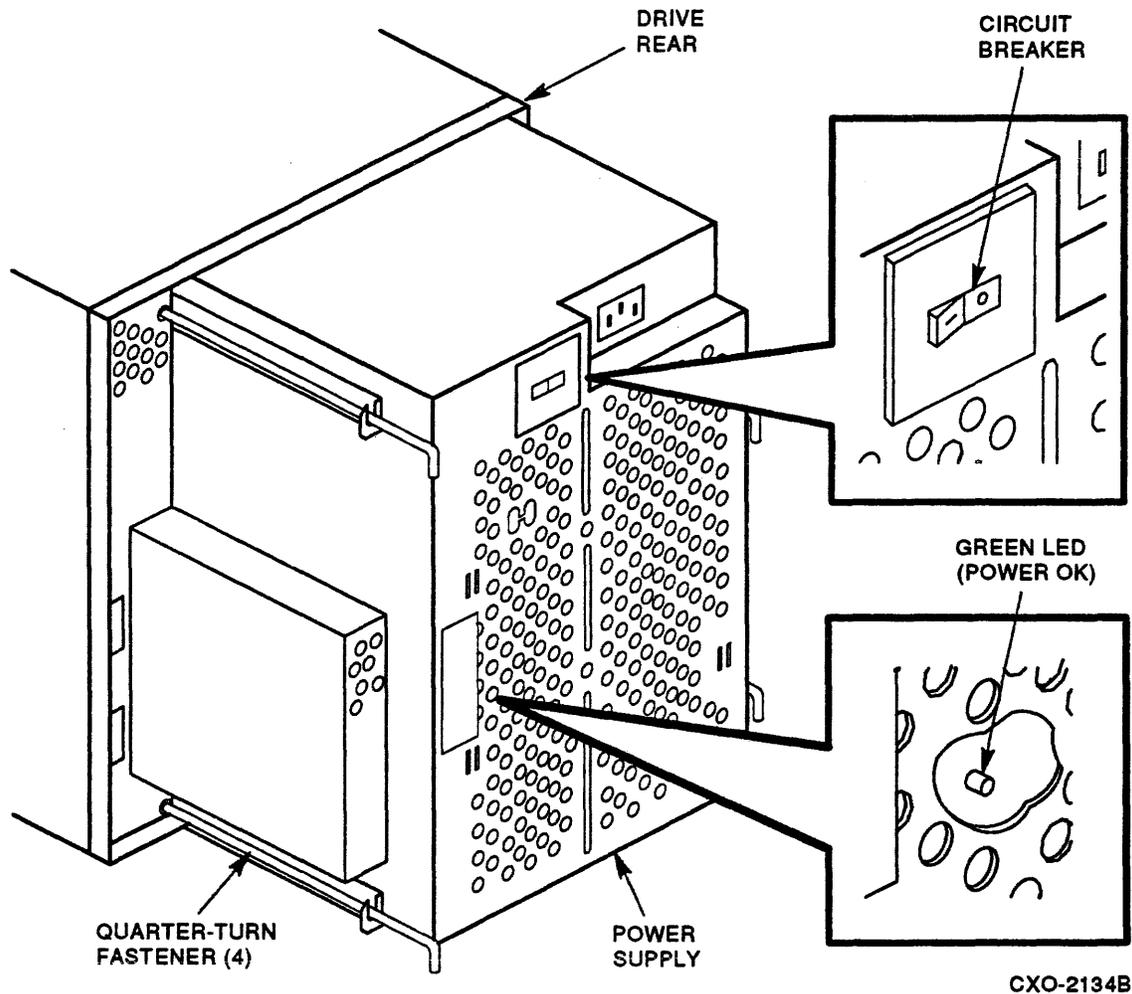


Figure 2-10 RA90/RA92 Power Supply Controls and Indicators

2.5.1 Plugging in the Power Cord

The drive power cords in a fully-configured cabinet are already plugged into the power controller. Only the ac power cord from the cabinet power controller needs to be plugged into an external power source.

NOTE

Do not apply power to the power controller until proper voltage has been selected. (Refer to Section 2.7.1.)

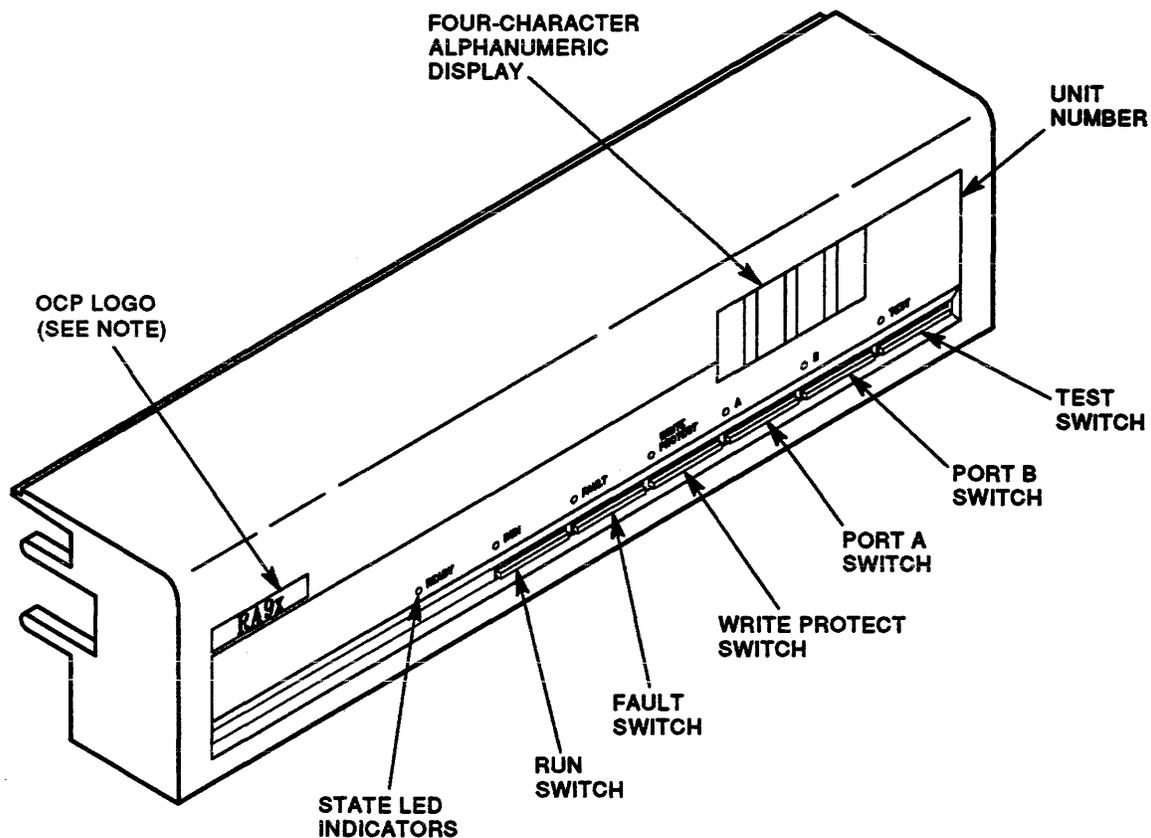
2.6 International Operator Control Panel Labeling

Each drive unit or cabinet configuration is shipped with a set of international labels for the operator control panel (OCP). The labels come in a packet or on a single sheet. Select and apply the set of labels applicable to the country in which the equipment is being installed.

2.7 RA90/RA92 Disk Drive Acceptance Testing Procedures

The following sections cover RA90/RA92 disk drive acceptance testing procedures. Follow each procedure to completion before starting the next.

Refer to Figure 2-11 while performing acceptance testing on RA90 and RA92 disk drives. A more detailed description of the RA90/RA92 OCP and its functions can be found in Chapter 3.



NOTE: RA90 PART NO. 74-35109-02
RA92 PART NO. 74-39769-01

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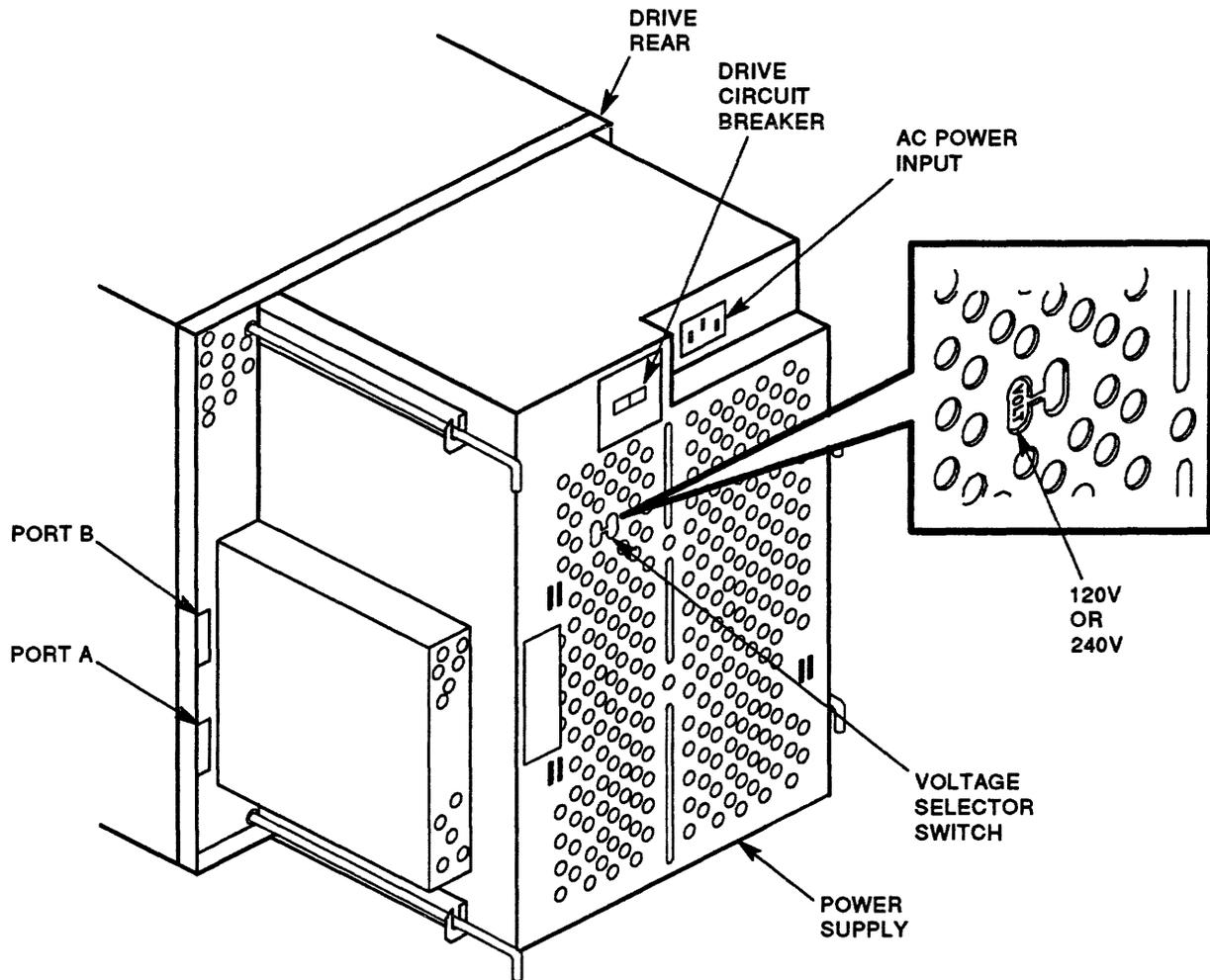
Figure 2-11 RA90/RA92 Operator Control Panel

2.7.1 Voltage Selection

Before applying power to RA90 or RA92 disk drives, ensure the proper operating voltage has been selected for your area of operation. The voltage selector is a slide switch capable of selecting 120 volts or 240 volts. (The frequency 60 Hz or 50 Hz is universal.) To select the proper voltage, perform the following steps:

1. Remove the cabinet rear access panel (refer to Section 2.4.1.2).
2. Verify the ac circuit breaker on the power controller is off.

3. Verify the circuit breaker on each disk drive is off (0).
4. Locate the voltage selector switch (Figure 2-12).
5. Using a non-conductive pointed object, slide the voltage selector switch into the position applicable to your site.



NOTE: VOLTAGE MARKINGS ON SOME POWER SUPPLIES READ 115/230V.

CXO-2135D

Figure 2-12 Location of Voltage Selector Switch

2.7.2 Applying Power to the Drive

Use the following procedure to apply power to RA90/RA92 disk drives:

1. Verify drive voltage selector switch has been properly set (see Section 2.7.1).
2. Verify the ac circuit breaker on the power controller is off. Also verify the circuit breaker on each disk drive is off. See Figures 2-10 and 2-13 for circuit breaker locations.

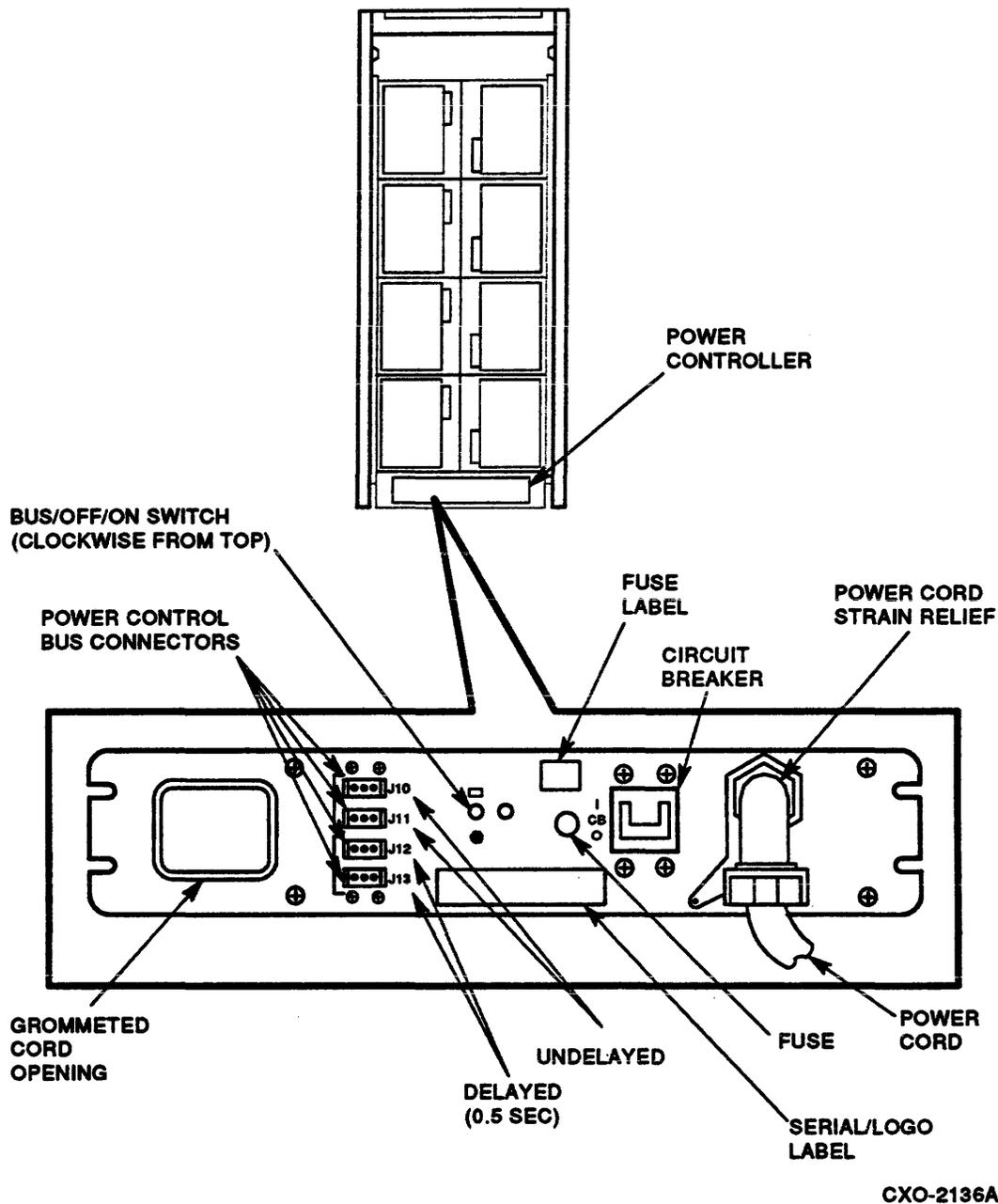


Figure 2-13 Location of Power Controller Controls—881 Example

3. Verify the Local/Remote switch on the 881 power controller is in the Local position.
4. Verify the drive power cord is plugged into the power controller.
5. Verify the external power source is correct.
6. Plug the ac power cord from the power controller into an external power receptacle.
7. Switch the ac circuit breaker on the power controller to the on position.
8. Switch the ac circuit breaker on the RA90 or RA92 disk drive to the on position.

2.8 Power-Up Resident Diagnostics

A sequence of drive-resident diagnostics run at power-up. The sequence consists of hardcore tests with basic processor tests. Successful completion of the hardcore tests is indicated by the following OCP displays:

1. Blank (1 second)
2. **WAIT** (16 seconds)
3. **[0000]** (If previously programmed, the drive unit number is displayed; otherwise, zeros are displayed.)

2.8.1 OCP Lamp Testing

Before continuing with acceptance testing, perform an OCP lamp test to ensure the LED state indicators and alphanumeric display are working properly. Perform the following procedure before selecting any other OCP switches (refer to Figure 2-11):

1. Select the Test switch. The Test LED indicator lights.
2. Select the Fault switch. All lamps light momentarily.
3. Deselect the Test switch.

All lamps should momentarily light. If not, ensure the OCP is seated properly and power is applied to the drive. Repeat the test.

Replace the OCP if any lamps fail (refer to Section 6.7).

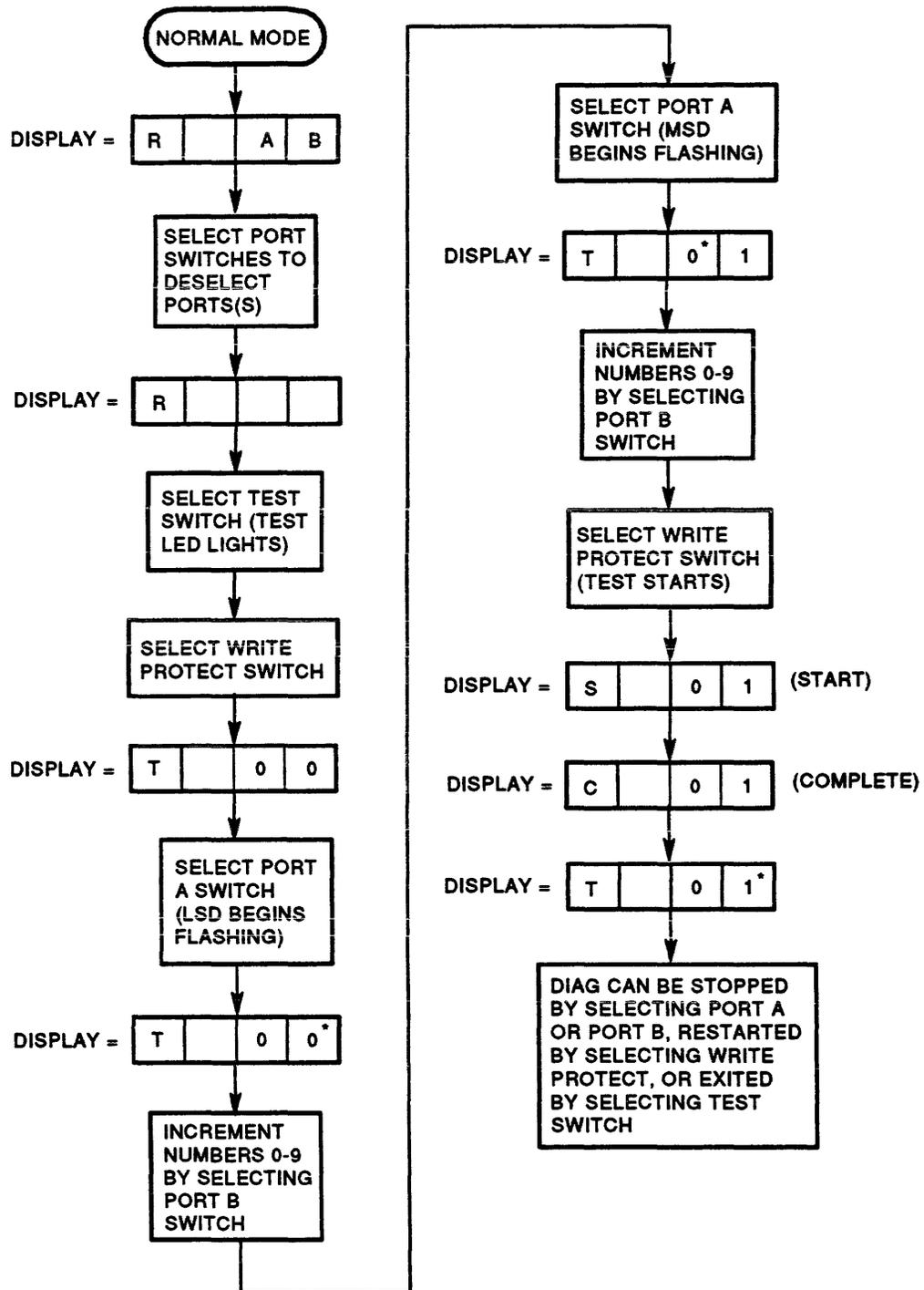
2.8.2 Test Selection from the OCP

It is necessary to select and run resident diagnostics from the OCP to complete acceptance testing. Use the following procedure to select and run diagnostics from the OCP. Figure 2-14 is a flowchart of this procedure.

1. Power up the drive (if not done previously).
2. Select the Test switch (test defaults to zero; no other operator action is required).
3. Select the Write Protect switch.
4. Select the diagnostic to run by using Port A and Port B switches. See the test selection flowchart (Figure 2-14).
5. Start the test by selecting the Write Protect switch.
6. Stop the test by selecting either the Port A or Port B switch.
7. Restart the test by selecting the Write Protect switch again.
8. Select the Test switch to exit the test mode.

2.8.3 RA90/RA92 Idle Loop Acceptance Testing

After the hardcore diagnostics have successfully run, the drive automatically enters an idle loop diagnostic test sequence. Do not select any front panel switches. Allow the drive to remain in the idle loop test for 5 minutes.



* INDICATES FLASHING READOUT

CXO-2139B

Figure 2-14 Test Selection Flowchart

If an error occurs during power-up or during idle loop testing, the drive attempts to display an error code. Table 2-1 lists error codes and required operator actions. Error codes not found in Table 2-1 indicate a problem requiring additional troubleshooting. Refer to Chapter 5 for troubleshooting strategy.

Table 2-1 OCP Error Codes

Error	Description	Action
0F	Drive write protected	Disable write protection with the OCP Write Protect switch or turn off software write protection.
22	Drive over-temperature condition	Spin down and remove power from the drive. Ensure the cabinet air vent grill is clean and room temperature is within recommended limits. Call Digital Customer Services if dirty air vent grill or temperature has not caused an over-temperature condition.
2D	Power supply over-temperature condition	Spin down and remove power from the drive. Ensure the cabinet air vent grill is clean and room temperature is within recommended limits. Call Digital Customer Services if dirty air vent grill or temperature has not caused an over-temperature condition.
3A, 6F	Write protect errors	Disable write protection with the OCP Write Protect switch or turn off software write protection.

2.8.4 Testing Spun-Down Drive

To invoke resident diagnostics while the drive is still spun down:

1. Select Test switch (Test indicator lights).
2. Select the Write Protect switch: [T 00] is displayed.
3. Input [T 60] into display. This is a loop-on-test utility.
4. Start T60 by selecting the Write Protect switch a second time. The following occurs:
 - [S.60]
 - [LOT]
 - [C.60]
 - [T 00] (LSD flashing)
5. Input [T 00] into display.
6. Start T00 by selecting the Write Protect switch a second time.

The drive is now running a sequence of resident diagnostics. A number of displays are seen during the execution of the diagnostics. These displays are normal. Examples of these displays are shown in Figure 2-15.

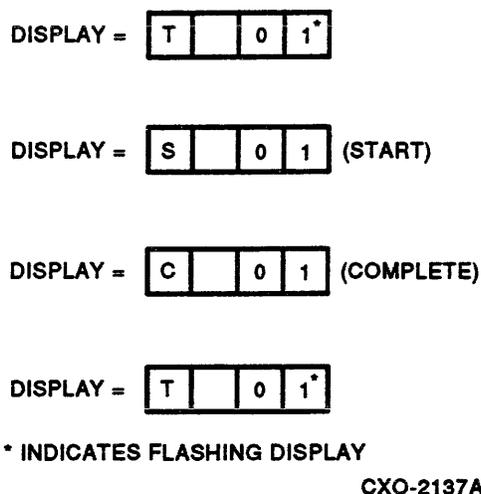


Figure 2-15 OCP Displays During Testing

Allow drive tests to run for 5 minutes before continuing acceptance testing. To halt testing, select the Test switch (Test LED extinguishes).

2.8.5 Testing Spun-Up Drive

To spin up the RA90 or RA92 disk drive, select the Run switch. The Run indicator lights and an [R...] appears in the display. Allow the drive to come to the ready state as indicated by the front panel Ready indicator.

If either of the ports (A/B) are selected when the drive reaches the ready state, deselect the port switches, then proceed as follows:

1. Select the Test switch. Test indicator lights.
2. Select the Write Protect switch. [T 00] is displayed.
3. Input [T 60] into display. This is a loop-on-test utility.
4. Start T60 by selecting the Write Protect switch a second time. [LOT] is displayed in the OCP.
5. Select the Write Protect switch.
6. Input [T 00] into the display.
7. Start T00 by selecting the Write Protect switch a second time.

The above steps invoke a sequence of resident-diagnostic tests. The tests check drive functions in the following areas:

- Processor
- Servo bus
- Positioner
- Head select
- Read/write circuitry
- Fault detection circuitry

Allow the tests to run for 30 minutes to complete acceptance testing, then select the Test switch to exit the test mode. The Test LED extinguishes, an [R...] appears in the display and the Ready and Run indicators light. Additionally, if either port switch is selected, it will be displayed after the unit address: [R AB].

If an error occurs during power-up or during the idle loop diagnostics, the drive attempts to display an error code. Table 2-1 lists error codes and required operator actions.

If no problems are encountered, place the drive on line.

NOTE

In an HSC cluster environment, you can duplicate system usage by running ILEXER for a few minutes; in a non-HSC environment, a successful operating system disk initialization and mount operation are sufficient for verifying subsystem operation.

2.9 Placing the Drive On Line

The following procedure assumes drive acceptance testing and cabling procedures have been completed. If not, refer to the appropriate sections of this manual for details.

2.9.1 Programming the Drive Unit Address

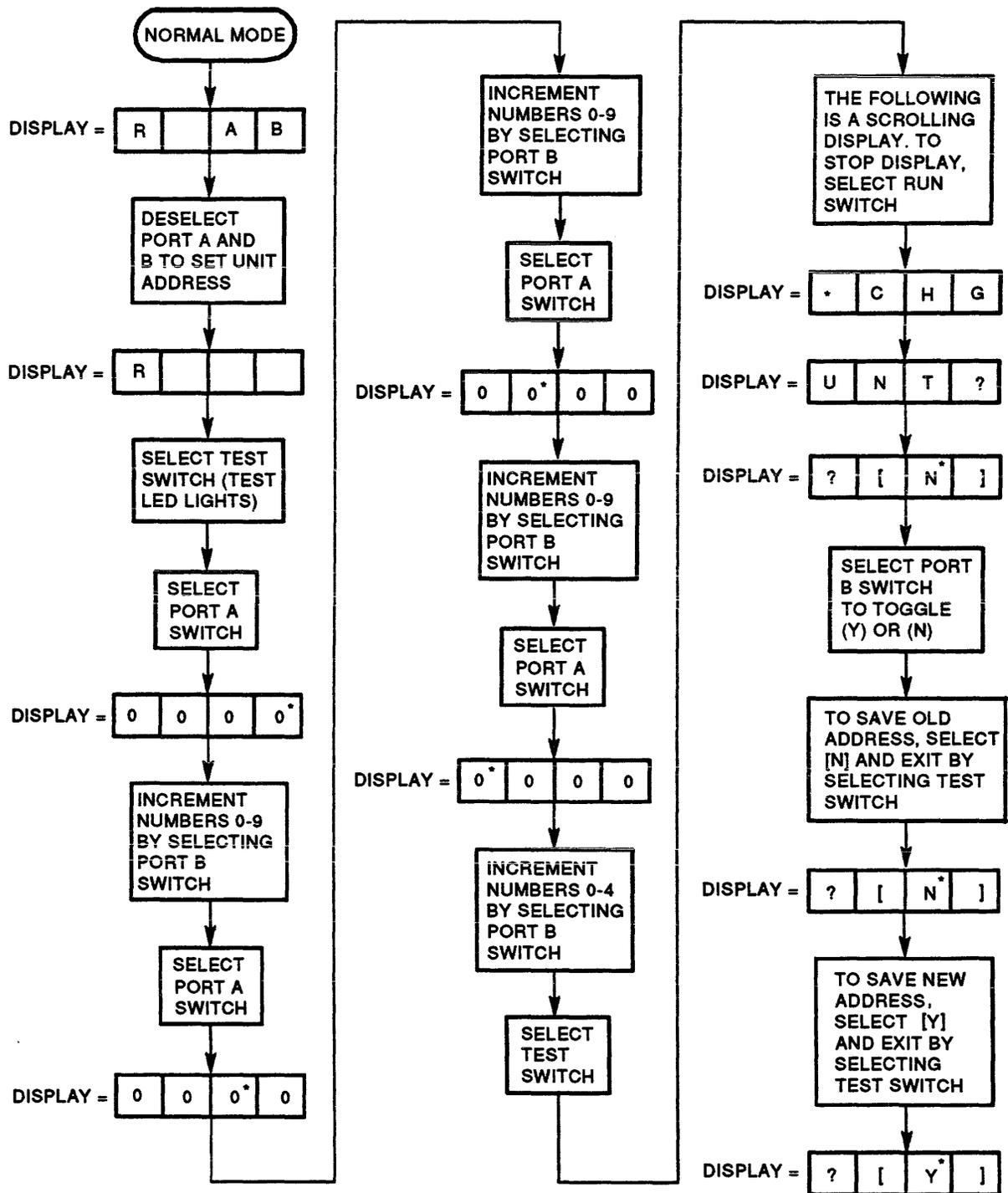
The unit address can be set once power has been applied to the drive. The unit address is programmable in the range of 0 to 4094. †

Enter the test mode to set the unit address. In the test mode, Port A and Port B switches have the added function of selecting both the unit address numbers and test numbers.

After applying power, follow this procedure to set the drive unit address. Figure 2-16 is a flowchart of this procedure.

1. Select the Test switch. The Test LED lights and zeros are displayed. (Something other than zeros may be displayed if the unit address has been previously programmed.)
2. Select the Port A switch for the ones position. Position zero will blink.
3. Select the Port B switch. Position zero will increment 1 through 9 for every time Port B is selected.
4. Select the Port A switch for the tens position. Position one will blink.
5. Select the Port B switch. Position one will increment 1 through 9 for every time Port B is selected.
6. Select the Port A switch for the hundreds position. Position two will blink.
7. Select the Port B switch. Position two will increment 1 through 9 for every time Port B is selected.
8. Select the Port A switch for the thousands position. Position three will blink.
9. Select the Port B switch. Position three will increment 1 through 4 for every time Port B is selected.
10. Select the Test switch to exit the unit selection function.

† The KDA50/UDA50/KDB50 support drive logical unit addresses only up to 255.



* INDICATES FLASHING READOUT

CXO-2138A

Figure 2-16 Unit Selection Flowchart

Before exiting, you will be prompted to verify that you want the unit number changed. The OCP displays the following prompt:

CHG UNT # {? [N]}

1. If you do not want to change the unit address, select the Test switch a second time.
2. To change the unit address, proceed as follows:
 - Toggle the Port B switch. **CHG UNT # {? [Y]}** displays.
 - Select the Test switch. The old unit address will be overwritten, and the new unit address will be displayed in the OCP.

NOTE

The unit address number is written to EEPROM and is not lost if the drive loses power.

2.10 Installing RA90/RA92 Add-On Disk Drives in 60-Inch Cabinets

Information for unpacking and installing RA90/RA92 add-on disk drives into 60-inch cabinets can be found in product-specific documentation. Refer to the preface, *About This Manual*, for a list of related documentation.

3

Operating Instructions

3.1 Introduction

This chapter describes each of the RA90 and RA92 disk drive components. Module compatibility tables are provided to explain the relationships between RA90 and RA92 disk drive hardware. Drive block diagrams are included to illustrate component relationships.

This chapter also explains various operating modes of RA90/RA92 disk drives, and covers drive unit address programming, test functions, and fault functions.

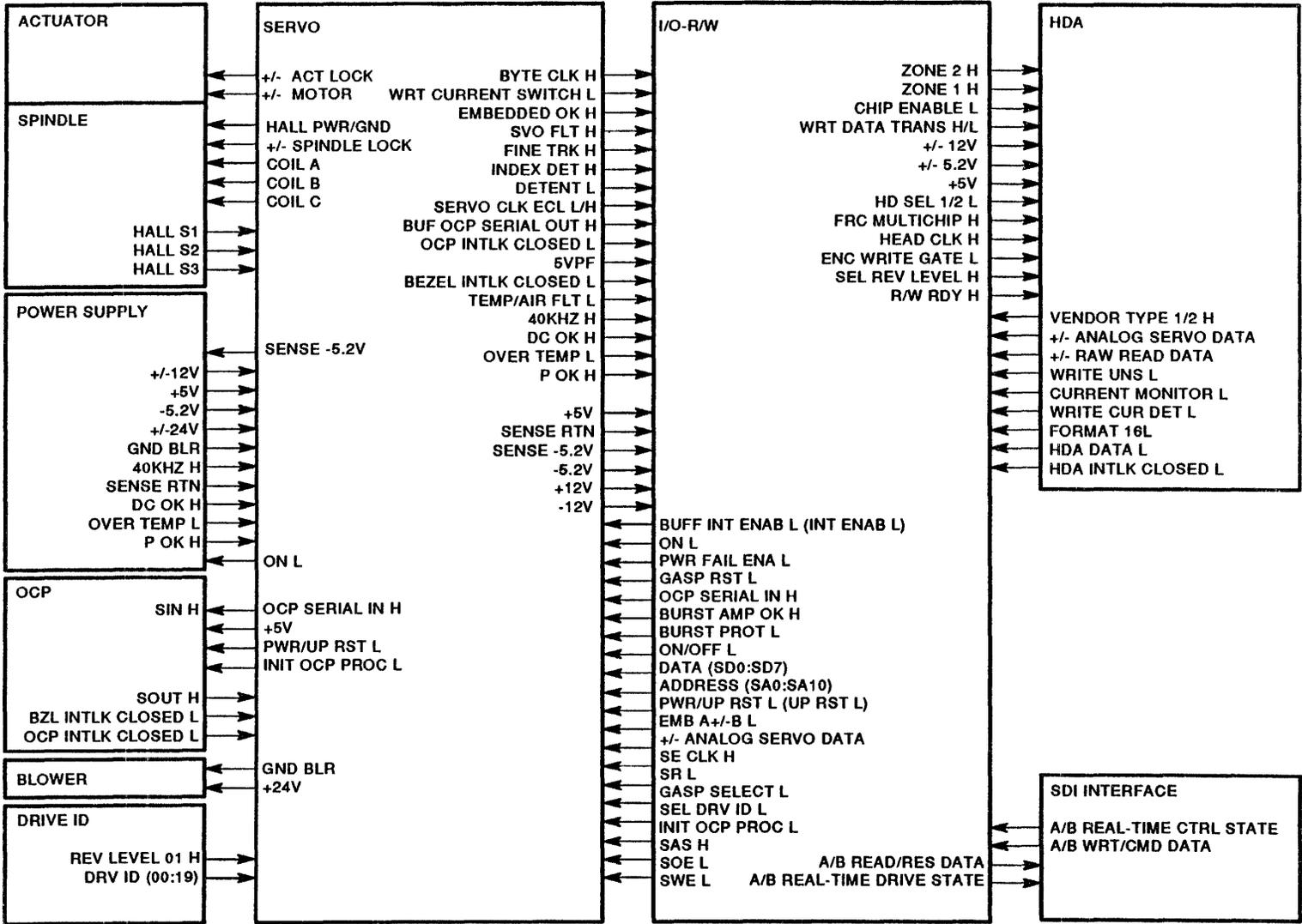
3.2 RA90/RA92 Disk Drive Components

The main components of RA90 and RA92 disk drives are:

- The electronic control module (ECM)
- The preamp control module (PCM)
- The blower motor assembly
- The head disk assembly (HDA)
- The drive power supply
- The operator control panel (OCP)

RA90/RA92 disk drives use three microprocessors to accomplish drive functions. The processors are the master (or I/O), the servo (or DSP), and the operator control panel (OCP) processor.

Figure 3-1 shows a simplified block diagram of RA90/RA92 disk drives.



CXO-2185A

Figure 3-1 RA90/RA92 Disk Drive Block Diagram

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3.2.1 Electronic Control Module (ECM)

The ECM field replaceable unit (FRU) consists of two modules back-to-back mounted on a slide carrier. One module contains the input/output-read/write (I/O-R/W) circuitry and is referred to as the I/O-R/W module. The second module contains the servo circuitry and is referred to as the servo module.

Each module has a set of four physical jumpers that are hard-wired at the factory. These jumpers are ECO-controlled and are used to mark the differences in functionality between the two hardware versions of the ECM modules. (These jumpers allow the microcode to display the correct hardware revision codes for the I/O-R/W and servo modules when running drive utility T45.)

The two 70-class ECM module set versions and related 54-class component part numbers are listed in Table 3-1.

Table 3-1 ECM Module Types — Compatibility Matrix

ECM P/N	I/O-R/W P/N	Servo P/N	Comments
70-22942-01 ¹	54-17771-01	54-17769-01	RA90 with HDA 70-22951-01 or 70-27268-01
70-22942-02 ¹	54-17771-02	54-17769-02	RA92-compatible

¹The ECM FRU is available as a 70-class part. The individual 54-class parts are not field/customer available due to repair and error log history strategies implemented by Digital.

The Digital circuit schematic (CS) revision alphanumeric marking on the ECM and its 54-class component modules does not reflect the microcode loaded into the non-volatile EEPROM as firmware code. This code is loaded in the field through the use of a microcode update cartridge. The microcode can then configure itself (enabled by the physical jumpers on the ECM modules) to assure the correct functionality of that particular ECM module.

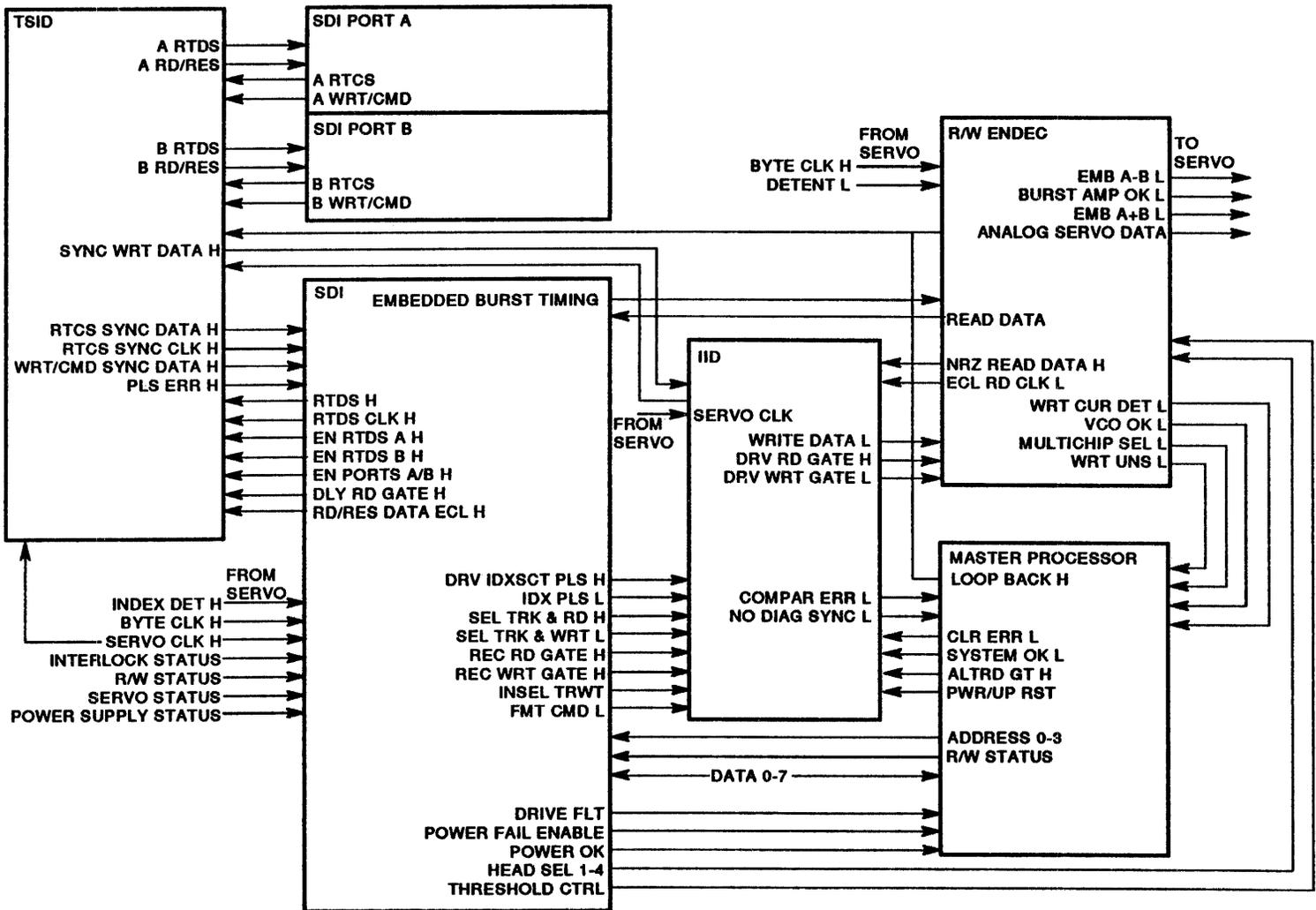
The functions of the I/O-R/W and servo modules are described in the sections that follow.

3.2.1.1 I/O-R/W Module

Functionally, the I/O-R/W module can be divided into three primary areas: SDI interface, control, and read/write. Figure 3-2 provides a block diagram of the I/O-R/W module.

The control circuitry on this module contains the following:

- MC6801 microprocessor (Master processor)
- Memory (ROM and RAM)
- Output control registers
- Input status registers



CXO-2186A

Figure 3-2 I/O-R/W Module Block Diagram

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The master microcode software controls drive functions through the control and status registers. Functional and diagnostic software for the master is stored in ROM, RAM, EEPROM and PROM memories. The master is the logic processor, and it controls and performs the following tasks:

- OCP communications
- Drive fault detection (including error recovery)
- Servo processor communications
- Functional servo microcode loading
- Standard disk interconnect (SDI) processing

The master processor controls the servo processor through the use of software. The servo processor's response to master processor commands is also accomplished through the use of software.

Upon power-up, the master processor (after self-testing the logic on the I/O-R/W) has the ability to test portions of the servo processor logic, including the servo processor RAM memory. After a successful test of the servo RAM, the master processor will execute a load of the functional servo microcode from the EEPROM located on the I/O-R/W module.

RA90/RA92 disk drives are equipped with special error recovery circuits which the master processor controls. If the drive receives error recovery commands from the disk controller, the master processor software activates combinations of error recovery signals. As a result, drive read/write and servo characteristics are altered in an attempt to recover drive data. Appendix B contains a more detailed description of the RA90/RA92 error recovery mechanisms.

The master processor retains the drive OCP switch state information and drive unit number in memory. This state information is saved into non-volatile EEPROM memory if a power loss is detected. Upon restoration of drive power, the original state of the drive can be resumed.

Functional microcode in the drive provides base level revision information concerning the I/O-R/W module. Drive utility T45 (refer to Chapter 4) displays a numeric number (decimal) code that translates to the module's hardware revision. The display format is [IOP=xx]. Table 3-2 presents the displayed codes and the corresponding module part numbers and revisions.

Table 3-2 I/O-R/W Module — Hardware Revision Matrix

T45 Displayed Revision IOP=xx	I/O-R/W Module Part Number	C/S Part Revision	Etch Revision	Compatibility
00	54-17771-01	Lx - Nx	E	RA90 only
01	54-17771-01	Rx - xx	F	RA90 only
03	54-17771-02	Ax -	F	RA92-compatible

3.2.1.2 Servo Module

Figure 3-3 is a simplified block diagram of the servo portion of the ECM module. The servo portion of the ECM uses a digital signal processor of the Texas Instruments TMS family. The digital signal processor is called the servo processor (or sometimes the DSP processor).

The servo processor communicates with the master processor and does the following:

- Obtains embedded servo information from the I/O-R/W module for offset calibration of the read/write heads.
- Obtains dedicated servo information for positioning the read/write heads.

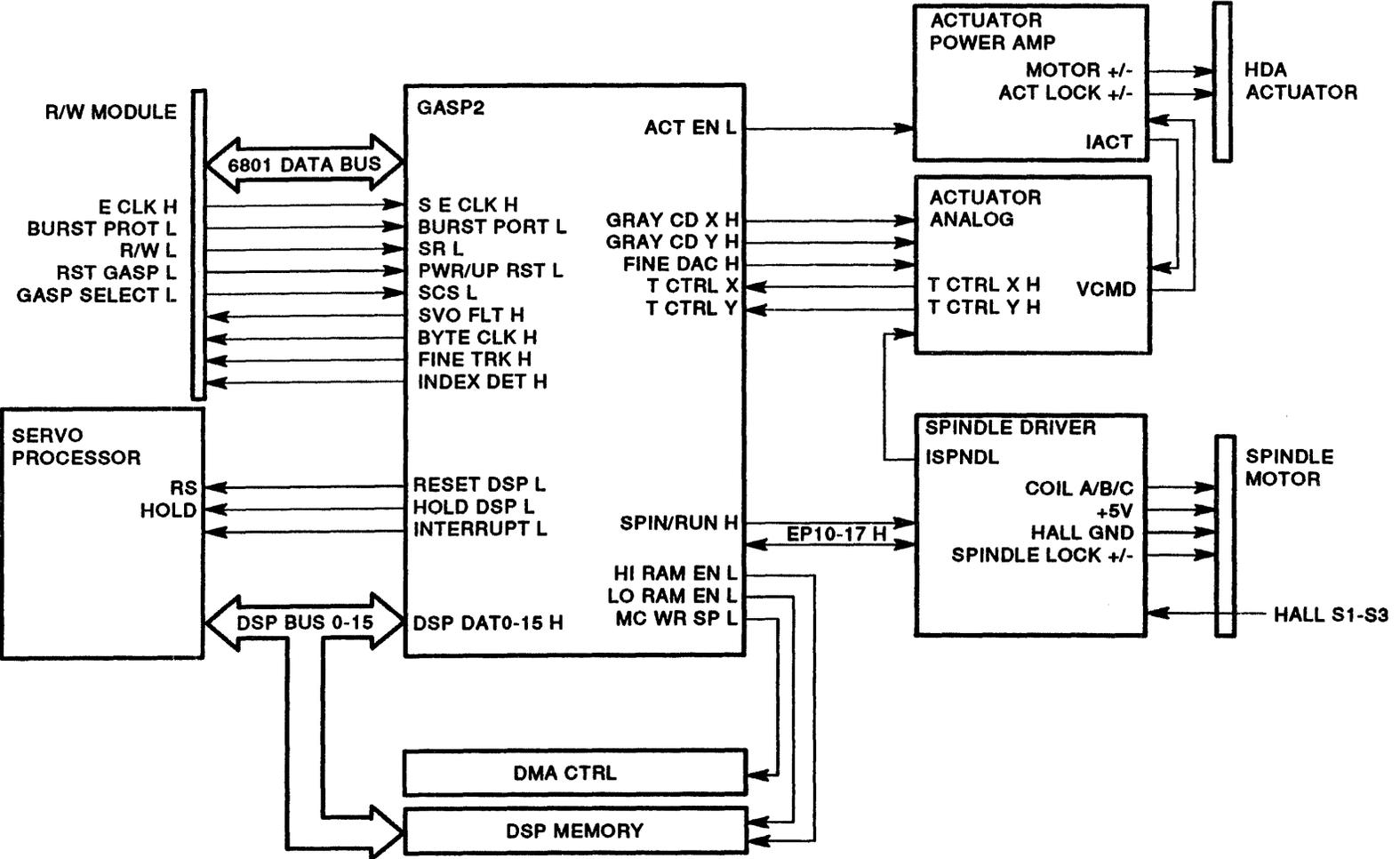


Figure 3-3 Servo Module Block Diagram

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CXO-2187A

- Controls spindle motor spin-up and spin-down operations.
- Monitors HDA spindle speed and servo positioning (including errors).
- Controls servo-related internal diagnostics.

Additionally, the servo processor controls the following:

- Retract (moving heads off data surface)
- Return to zero (RTZ)
- Fine track (keeping heads on track centerline)
- Seeks

Functional microcode in the drive provides base level revision information concerning the servo module. Drive utility T45 (refer to Chapter 4) displays a numeric number (decimal) code that translates to the module's hardware revision. The display format is [SRV=xx]. Table 3-3 presents the displayed codes and the corresponding module part numbers and revisions.

Table 3-3 Servo Module — Hardware Revision Matrix

T45 Displayed Revision SRV=xx	Servo Module Part Number	C/S Part Revision	Etch Revision	Compatibility
00	54-17769-01	Ax - Nx	E	RA90 only
01	54-17769-01	Px - xx	F	RA90 only
03	54-17769-02	Ax -	F	RA92-compatible

3.2.2 Preamp Control Module (PCM)

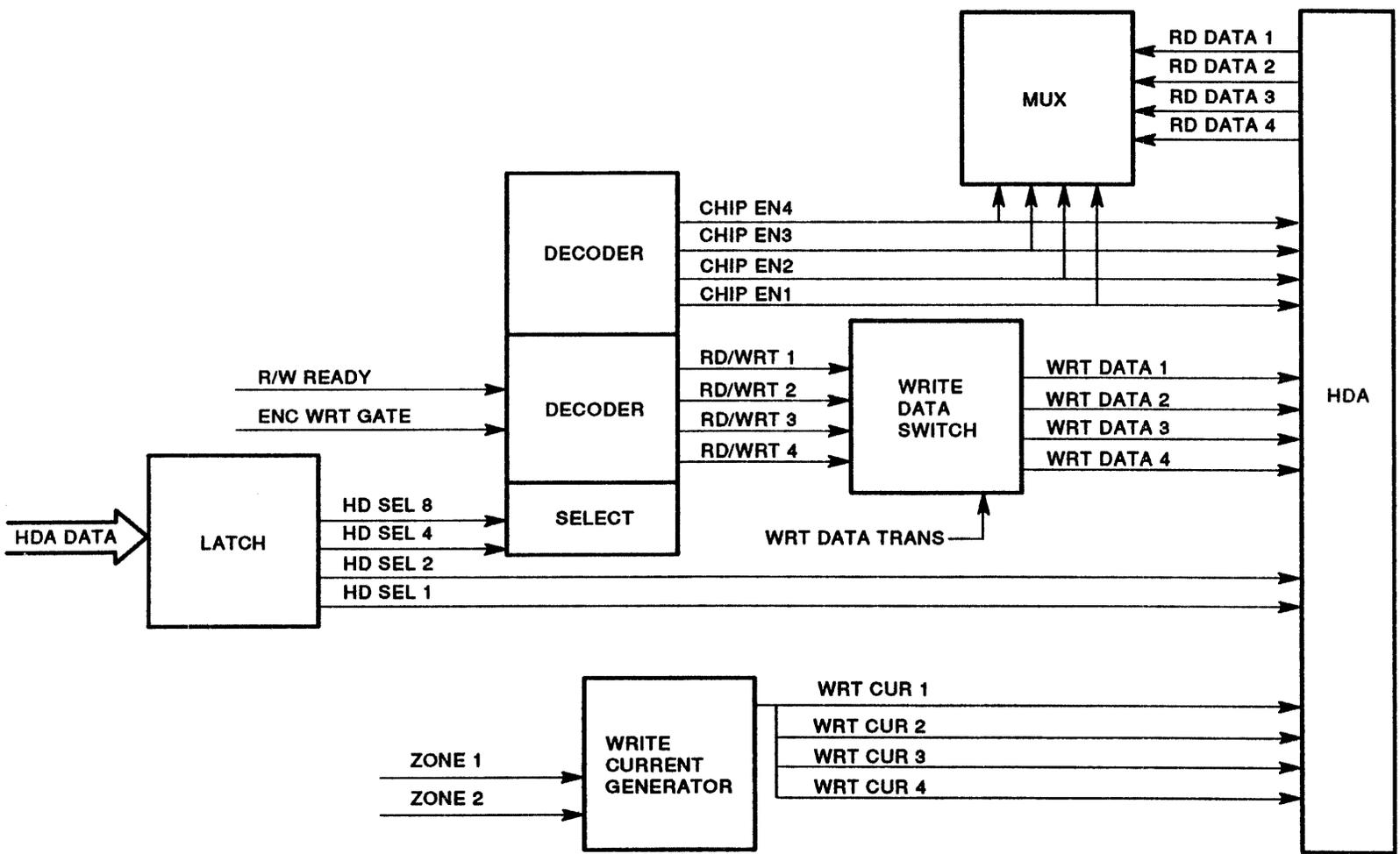
The PCM FRU is part of the HDA/carrier assembly which is also an FRU. Figure 3-4 is a simplified block diagram of the PCM.

The PCM performs the following operations:

- Decodes head select signals sent from the master to select the appropriate read/write head matrix chips (located inside the HDA), and the appropriate output from each matrix chip.
- Monitors unsafe read/write conditions.
- Provides differential write pulses to the preamplifiers.
- Passes through the HDA vendor type bits from the HDA to the master processor.
- Passes the type of format bits from the PCM switch pack to the master processor.

Two different PCM modules exist in the RA90/RA92 disk drive family. The two PCM types are electrically incompatible in the interconnect between the PCM and the internal HDA electronics. However, the PCMs are functionally compatible between the PCM and internal HDA and the ECM variants that may be attached. A physical mechanism prevents the use of an incompatible PCM with an HDA.

Table 3-4 describes the PCM switch pack settings with regard to the type of PCM, HDA, and RA9x model.



CXO-2188A

Figure 3-4 PCM Block Diagram

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Table 3-4 PCM Switch Pack Setup

PCM P/N	HDA P/N	PCM SW Pack Settings*				Comments
		S1-1	S1-2	S1-3	S1-4	
54-17758-01	70-22951-01	0	0	0	0	RA90 long arm only
54-19724-01 ¹	70-27268-01	0	1	0	1	RA90 short arm
54-19724-01 ¹	70-27492-01	1	0	0	1	RA92 only
54-19724-01 ¹	70-27492-01	0	0	0	1	Incompatible setup ²
54-19724-01 ¹	70-27492-01	1	1	0	1	Incompatible setup ²
54-19724-01 ¹	70-27268-01	0	0	0	1	Incompatible setup ²
54-19724-01 ¹	70-27268-01	1	1	0	1	Incompatible setup ²

*0 = ON = CLOSED, 1 = OFF = OPEN

¹PCM spares shipped from logistics are configured by default to declare an incompatible situation. This forces the field person to properly configure the replacement PCM to indicate the proper HDA format type. The drive microcode uses the switch setting information to properly configure servo operations.

²Drive LED error code C0 signifies that the microcode has determined an incompatible situation between the hardware and/or microcode components of the drive configuration, or a hardware failure has caused the drive to believe the configuration is improper.

Functional microcode in the drive provides base level revision information concerning the PCM module. Drive utility T45 (refer to Chapter 4) displays a numeric number (decimal) code that translates to the module's hardware revision. The display format is [PCM=xx].

Table 3-5 presents the displayed codes and the corresponding module part numbers and revisions.

Table 3-5 PCM Module — Hardware Revision Matrix

T45 Displayed Revision PCM=xx ¹	PCM Module Part Number	C/S Part Revision	Etch Revision	Compatibility
00	54-17758-01 ²	Ex - Hx	E	HDA 70-22951-01 only
01	54-19724-01 ²	Ax -	A	HDA 70-27268-01 and 70-27492-01

¹Switch position S1-3 and S1-4 of Switch Pack S1 determine the displayed PCM hardware revision.

²These modules have a mechanical interlock that prevents the inadvertent mating of electrically incompatible PCMs to the HDA.

There is a four-position switch pack on the PCM. Switch pack switches S1-3 and S1-4 determine the PCM hardware revision (not CS revision) through OCP display T45. Switches S1-1 and S1-2 are used to tell the drive functional microcode the format type written on the HDA. There are two planned format types — RA90-compatible and RA92-compatible.

A new HDA/carrier assembly FRU should have the switch pack set correctly by the manufacturing plant. If the PCM is defective, set the switch pack switches appropriately. Figure 3-5 shows the location of the switch pack on the PCM.

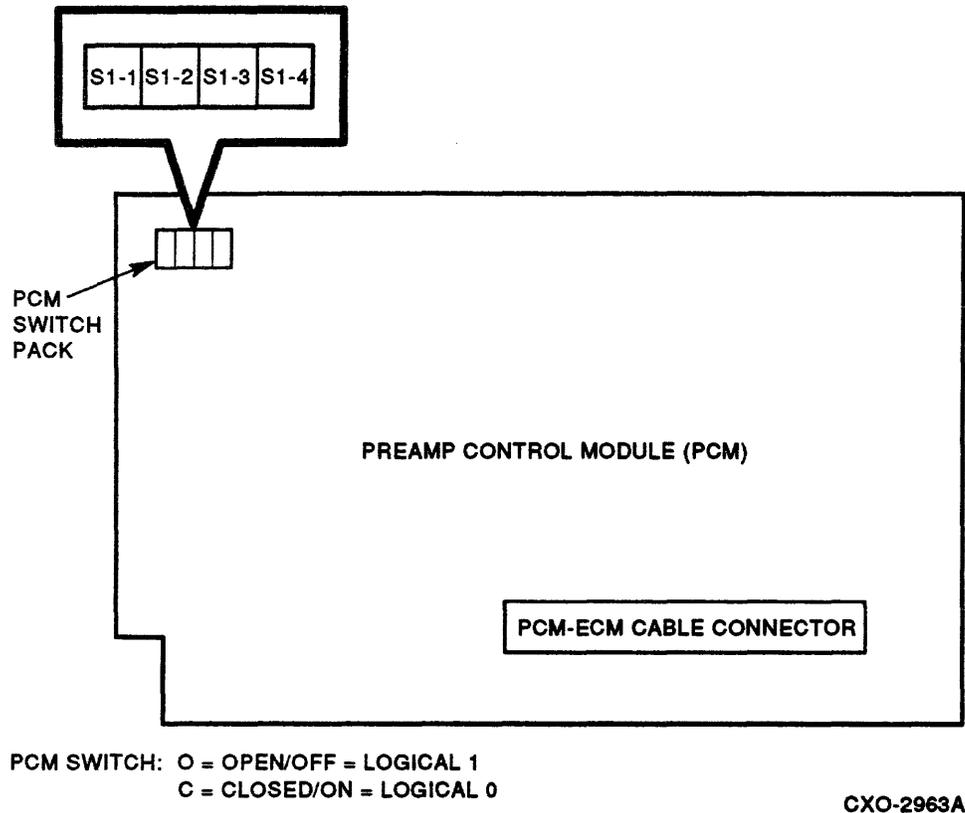


Figure 3-5 PCM Switch Pack Location

3.2.3 Head Disk Assembly and Carrier Assembly

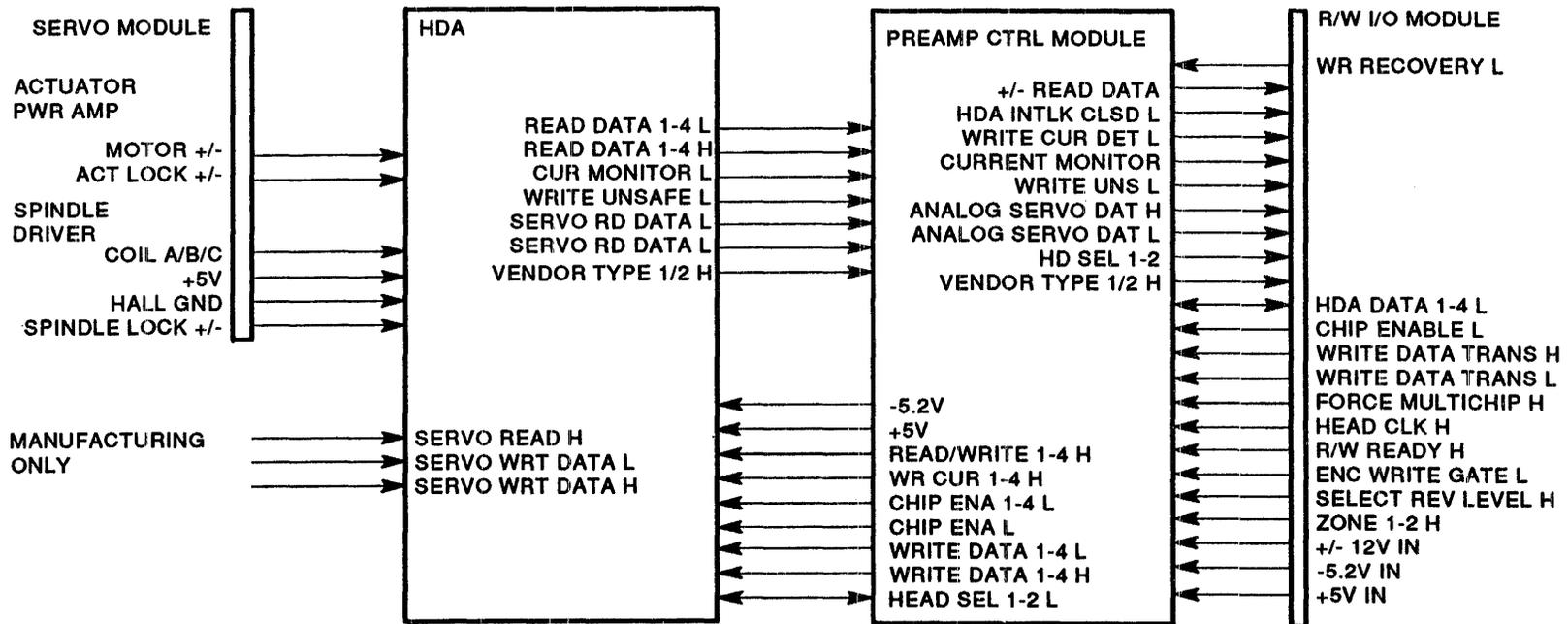
Figure 3-6 is a simplified block diagram of the RA90/RA92 head disk assembly (HDA) and its relationship to the rest of the drive.

The HDA consists of the following components:

- The spindle motor, spindle, and recording media
- The actuator motor to position the read/write heads
- The Hall sensors to monitor spindle speed
- The preamp/select chips
- The brake assembly
- The ground brush
- The positioner lock mechanism

Currently, there are three different HDAs in the RA9x disk drive products family. Two different PCMs are available for these three HDAs. Table 3-6 is a compatibility matrix for HDA types, PCM types, and RA9x models.

Figure 3-6 HDA Block Diagram



CXO-2189A

Table 3-6 RA90/RA92 HDA Hardware Compatibility Matrix

HDA P/N and Type	RA90 70-23899-01 ¹	RA90 70-23899-02,	RA92 7027490-01	PCM P/N
70-22951-01, Long-arm RA90 HDA	Original*	Compatible	Incompatible	54-17758-01
70-27268-01, Short-arm RA90 HDA	Compatible	Original*	Incompatible	54-19724-01 ²
70-27492-01, Short-arm RA92 HDA	Incompatible	Incompatible	Original*	54-19724-01 ²

*Original = HDA type original to drive

¹The RA90 disk drive was originally made from the base drive part number 70-23899-01. With the introduction of the short-arm HDA, the variant of the base part number for the RA90 disk drive was changed. The size and SDI disk topology of the 70-23899-01 and 70-23899-02 variant RA90 disk drives are *identical*. There is not a duplication of drive serial numbers between the 70-class numbers. Architecturally, the drives are *identical*. At the HDA FRU level, the short-arm HDA is electrically compatible with the original long-arm HDA. However, microcode compatibility issues must be watched.

²The PCM switch pack must be set to indicate the type of HDA.

3.2.4 Dual Outlet Blower Motor

The blower motor assembly provides drive cooling. In addition, the blower motor contains speed control circuitry to activate higher throughput if the ambient air temperature exceeds 23°C (75°F). If the drive is operating without problems at or below this temperature, blower speed is reduced for better acoustic levels.

3.2.5 Power Supply

The power supply provides the following voltages to RA90/RA92 disk drives:

- ±12 Vdc
- ±5.1 Vdc
- ±24 Vdc
- -5.2 Vdc

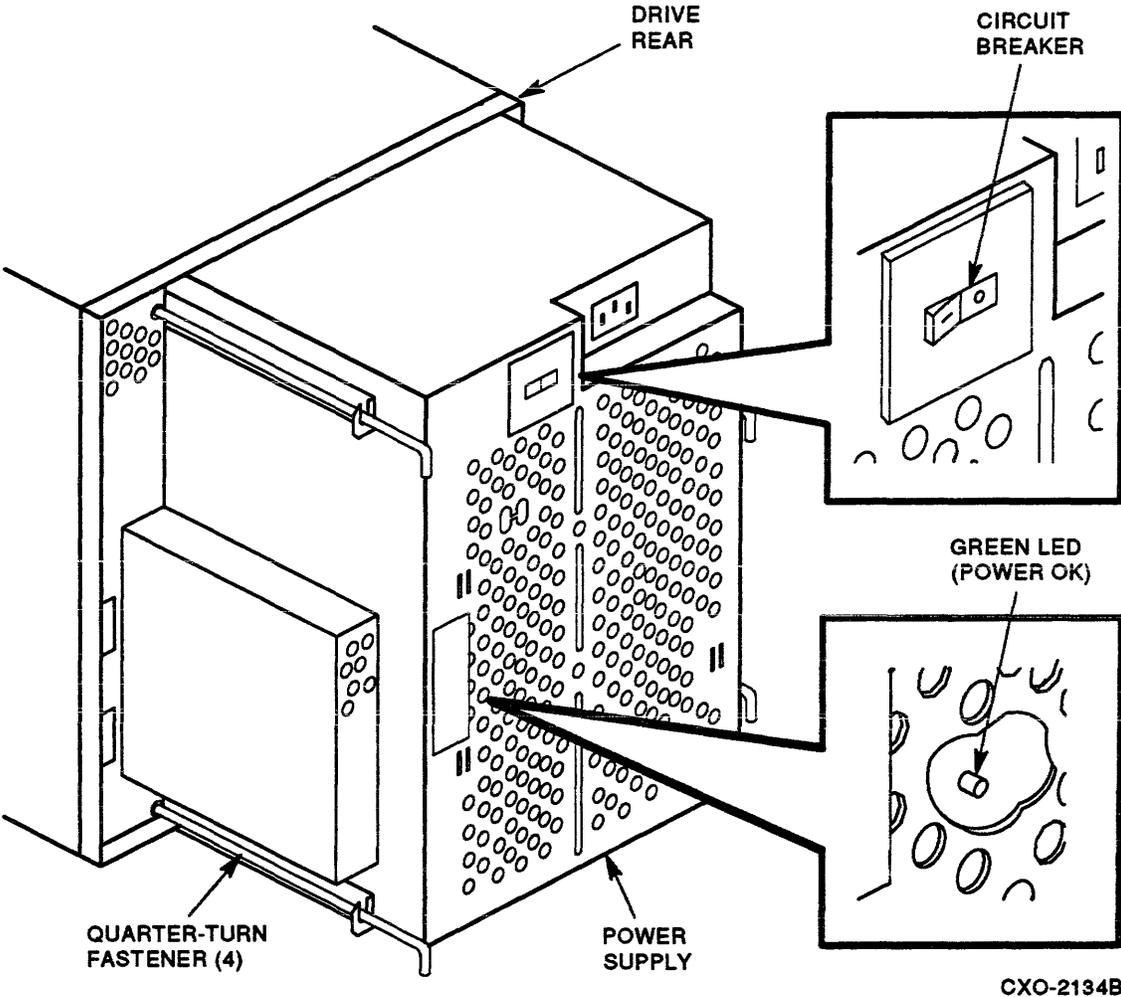
Normal power supply operation is indicated by the presence of a green Power OK LED located at the rear of the drive. Refer to Figure 3-7 for the location of the Power OK LED.

The power supply operates on any line frequency within the range of 47 HZ to 63 HZ. It is switch-selectable to either of two ranges: 120 Vac or 240 Vac.

CAUTION

If a unit has its voltage selector switch in the 120 Vac position and is plugged into 240 Vac, the power supply will be damaged.

If a unit has its voltage selector switch in the 240 Vac position and is plugged into 120 Vac, it may work, but would be very sensitive to low line voltage.



CXO-2134B

Figure 3-7 Power Supply OK LED

This power supply has two vendors, designated Vendor A and Vendor B. Power supplies from Vendor A have a serial number with a CX site code. Power supplies from Vendor B have a serial number with a KB site code. (Voltage markings on some power supplies may read 115/230 Vac.) The power supplies from both vendors are functionally identical and carry the same Digital part number.

3.2.6 Drive Functional Microcode

The drive functional microcode can be field loaded and upgraded using the OCP microcode update port. ROM-based utility programs contained on the ECM module (I/O-R/W) allow microcode loading.

Table 3-7 is a compatibility matrix for microcode cartridges, microcode levels, and ECM and HDA FRUs.

Table 3-7 RA90/RA92 Microcode Compatibility With Drive FRUs

Microcode Cart. P/N and Rev	Micro- code Level	ECM FRU		HDA FRU		
		P/N 70-22942-01	P/N 70-22942-02	P/N 70-22951-01	P/N 70-27268-01	P/N 70-27492-01
70-24432-02 A1	8	Yes	No ¹	Yes	No	No
70-24432-02 A1	9	Yes	No ¹	Yes	No	No
70-24432-02 B1	10	Yes	No ¹	Yes	No	No
70-24432-02 C1	11	Yes	No ²	Yes	No	No
70-24432-02 D1	13	Yes	No ²	Yes	No	No
70-27950-01 A1	20	Yes	Yes	No	Yes	Yes
70-27950-01 B1	25	Yes	Yes	Yes	Yes	Yes

¹Results in LED Code 13

²Results in LED Code E2

NOTE

Microcode compatible with an ECM FRU means the code can be loaded into the ECM FRU without error and will function, provided there is a compatible HDA with the appropriate PCM and PCM switch settings are correct. (This does not apply to Hard faults, because the microcode cannot be loaded into the ECM.)

Microcode compatible with an HDA FRU, means that the code (when loaded into a compatible ECM) will support the HDA identified in Table 3-7.

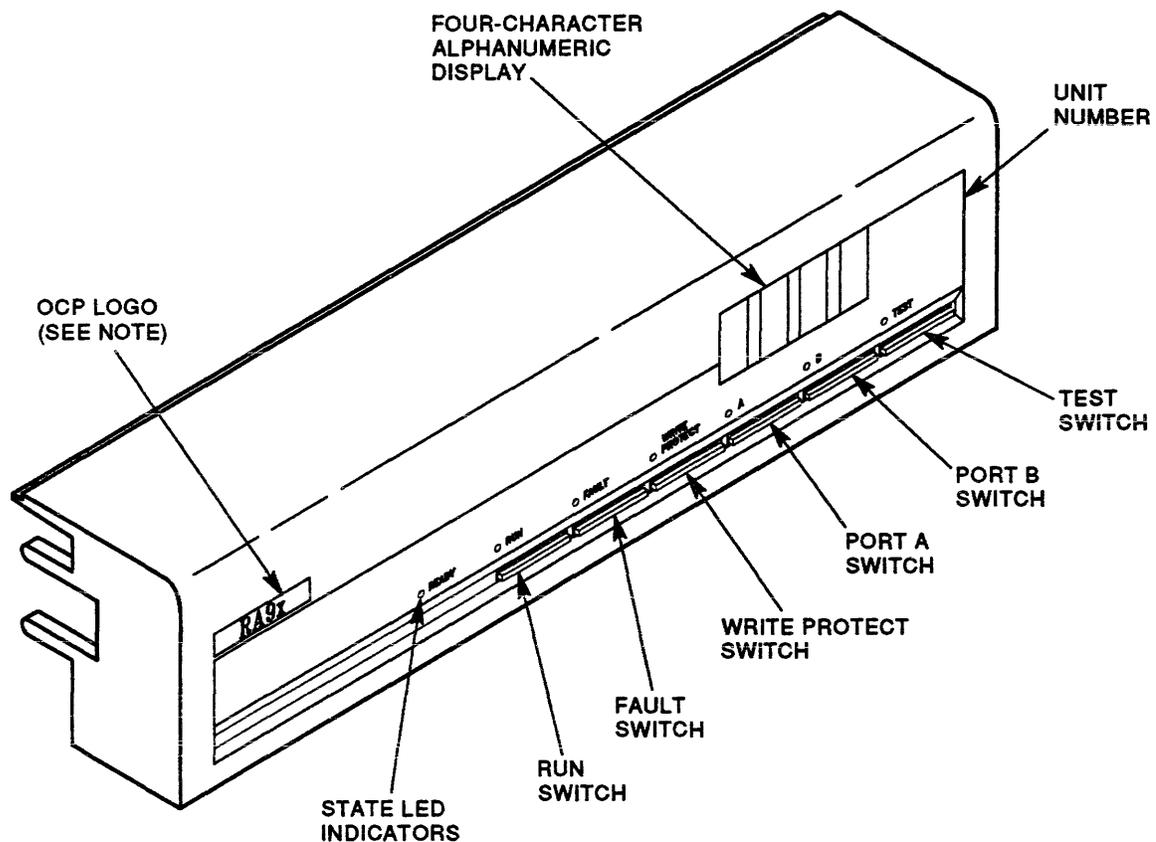
To determine *total* compatibility, you must verify the following:

- Code compatibility to ECM (Table 3-7)
- Code compatibility to HDA (Table 3-7)
- ECM compatibility to HDA (Table 3-1)
- PCM and HDA compatibility (Table 3-4)
- PCM switch pack setup (Table 3-4)

3.2.7 OCP Functions

The operator control panel (OCP) shown in Figure 3-8 functions as the interface to the RA90/RA92 disk drive. The OCP performs the following functions:

- Selects and displays the unit address.
- Selects Run, Write Protect, Port A, and Port B.
- Displays fault indication and error codes.
- Selects tests in the test mode.
- Controls the drive software update process.
- Communicates with the RA90/RA92 master processor.
- Monitors momentary contact switches for closure.



NOTE: RA90 PART NO. 74-35109-02
RA92 PART NO. 74-39769-01

CXO-2962A

Figure 3-8 RA90/RA92 OCP

To execute or select these functions, you must be familiar with the following OCP features (refer to Figure 3-8):

- Six input switches (Run, Fault, Write Protect, Port A, Port B, and Test).
- Seven LED indicators (Ready, Run, Fault, Write Protect, Port A, Port B, and Test).
- A four-character alphanumeric display.
- A software update port (refer to Chapter 7).

3.3 RA90/RA92 Operating Modes

RA90/RA92 disk drives operate in three setup modes: normal, fault display, and test. The following sections describe the function of each of these modes.

3.3.1 Normal Mode Setup

The normal mode setup is the usual operating mode of the RA90 and RA92 disk drives. Switch selection during normal operation usually consists of the Run switch, Write Protect switch (for normal write protection), and Port A or Port B switch. No Fault or Test indicators are lit. The switch states are displayed in the alphanumeric display, and the state of the drive relative to the controller is displayed in the LED indicators.

In the normal operating mode:

1. Selecting the Run switch causes an **R** to appear in the OCP display and causes the drive to spin up. Additionally, the Run LED indicator lights. The Ready LED indicator lights once the drive is up to speed.
2. Selecting the Port A or Port B switch causes an **A** or **B** to appear in the OCP display and logically makes the drive available to the controller.
3. Selecting the Write Protect switch logically write protects the drive and lights the Write Protect LED indicator.
4. Selecting the Fault switch:
 - (Without a fault indicator) causes a 2-second OCP lamp test.
 - (With a fault indicator) causes an error code to display. Selecting the Fault switch a second time (with a fault indicator) clears the fault. (Refer to Section 3.3.2.)
5. Selecting the Test switch:
 - (With the Port A or Port B switch selected) causes a 2-second display of the unit address. (Refer to Section 3.4.1 for information on the alternate unit address display mode.)
 - (Without the Port A or Port B switch selected) causes the drive to enter the test mode. (At this time the Ready LED is extinguished.)

Table 3-8 details operator actions and the result of OCP switch selection(s) in the normal mode. Power-up OCP functions and normal switch selection functions are covered.

Table 3-8 Power-Up: Normal Mode Operations

Operator Action	OCP Result	Drive Function
<Power-up>	[WAIT]	Drive is running power-up diagnostics
Default	[0000]	Unit number displayed may be something other than zero
<RUN>	[R...]	Spinup command issued to spindle
<A>	[R.A.]	Port A is enabled
	[R.AB]	Port B is enabled

3.3.2 Fault Display Mode Setup

The fault display mode can only be entered if the Fault indicator is lit; otherwise, selecting the Fault switch causes a 2-second OCP lamp test.

To enter the fault display mode, select the Fault switch. An error code is displayed in the format shown in Figure 3-9. To exit the fault display mode and clear the fault, select the Fault switch a second time.

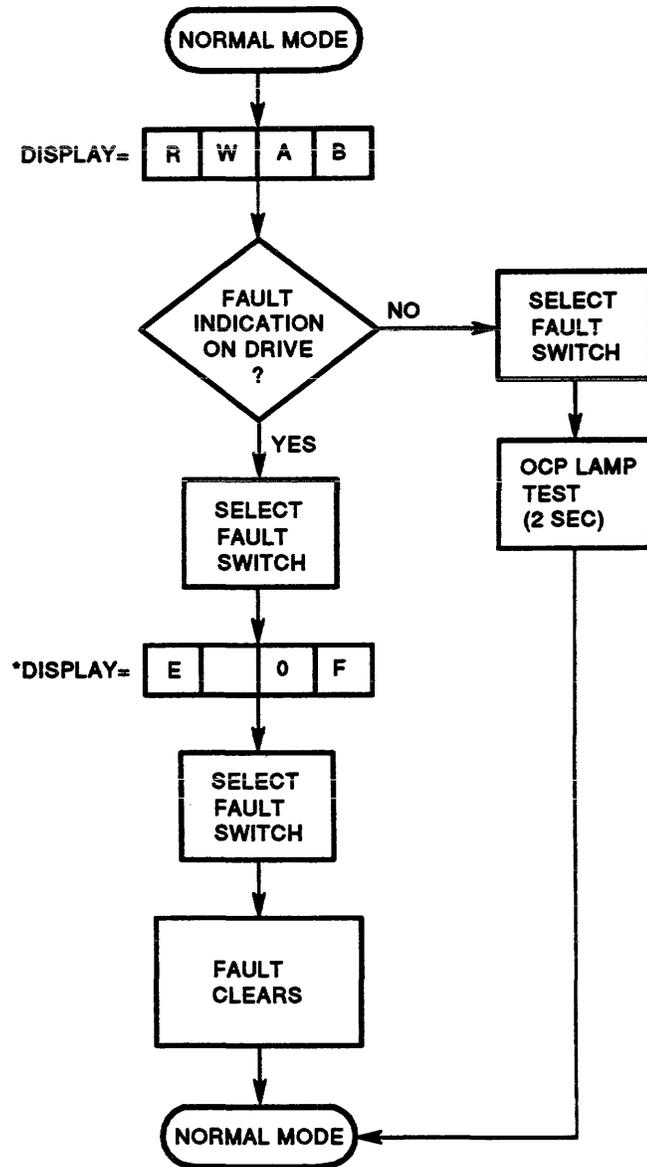
NOTE

Hard faults will not clear.

Figure 3-9 shows a characteristic alphanumeric fault display error code. Figure 3-10 is a fault display mode flowchart.



Figure 3-9 OCP Fault Display Error Code Example



*NOTE: ANY COMBINATION OF LEGAL ALPHANUMERIC ERROR CODES (HEX).

CXO-2191B

Figure 3-10 Fault Display Mode Flowchart

3.3.3 Test Mode Setup

You must enter the test mode to set the RA90 or RA92 disk drive unit address or to run resident diagnostic tests. In this mode, Port A and Port B switches have the function of selecting both the unit address numbers and test numbers. In addition, the port switches are used to abort running diagnostics. The Write Protect switch starts the tests and the Port A or Port B switch stops selected tests.

The test mode is characterized by three displays. Figure 3-11 shows an OCP after test selection is made. Figure 3-12 shows a display while the test is running.

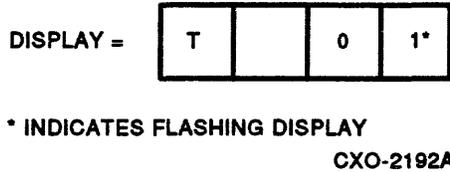


Figure 3-11 OCP Display After Test Selection

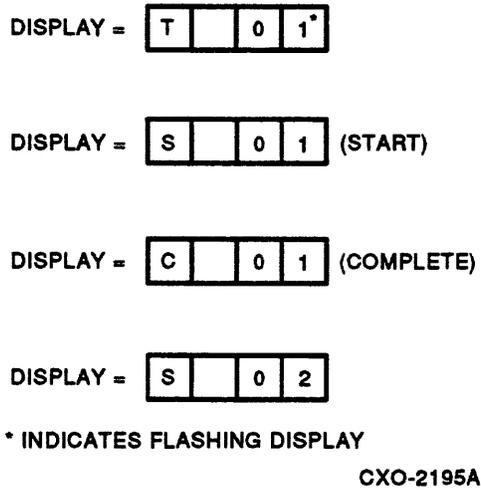


Figure 3-12 OCP Display While Running Test

3.4 Programming the Drive Unit Address

The unit address can be set once power has been applied to the drive. You must set the drive unit address before placing the drive on line.

The RA90 or RA92 unit address is programmable from 0 to 4094. (Note that the operating system or subsystem type can limit the unit address range.)

Use the following procedure to set the drive unit address. (Refer to Figure 3-13 for a flowchart of this procedure.)

1. Select the Test switch. (The Test LED indicator lights and a unit address (if previously programmed) is displayed; otherwise, zeros are displayed.)
2. Select the Port A switch for the ones position. (Position zero blinks.)
3. Select the Port B switch. (Position zero increments 1 through 9 every time Port B is selected.)
4. Select the Port A switch for the tens position. (Position one blinks.)
5. Select the Port B switch. (Position one increments 1 through 9 every time Port B is selected.)
6. Select the Port A switch for the hundreds position. (Position two blinks.)
7. Select the Port B switch. (Position two increments 1 through 9 every time Port B is selected.)
8. Select the Port A switch for the thousands position. (Position three blinks.)
9. Select the Port B switch. (Position three increments 1 through 4 every time Port B is selected.)
10. Select the Test switch to exit.

At this point, the OCP prompts you to verify that you want to change the unit address. The following prompt scrolls through the OCP display:

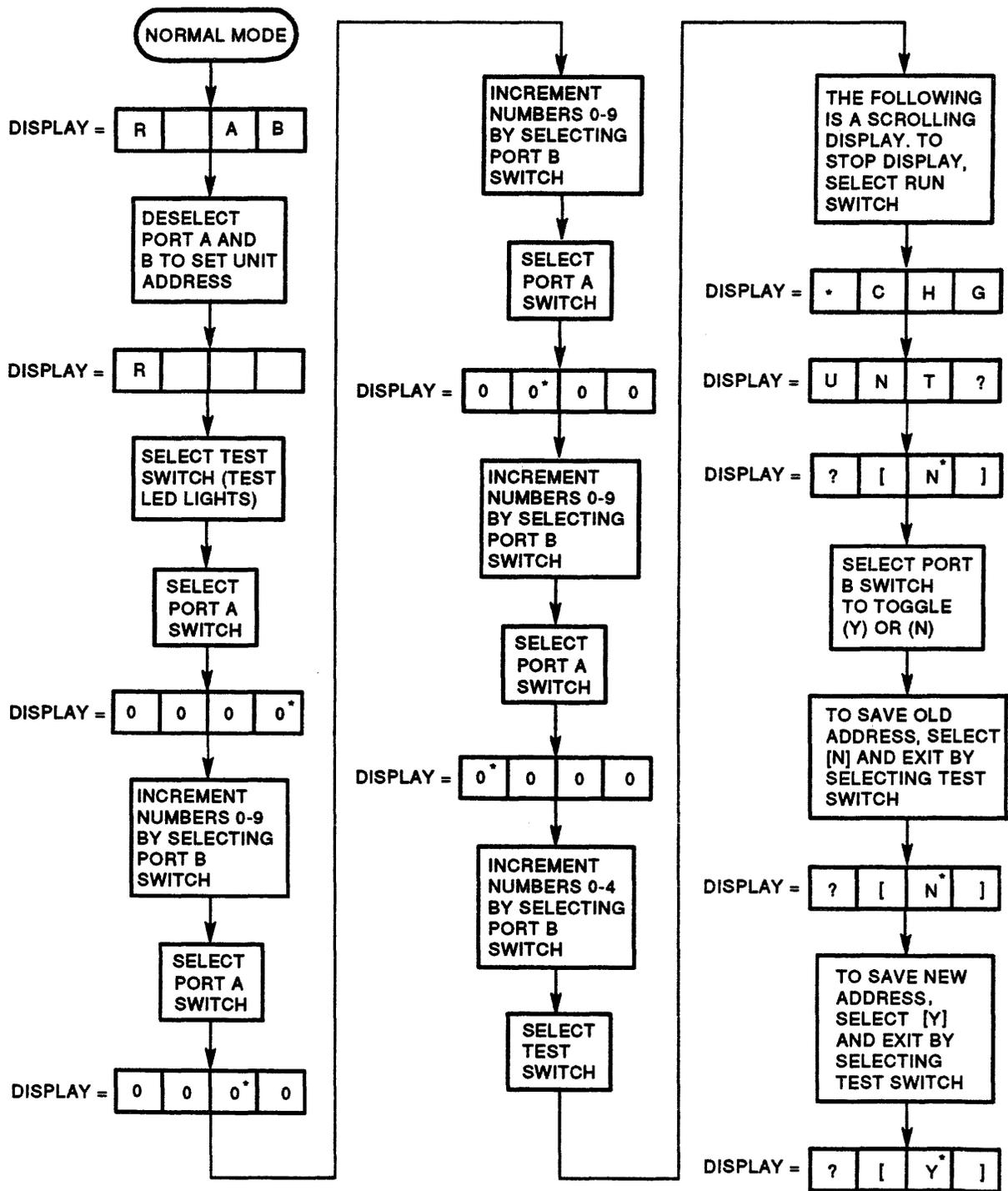
CHG UNT # {? [N]}

- If you do not want to change the unit address, select the Test switch a second time. The drive returns to normal mode.
- To change the unit address:
 1. Toggle the Port B switch. **CHG UNT # {? [Y]}** displays.
 2. Select the Test switch.

The old unit address is overwritten with the new address. The new unit address is displayed in the OCP.

NOTE

The new unit address is written to EEPROM and is not lost if the drive loses power.



* INDICATES FLASHING READOUT

CXO-2138A

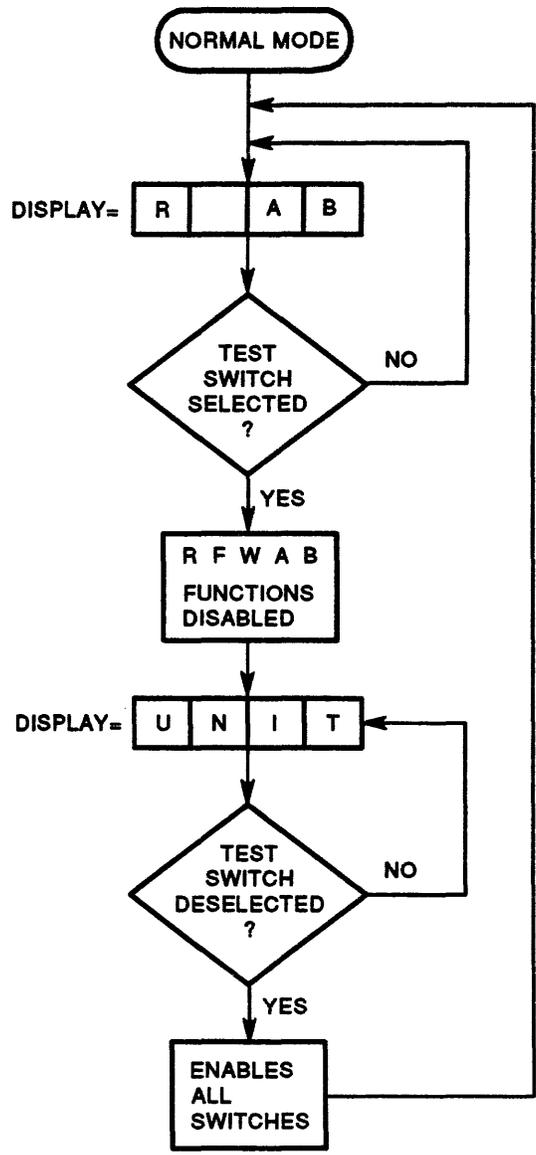
Figure 3-13 Unit Address Selection Flowchart

3.4.1 Alternate Unit Address Display Mode

Future RA90 and RA92 disk drives will incorporate a microcode enhancement that will provide an alternate unit address display mode. To display the unit address, refer to Figure 3-14 while performing the following procedure:

1. The OCP display shows an R, A, and/or B.
2. While in normal mode, select the Port A and/or Port B switch.
3. Select the Test switch. At this point, the Run, Fault, Write Protect, Port A, and Port B switches are disabled.
4. The unit address is displayed until:
 - The Test switch is deselected.
 - Power is cycled.
 - An SDI HARD INIT occurs, or the drive forces a hard initialization due to a fatal error.

Any of these conditions will clear the OCP from the alternate display mode.



CXO-2958A

Figure 3-14 Alternate Unit Address Display Mode Flowchart

Drive-Resident Diagnostics and Utilities

4.1 Introduction

This chapter describes drive-resident diagnostic fault detection, power-up and idle loop diagnostic routines, and sequenced or chained diagnostics. The RA90/RA92 drive-resident diagnostics and utilities are described individually. These drive-resident diagnostics test for and detect errors in the following field replaceable units (FRUs):

- Electronic Control Module (ECM) (input/output-read/write (I/O-R/W) and servo modules)
- Preamp Control Module (PCM)
- Head Disk Assembly (HDA)

4.2 Power-Up and Idle Loop Diagnostics

Resident diagnostics execute any time the drive is powered up or the master processor is reset. Additionally, diagnostic routines execute during idle loop with the drive spun up or down. The Test LED, when lit, indicates the drive is in idle loop testing.

The following sections describe power-up (reset) and idle loop diagnostic sequences.

4.2.1 Power-Up (Hardcore) Diagnostics

The following hardcore tests are run at power-up or upon reset of the master processor (refer to Section 4.7 for a description of each test):

- Master CPU test (POR)
- Master ROM test (T01)
- Master RAM test (POR)
- Master timer test (T02)
- Serial communication test (SCI) (POR)
- Servo data bus loopback test (T03)
- Servo RAM test (POR)

4.2.2 Idle Loop Tests (Drive Spun Down)

Idle loop is defined as the drive being off line to the controller. The following sequence is executed every 30 seconds during idle loop (refer to Section 4.7 for a description of each test):

- Master ROM test (T01)
- Master timer test (T02)
- Servo data bus loopback test (T03)
- Head select test (T06)
- Sector/byte counter test (T07)
- SDI loopback test (internal) (T08)

4.2.3 Idle Loop Tests (Drive Spun Up)

The following tests are run during idle loop with the drive spun up (refer to Section 4.7 for a description of each test):

- Master ROM test (T01)
- Master timer test (POR)
- Servo data bus loopback test (T03)
- Head select test (T06)
- Gray code (track counter) test (T29)
- Guardband test (T30)
- Incremental seek test (quick verify mode) (T31)
- Random seek test (quick verify mode) (T33)

4.3 Sequence Diagnostics

A number of tests are sequenced together to form a chain of tests. The test [chain] numbers and the individual test numbers that make up the chain are listed here. An example of the information seen in the OCP alphanumeric display is also included. Refer to Section 4.7 for a description of each test.

- T00 and T23 are the same when the drive is spun down, and include:

T01
T02
T03
T06
T07
T08
Duration: 12 seconds

- T00 and T22 are the same when the drive is spun up, and include:

T01
T02
T03
T06
T29
T30
T31
T33

T14
T15
T16

Duration: 7:10 minutes

The following is an example of the information seen in the alphanumeric display as the drive sequences through a chain:

1. [T 00] Enter test T00 from the OCP front panel.
 2. [S 00] Start T00.
 3. [S 01] T01 starts.
 4. [C 01] T01 completes.
 5. [S 02] T02 starts.
 6. [C 02] T02 completes.
- (and so on until each diagnostic in the chain is completed)
7. [T 00] Concludes with this display and the least significant digit (LSD) blinking. The OCP display is read from left to right with the LSD on the right side.

The majority of tests are of a relatively short duration, with the following exceptions:

- T31 (2.5 minutes; indefinite when standalone)
- T32 (1 minute; indefinite when standalone)
- T33 (55 seconds; indefinite when standalone)

Additional test chains are:

- T18: T01, 02, 03, 06 (8 seconds total)
- T19: T14, 15, 16 (20 seconds total)
- T20: (4 seconds if spun down; 2 seconds if spun up)
- T21: T03, 29, 30, 31 (4.5 minutes), 32, 33 (7:10 minutes total); error if spun down
- T22: Same as T00 except T31 (4.5 minutes) (7 minutes total)
- T23: T01, 02, 03, 06, 07, 08 (20 seconds total)

4.4 Standard OCP Displays Indicating Procedural Problems

If you attempt to load and run a nonexistent test, [INVL] (invalid) displays in the OCP, followed by an error code. For example, if you attempt to run T10 (an invalid test number), the following occurs:

1. [T 10] (Display)
2. [S 10] (Display)
3. [INVL] (2 seconds—indicates invalid test)
4. [C 10]
5. [T 10]

No error code is generated. To continue, simply select another diagnostic.

If you attempt to run a diagnostic while the drive is faulted and that particular diagnostic cannot be run under fault conditions, the OCP displays [NRUN].

For example, read/write or seek tests cannot be run while the drive is faulted. However, ROM or RAM tests can be run.

If you attempt to run a test that requires the drive be spun up (but the drive is spun down), the following occurs:

1. [T 14] Load T14.
2. [S 14] Start T14.
3. [T 14] (with fault light)
4. Select Fault switch.
5. [E.CA] error code indicates the drive must be spinning for the test to run successfully. Unless otherwise indicated, this is the format for all errors.

Select the Fault switch again to clear the fault and continue.

If you attempt to run a test that requires the drive be spun down (but the drive is spun up), the following occurs:

1. [T 07] Load T07.
2. [S 07] Start T07.
3. [T 07] (with fault light)
4. Select the Fault switch.
5. [E 7B] Invalid-test-while-drive-is-spinning error. This is the format for all tests that are invalid while the drive is spinning.

Select the Fault switch again to clear the fault and continue.

Some diagnostic test numbers call up other tests. These are displayed in the OCP after the diagnostic starts. An example of this is T24. The following is displayed in the OCP:

1. [T 24] Load T24.
2. Start test.
3. [S 63] See test T63.
4. After the head(s) are selected, select Write Protect.
5. [T 31] Loaded by the drive.
6. [S 31] See test T31.

The reverse is not true. T63 does not start T24.

4.5 Software Jumper

References to a software jumper are frequently made throughout the discussion of diagnostics. To use the software jumper, simply select the Run/Stop switch within 1.5 seconds of starting a diagnostic requiring the jumper's use.

CAUTION

Do not use the jumper unless it is required. Valuable drive component information can be accidentally lost. Use the jumper only when instructed to do so.

4.6 Temperature's Affect on Drive Performance

The RA90/RA92 drive utilities T36, T38, and T39 measure various seek time parameters. Compare measured times to drive specifications in cases where seek time is in question.

At the areal densities of the RA90/RA92 disk drives, variations of mechanical responses within the HDA mechanical structures change significantly over the wide temperature ranges acceptable to the drive. To control these variations and their impact on the subsystem, the drive monitors and compensates its seek profile to optimize the seek time performance. This compensation is a dynamic process, that assures top seek performance of the disk drive.

4.7 Diagnostics Descriptions

This section describes each of the diagnostic tests and utilities resident in the RA90/RA92 disk drive. Tests are listed by a test number (where applicable), a name, an explanation of how the test is invoked, and a test description.

Conventions include the following:

- (T00): test number
- (POR): power-up or reset
- (SDI): initialization performed by the controller over the SDI cable
- ([0000]): items enclosed in square brackets represent the OCP alphanumeric display

NOTE

Some diagnostics implement a scrolling display pattern. To stop the scrolling display pattern, select the Run switch; this halts the display until you are ready to continue. Select the Run switch again to continue the display.

Some tests run for several seconds then have results to display. These tests stop the scrolling display and send an asterisk to the display. Press the Run switch to display test results.

Master CPU Test (POR)

The Master CPU test verifies the basic functions of the drive master processor. Accumulator functions, conditional codes, and other MCU chip functions are tested.

Master RAM Test (POR/SDI)

The Master RAM test runs at power-up only. It verifies the master processor internal and static RAM. The test reads and writes, then reads each RAM location again to verify data integrity of the component. The test is executed in both forward and reverse directions.

Serial Communications Interface (SCI) Test (POR)

The SCI test checks the master processor serial communication interface by looping a data pattern from the serial output back to the serial input. It compares data out to data in for integrity. Additionally, the serial port is tested for overrun error detection and overrun recovery. The test simulates OCP MCU communication with the master MCU.

Servo RAM Test (POR)

The Servo RAM test checks the servo processor RAM by writing a pattern of ones and zeros through RAM. The entire 16 Kbytes of RAM is tested.

(T01) Master ROM Test

The Master Processor ROM test verifies the master processor internal ROM, EEPROM, and the associated address decode logic. A checksum is done on each ROM. Next, the test verifies that the consistency codes match between the MCU ROM and the master processor EPROM and EEPROM. If a failure occurs, the master processor attempts to display an error code to the OCP.

(T02) Master Timer Test (POR/SDI)

The Master Timer test verifies the output compare timer in the master processor by checking the Output Compare Flag (OCF) for stuck bits. Additionally, the test operates the timer in polling and interrupt modes.

In polling mode, the output compare register generates a compare every 50 ms and ensures that the OCF sets within 60 ms.

In interrupt mode, the output compare register generates a compare every 50 ms and checks for one interrupt within a 75 ms period.

(T03) Servo Data Bus Loopback Test (POR/SDI)

The Servo Data Bus Loopback test checks the data bus interface between the I/O-R/W module and the servo module (ECM) by rotating a single bit through each bit position on the servo data bus. The data pattern is written to the GASP register #1 and read back through GASP register #7.

(T04) Drive S/N Bus Test (POR/SDI)

The Drive S/N Bus test checks the drive serial number bus (the rear flex cable between the HDA and the servo module with the PCM switch pack). The three drive ID ports hardwired on the rear flex cable assembly are read and concatenated into one 20-bit binary encoded serial number.

Bits 19 and 18 represent the manufacturing plant code of the drive (CX or KB). Bits 17 through 0 are the alphanumeric serial number (00000-Z9999). The numbering scheme is displayed using the following:

Encoded Serial Number Displayed	Decimal Drive Serial Number
00000-99999	0-99,999
A0000-A9999	100,000-109,999
B0000-B9999	110,000-119,999
C0000-C9999	120,000-129,999
D0000-D9999	130,000-139,999
E0000-E9999	140,000-149,999
F0000-F9999	150,000-159,999
H0000-H9999	160,000-169,999
J0000-J9999	170,000-179,999
K0000-K9999	180,000-189,999
L0000-L9999	190,000-199,999
M0000-M9999	200,000-209,999
N0000-N9999	210,000-219,999
P0000-P9999	220,000-229,999
R0000-R9999	230,000-239,999
S0000-S9999	240,000-249,999
T0000-T9999	250,000-259,999
U0000-U9999	260,000-269,999*
V0000-V9999	270,000-279,999
W0000-W9999	280,000-289,999
Y0000-Y9999	290,000-299,999
Z0000-A9999	300,000-309,999

***NOTE**

U2143 is the maximum serial number that can be coded for the KB manufacturing site because only the bottom 18 binary bits are used for the serial number range.

4-8 Drive-Resident Diagnostics and Utilities

(T07) Sector/Byte Counter Test

The test passes or fails based on the following valid and invalid bit-encoded binary information:

VALID DRIVE S/N CODES

19	18	
---	---	
0	0	CXO-built drive (serial number 1 through 262,143)
0	1	CXO-built drive (serial number 262,144 through 309,999) Limitation is based upon the number of alphabetic characters available.
1	0	KBO-built drive (serial number 1 through 262,143)

INVALID DRIVE S/N CODES

BITS	MIN BINARY VALUE	MAX BINARY VALUE
19 18	BITS<17:00>	BITS<17:00>
-----	-----	-----
0 1	001011101011110000	111111111111111111
1 1	000000000000000000	111111111111111111

NOTE

Do not alter these switches in the field unless you are instructed to do so during an ECO/FCO installation.

(T06) Head Select Test

The Head Select test checks the SDI gate array (SGA) head select register for stuck-at conditions. The test writes a head select pattern to an SGA internal register and verifies the pattern by reading it back through another SGA internal register. Each head select pattern is clocked to the preamp control module (PCM) verifying the correct head select chip can be enabled.

(T07) Sector/Byte Counter Test

The Sector/Byte Counter test checks the sector preset by writing and reading each bit in the sector preset register. The test checks the byte preset counter by presetting the byte counter. A full counting sequence is needed to increment the sector count by one. Finally, the sector/byte counter is checked with the actual preset values used in the functional code. A diagnostic clocking signal is used.

(T08) SDI Loopback Test (Internal)

The internal SDI Loopback test is executed with the **TSID GATE ARRAY** in loopback mode.

The State Frame part of this test asserts the state bits (**RDY, ATN, R/W, SEC**) in the Real Time Drive State (**RTDS**) frame and checks the corresponding state bits (**RDY, WRT, RD, INI**) in the Real Time Controller State (**RTCS**) frame for accuracy.

The Response Serializer part of this test sends framing codes (**START, CONTINUE, END**) by way of the **CMDREG** register, along with response data (a pattern) by way of the **RSPDAT** register. The test checks the correct framing codes by way of the **INSTR2** register and the correct command data through the **CMDATA** register. This test is executed on Ports A and B.

(T09) SDI Loopback Test (External)

The external SDI Loopback test is the same as the internal SDI Loopback test except the SDI signals are looped back via connectors at the end of the SDI cables. See Figure 4-1.

(T14) Read-Only Test

The Read-Only test compares prerecorded data information from cylinder 2659 to the data read by each head. The data pattern is different for each head. If the compare fails, an error code is generated. In addition, if five off-track errors are detected while reading with any one head, an error is generated. Errors are analyzed in the following manner:

- A sector is considered bad if the same sector fails to read the correct data three out of five times.
- A head is considered bad if the same head contains nine bad sectors.

If no errors are detected during this test, a compare error is induced to ensure that the IID chip compare circuitry can detect a compare error.

(T15) Write/Read Test

The Write/Read test executes only after the read-only (T14) test has passed. This test writes and reads dedicated cylinder 2660 using all read/write heads.

Two patterns are used during this test:

1. First, all the heads are written with an all-zeros-plus-a-SYNC-BIT pattern and read to verify that the data compares. If there are no errors, a NO SYNC detection test is run verifying that the IID sync detection circuitry is working correctly and that it can detect a NO SYNC error.
2. Second, a ones-plus-a-SYNC-BIT pattern is written to cylinder 2660 and read back using each data head. Data is compared to ensure data integrity.

4-10 Drive-Resident Diagnostics and Utilities
(T15) Write/Read Test

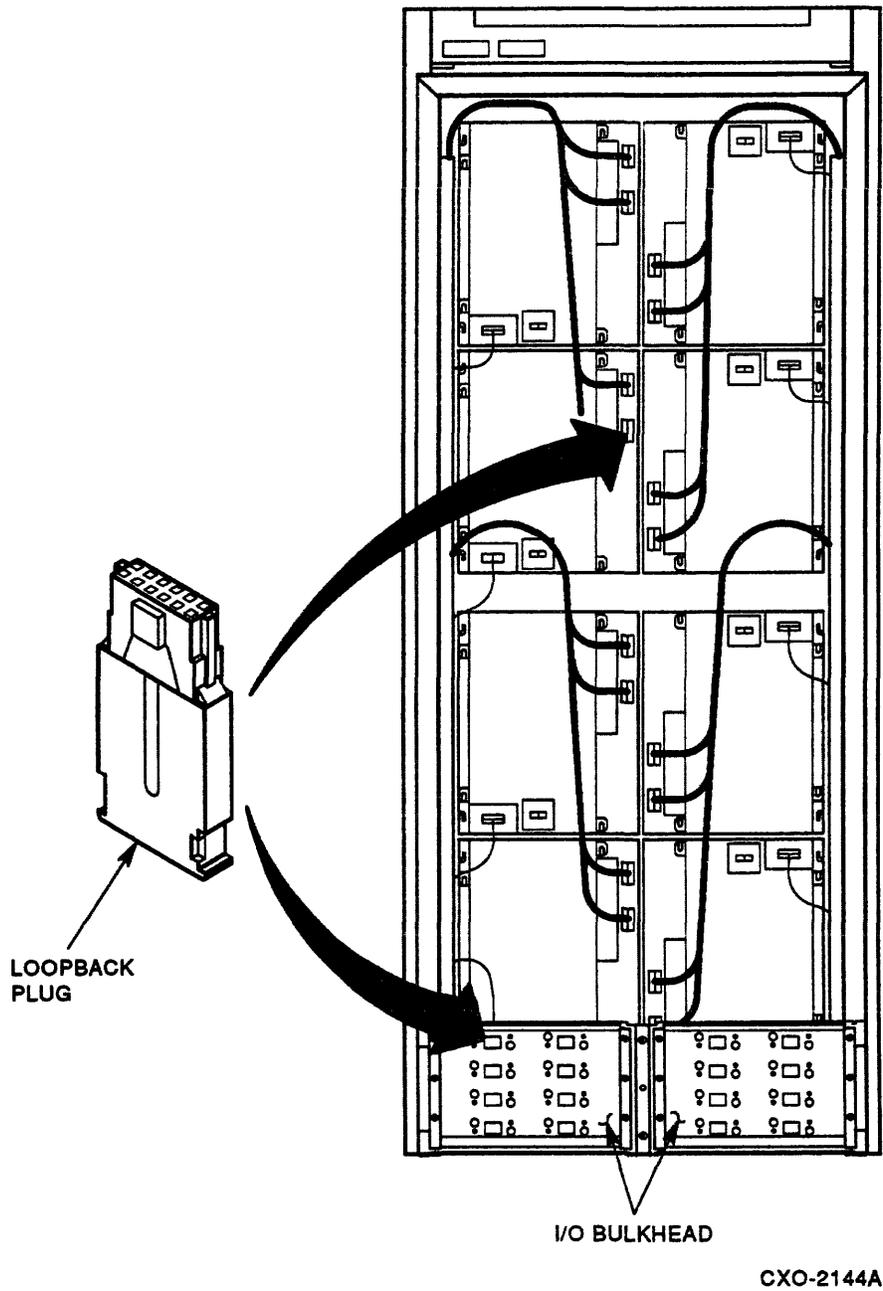


Figure 4-1 Using Loopback Connectors

(T16) Read/Write Force Fault Test

Read/write safety detection circuits are tested by software and hardware routines that force read/write faults.

(T17) Read-Only Cylinder Formatter

Read-only cylinder 2659 is written with a zeros-plus-a-SYNC-BIT pattern (all heads) and read back to verify data. Then another pattern is written and read back, and the data is compared for accuracy. This cylinder is not formatted by any other subsystem formatter.

NOTE

Use a software jumper to execute this utility. This protects the stored information from unintentional clearing. Refer to Section 4.5.

Reformatting this cylinder is sometimes necessary in the field.

(T18) Hardcore Sequence Test

This sequence diagnostic consists of T01, 02, 03, and 06. Duration: 20 seconds. Drive may be spun up or down.

(T19) Read/Write Sequence Test

The drive must be spun up to run the Read/Write sequence test. This sequence diagnostic consists of T14, 15, and 16. Duration: 25 seconds.

(T20) Servo Spinup Sequence Test

See T03.

(T21) Total Servo Sequence Test

The drive must be spun up to run the Total Servo Sequence test. This sequence diagnostic consists of T03, 29, 30, 31, 32, and 33. Duration: 4.5 minutes.

(T22) Total Drive Sequence Test (Spinning)

The drive must be spun up to run this test. This sequence diagnostic consists of T01, 02, 03, 06, 29, 30, 31, 33, 14, 15, and 16. Duration: 7 minutes.

(T23) Total Drive Sequence Test (Spun down)

The drive must be spun down to run this test. This sequence diagnostic consists of T01, 02, 03, 06, 07, and 08. Duration: 20 seconds.

(T24) Head Select and One Seek Test Sequence

See T63.

(T28) Drive-Sensed Temperature Display Utility

This utility was implemented with version 25 of the drive microcode to display the drive-sensed temperature in degrees Fahrenheit, in a scrolling display on the OCP. Version 26 of the microcode displays this temperature in degrees Fahrenheit and Celsius.

The OCP scrolling display is as follows:

[*TEMP=xxx°F/xxC*]

(T29) Gray Code (Track Counter) Test

The Gray Code test checks that the correct gray code is generated from the two least significant bits of the track counter as the drive seeks from cylinder 0 to 3 and 3 to 0. This test is executed on the dedicated servo surface only.

(T30) Guardband Test

The Guardband test checks the drive's ability to find inner and outer guardbands during seeks to these areas.

(T31) Incremental Seek Test

The Incremental Seek test exercises the servo by seeking between two cylinders using an incremental seek pattern. The starting cylinder, ending cylinder, and incremental value can be default or user defined.

Default seek parameters are: starting cylinder 0, ending cylinder 2655 (last data cylinder), and an incremental value of 1.

An example of the seek algorithm using the default seek parameters:

```
BEG: 0-1-2-3-4-5- // 2653-2654-2655 :END
```

(T32) Toggle Seek Test

The Toggle Seek test does repetitive seeks between two cylinders. The starting and ending cylinders can be user defined or default cylinder addresses.

Default seek parameters are: starting cylinder 0 and ending cylinder 2655 (last data cylinder).

An example of the seek algorithm using the default seek parameters:

```
BEG: 0-2655-0-2655-0-2655- etc... :END
```

(T33) Random Seek Test

The Random Seek test does repetitive seeks between two cylinders. The starting and ending cylinders can be user defined or default cylinder addresses.

Default seek parameters are: starting cylinder 0 and ending cylinder 2655 (last data cylinder).

(T34) Tapered Seek Test

The Tapered Seek test exercises the servo by seeking between two cylinders using a tapered seek pattern. The pattern starts at the cylinder with the longest stroke and ends at the cylinder with the shortest stroke.

The starting and ending cylinders can be user defined or default cylinders.

Default seek parameters are: starting cylinder 0 and ending cylinder 2660 (diagnostic write cylinder).

This example has the reference cyl=0 and ending cyl=2660:

```
BEG: 0-2660-0-2659-0-2658-0-2657-0-2656- etc. 0-6-0-5-0-4-0-3-0-2-0-1-0 :END
```

This example has the reference cyl=2660 and ending cyl=2660:

```
BEG: 2660-0-2660-1-2660-2-2660-3-2660-4 etc. 2660-2658-2660-2659-2660 :END
```

This example has the reference cyl=1330 and ending cyl=2660:

```
BEG: 1330-2660-1330-2659-1330-2658 etc. 1330-1332-1330-1331-1330 :END  
BEG: 0-1330-1-1330-2-1330-3-1330-4 etc. 1327-1330-1328-1330-1329-1330 :END
```

4.7.1 Seek Timing Tests

The following diagnostics are classified as seek timing tests. Seek timing tests can be executed through the OCP or through the SDI level 2 DIAGNOSE command.

At the completion of a timing test, position three is blank, positions two and one contain a timing test acronym (MH, MX, AV, HD), and position zero contains an asterisk (*).

At this point, the results can be displayed. A scrolling message display reports the test results to the user. The message is scrolled, one character at a time, starting at the right side of the OCP and continuing off to the left side of the OCP. The Run switch is used to start and stop the scrolling display by pressing it once to start the display, and once to stop the display.

All the timing tests use a 1-microsecond clock to calculate seek times. Because of this, the short seek and head switch times are not as accurate as the long seek times.

(T36) Minimum Seek Timing Test

This test executes the minimum seek timing algorithm and displays the results of the test in the OCP. Test time is approximately 75 seconds.

The following scrolling message format is used to display test results:

```
[MIN TIM FWD=xx.xMS]  
[MIN TIM REV=xx.xMS]
```

where xx.x is the seek time (in milliseconds). The minimum seek time is defined as the average of 2655 single cylinder seeks (forward and reverse). This test uses the default incremental seek pattern.

NOTE

If the time exceeds 99.9, the decimal point is shifted one digit to the right. The OCP displays [999].

(T38) Average Seek Timing Test

This test executes the average seek timing algorithm and displays the test results to the OCP. This test takes 5-7 minutes to complete.

The following message is scrolled across the OCP display:

```
[AVG TIM FWD=xx.xMS]  
[AVG TIM REV=xx.xMS]
```

where xx.x is the seek time (in milliseconds). The average seek time is defined as the average of 512 one-third-length seeks. For the RA90 disk drive, the seek length is 855 cylinders. For the RA92 disk drive, the seek length is 1035 cylinders.

Average seek time: < 21 milliseconds for RA90.

Average seek time: < 19 milliseconds for RA92.

(T39) Head Switch Timing Test

This test executes the head switch timing algorithm and displays the test results to the OCP. This test takes approximately 2 seconds to run. The following message is scrolled across the OCP display:

```
[HD SWT TIME=xx.xMS]
```

where **xx.x** is the head switch time (in milliseconds).

The head switch time is defined as the summation of all possible head switches divided by the total number of head switches.

(T40) Update Cartridge Utility (Spun Down)

The drive must be spun down to run the Update Cartridge utility.

This internal microcode update utility is used in the field to update the following internal drive microcode functions:

- Diagnostics microcode
- Servo microcode
- Functional microcode

New microcode is loaded in the following sequence:

1. Load update cartridge into update port.
2. Load test T40. (Drive must be spun down.)
3. Start test T40. The following occurs in the OCP display once this test has begun (S = start, P = pass, C = complete):
 - [S 40] (2 seconds).
 - [P 1] (20 seconds) Pass one checks PROM to be loaded.
 - [P 2] (20 seconds) Pass two writes the new code into the even pages in EEPROM.
 - [P 3] (20 seconds) Pass three writes the new code into the odd pages in EEPROM.
 - [C 40] (1 second) Update is complete.
 - [WAIT] (10 seconds) Exits test mode and goes through power-up hardware sequence.
 - [0000] Returns to display the drive unit address.

(T41) Display Error Log Errors

This utility displays the RA90/RA92 drive-resident error log. When initiated, it first verifies the integrity of the error log by reading the first four bytes of the error log header and comparing them to expected values. If the compare fails, the utility exits and an error code displays.

The error log is displayed starting with the latest entry first and continuing until all entries are displayed. Positions three and two represent the error log entry in decimal. Positions one and zero represent the two-digit LED hex error code. Each entry is displayed for 1.5 seconds with the option of starting and stopping the display using the Run switch.

NOTE

Null entries are displayed as 00 and should be ignored.

4.7.2 Time, Seeks, and Spinups Display Interpretation

The time, seeks, and spinups display utilities all use the following format to display the counts to the OCP:

POSITION	3	2	1	0
OCP 1	X	X	9	8
OCP 2				
OCP 3	7	6	5	4
OCP 4				
OCP 5	3	2	1	0
OCP 6				

CXO-2146B

The following conventions are used:

- TM = time
- SK = seeks
- SP = spinups

OCP 1 contains either TM, SK, or SP, and the binary digits 9 and 8.

OCP 3 contains binary digits 7, 6, 5, and 4.

OCP 5 contains binary digits 3, 2, 1, and 0.

OCP displays 2, 4, and 6 are used as separators to indicate the display is changing.

(T42) Display Time Utility

A 10-digit decimal number representing time is displayed when this utility is run. This number is time, in minutes, since the drive was first powered up. See Section 4.7.2 for display interpretation.

(T43) Display Seeks Utility

When this utility is run, the OCP displays the number of total seeks (times a thousand) since the drive was first powered up. A 10-digit decimal number is displayed in six segments at the OCP. Each segment is displayed for 1.5 seconds unless the display is halted by selecting the Run switch. See Section 4.7.2 for display interpretation.

(T44) Display Spinups Utility

This utility displays the total number of spinups since the drive was first powered up. When this utility is run, the total number of spinups is displayed on the OCP in six segments. Each segment is displayed for 1.5 seconds unless the display is halted by selecting the Run switch. See Section 4.7.2 for display interpretation.

(T45) Drive Revision Level Utility

This utility uses the following mnemonics to display drive component hardware and/or microcode revisions as follows:

- DRV = Drive hardware revision
- DCD = Drive microcode revision (microcode)
- IOP = Master processor module (hardware)
- SRV = Servo module (hardware)
- PCM = Preamp control module (hardware)
- ORV = Operator control panel (hardware)
- OCD = Operator control panel (microcode)

Running this utility displays the revision level for each module in a scrolling message format across the OCP. The following scrolling message format is used to display the information to the drive OCP:

- DRV= www
where www is the decimal hardware revision (0 to 255) of the drive.
- DCD= yyy
where yyy is the decimal revision number (0 to 255) of the combined functional, servo, and diagnostic microcode. The microcode is loaded from the microcode update cartridge.

NOTE

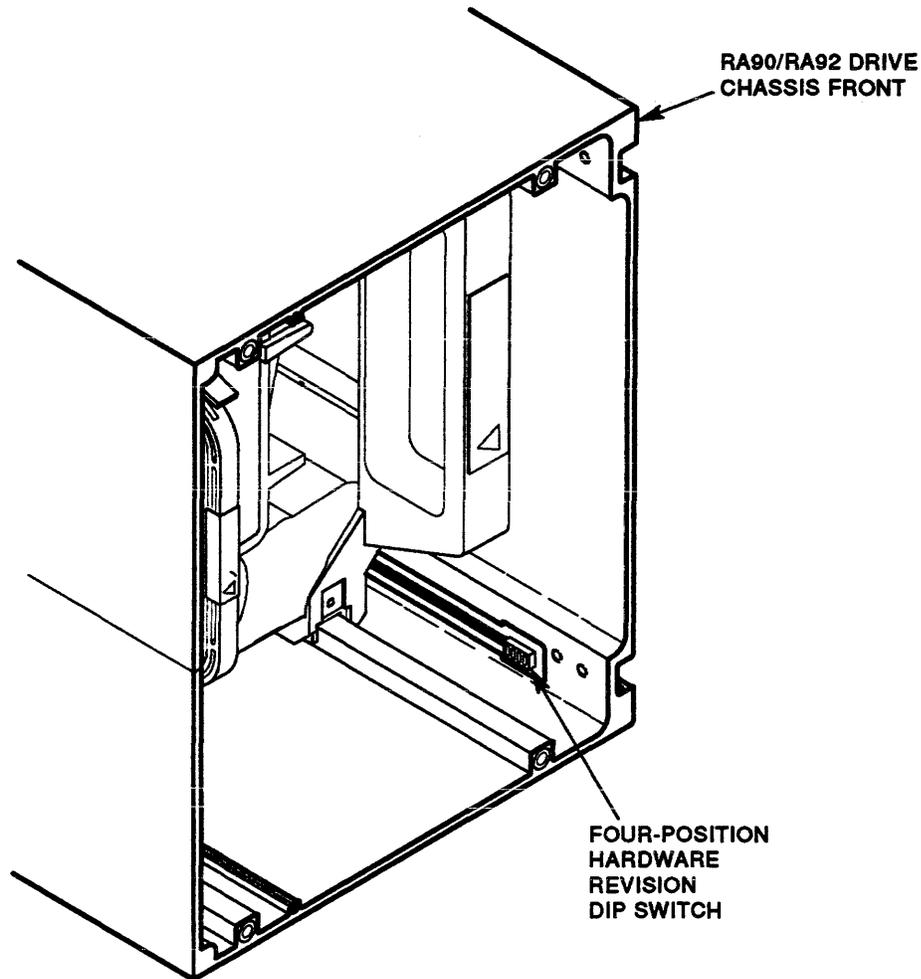
If a drive microcode revision (in the OCP display) contains an alpha character, for example, DCD=L200, this signifies unreleased code. The drive microcode should be updated with a formally released microcode revision.

- IOP= xx
where xx is the decimal revision number (0 to 15) of the appropriate module.
- SRV= xx
- PCM= xx
- ORV= xx
- OCD= z.z
where z.z is the decimal revision number (0.0 to 9.9) for the OCP microcode.

NOTE

If the OCD is displayed as version 5.1 (OCD= 5.1), the drive has an OCP that allows the alternate unit address display mode to be used. Refer to Chapter 3.

The hardware revision switches (Figure 4-2) provide the subsystem with the ability to determine base-level module revision compatibilities. The hardware switches are changed only by direction of a drive ECO/FCO. All ECO and FCO activity will take into account the impact of the changes to the drive and to the subsystem to which it is attached.



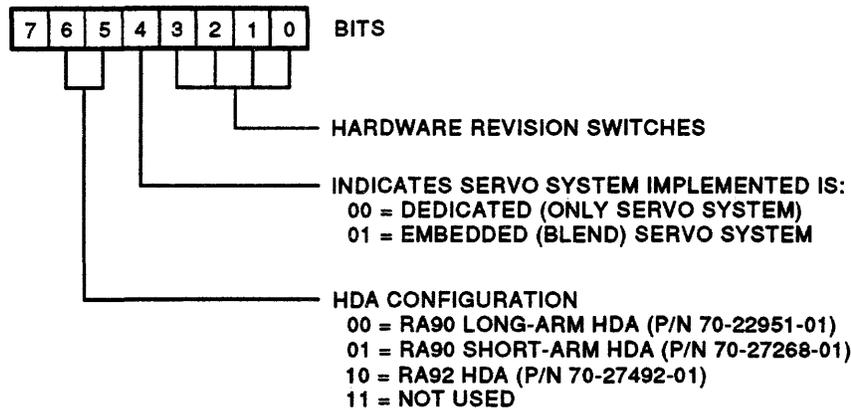
CXO-2147B

Figure 4-2 Hardware Revision Switches

NOTE

Do not alter these switches in the field unless you are instructed to do so during an ECO/FCO installation.

The hardware revision switches make up only part of the total reported hardware revision. The total reported hardware revision is a byte of information determined as shown in Figure 4-3.

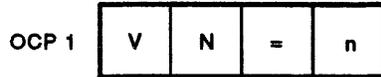


CXO-2716B

Figure 4-3 Hardware Revision Byte

(T46) HDA Revision Utility

This utility allows you to display the HDA revision/vendor bits in the OCP display. The first year of production will reflect HDA revision/vendor bit 0.



CXO-2148B

The two left-most places of the OCP display contain a VN for the vendor code. The right-most place of the OCP display contains a vendor code of 0 through 3. These revision/vendor bits are used to distinguish the HDA type to the drive microcode. These bits, in conjunction with PCM switches S1-1 and S1-2, tell the microcode how the servo system should be configured in microcode.

(T47) Display Drive Serial Number Utility

This utility displays the drive serial number to the OCP.

The following message is scrolled (left to right) across the OCP display:

[DRV S/N xxy_zzzz]

where:

- xx is the manufacturing location of the drive (CX=CXO, KB=KBO)
- y is the alphanumeric digit 0-9 or A-Z (G, I, O, Q, and X are not allowed)
- zzzz is 0000-9999

(T50) Error Log Checkpoint Utility

The Error Log Checkpoint utility allows you to enter a checkpoint entry into the internal drive error log. This is similar to a place marker.

(T53) Clear Seeks Utility

The Clear Seeks utility clears the total number of seeks since the drive was first powered up. Run this test any time the HDA is replaced.

NOTE

Use a software jumper to execute this utility. This protects the stored information from unintentional clearing. Refer to Section 4.5.

This test causes [INVL] to be displayed if you fail to use the software jumper.

(T54) Clear Spinups Utility

The Clear Spinups utility clears the total number of spinups since the drive was first powered up. Run this test any time the HDA is replaced.

NOTE

Use a software jumper to execute this utility. This protects the stored information from unintentional clearing. Refer to Section 4.5.

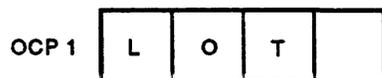
This test causes [INVL] to be displayed if you fail to use the software jumper.

(T55) Clear DD Bit Utility

The Clear DD Bit utility clears the DD bit set by the diagnostics or a controller.

(T60) Loop-On-Test Utility

This utility enables looping on a test. It can be set to loop on a diagnostic test or a diagnostic sequence of tests. [LOT] is displayed on the OCP for 1.5 seconds when the loop utility is run. The utility loops until an error is encountered or until the Test switch on the OCP is selected.



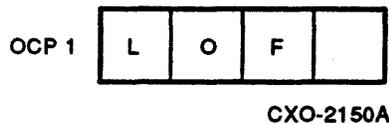
CXO-2149A

(T61) Loop-On-Error Utility

This utility loops continuously on errors encountered during the execution of drive internal diagnostics. The test loops as long as the error is present. [LOE] is displayed on the OCP for 1.5 seconds when the loop utility is run.

(T62) Loop-Off Utility

The Loop-Off utility terminates all loop-on conditions. [LOF] is displayed on the OCP for 1.5 seconds when this utility is run.

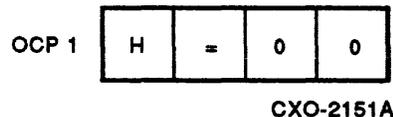


The effects of the LOT or LOE utilities may be canceled manually (LOF) or by exiting OCP test mode and letting the idle loop routine execute at least one time.

(T63) Head Select Utility

The Head Select utility allows you to select or change the head to be tested. When the utility is first run, the currently selected head number is displayed in decimal (0–12) in the OCP display, and the least significant digit (LSD) blinks.

The format is as follows:



The head number may be changed by selecting the Port B switch to increment the blinking digit.

When the desired head number is displayed in the OCP, pressing the Write Protect switch causes that head to be selected and the head number to be changed in RAM. If the Test switch is pressed, the test is aborted and the change does not take place.

The head remains selected until changed by this utility, power-up or reset, I/O processor reset, SDI INIT, or controller intervention.

(T64) One Seek Utility

The One Seek utility can be used to seek and lock on a cylinder. When run, the following OCP display is seen:

OCP 1	C	Y	L	=	(CYLINDER 1.5 SEC)
OCP 2	X	X	X	X	(CYLINDER VALUE: 0-2660 SEC)

CXO-2152A

The right-most digit blinks to indicate cylinder value selection can begin. Selecting the Port A switch selects the next desired digit position which starts blinking upon selection. Digit position is from right to left (LSD to MSD). A wrap back to the LSD occurs if the Port A switch is selected enough times. Selecting the Port B switch increments the blinking digit.

After the cylinder value is set, select the Write Protect switch to cause the heads to position themselves at the desired cylinder. Selecting the Test switch aborts the process without changing the cylinder value.

The selected cylinder value is stored in RAM until T64 is run again or a power-up reset, master processor reset, or SDI INIT occurs.

(T65) Seek Parameter Input Utility

Four seek parameters can be examined or changed when using the seek timing tests T36, T38, and T39. They are:

- FCY (first cylinder)
- LCY (last cylinder)
- INC (increment)
- DLY (delay)

Seek parameters are changed the same way as the seek utility parameters. Refer to tests T36, T38, and T39 for a discussion on altering parameters for diagnostics.

The following describes the sequence of events which occur when test T65 is run:

FCY= is the first display seen when this utility is started (Figure 4-4). The first cylinder value follows 1.5 seconds later. The FCY can be any decimal number between 0 and 2660.

OCP 1	F	C	Y	=	(FIRST CYLINDER VALUE 1.5 SEC)
OCP 2	X	X	X	X	(DESIRED VALUE: 0-2660 SEC)

CXO-2153A

Figure 4-4 T65 FCY OCP Display

Next, select the Write Protect switch. LCY= is displayed (Figure 4-5). The last cylinder value follows 1.5 seconds later. The LCY can be any decimal value between 0 and 2660.

OCP 1	L	C	Y	=	(LAST CYLINDER VALUE 1.5 SEC)
OCP 2	X	X	X	X	(DESIRED VALUE: 0-2660 SEC)

CXO-2154A

Figure 4-5 T65 LCY OCP Display

Select the Write Protect switch again. INC= is displayed (Figure 4-6). The incremental value follows 1.5 seconds later. The INC value can be any decimal number between 1 and 2660. If a value of 0 is chosen, the test loops indefinitely.

OCP 1	I	N	C	=	(CURRENT INCREMENT VALUE 1.5 SEC)
	X	X	X	X	(DESIRED VALUE: 0-2660 SEC)

CXO-2155A

Figure 4-6 T65 INC OCP Display

Select the Write Protect switch and DLY= is displayed (Figure 4-7). The delay value between seeks is displayed 1.5 seconds later. A delay value can be between 0 and 2999 milliseconds.

OCP 1	D	L	Y	=	(CURRENT DELAY VALUE 1.5 SEC)
OCP 2	X	X	X	X	(DESIRED VALUE: 0-2999 SEC)

CXO-2156A

Figure 4-7 T65 DLY OCP Display

The seek parameters remain changed until this utility is run again or a power-up reset, I/O processor reset, or SDI INIT occurs.

NOTE

T65 does not check for out-of-range values. Do not exceed the maximum specified input values. Also, the last cylinder parameter must always be equal to or greater than the first cylinder parameter. If an invalid cylinder value is entered, a (servo) seek failed error (F5) occurs.

(T66) Variable Average Seek Timing Test

This test executes the average seek timing algorithm and allows you to time any length seek. To set the seek length, modify the first (FCY) and last (LCY) cylinder addresses through the seek parameter input utility (T65).

The run time for this test varies, depending on the length of the seek used. The run time should not take longer than 45 seconds, regardless of the length of the seek.

The following message is scrolled across the OCP display:

```
[AVG TIM FWD=xx.xMS]  
[AVG TIM REV=xx.xMS]
```

where xx.x is the seek time (in milliseconds). The variable average seek time is defined as the average (AVG) of 512 seeks in forward (FWD) and reverse (REV) directions.

Troubleshooting and Error Codes

5.1 Troubleshooting Reference Material

When running diagnostics and interpreting error logs, you will need the documents listed (alphabetically) in Table 5-1.

Table 5-1 Reference Material for Troubleshooting

Document Title	Order Number
<i>DSA Error Log Manual</i>	EK-DSAEL-MN
<i>DSA Error Log Pocket Service Guide</i>	EK-DSAEL-PG
<i>Getting Started With VAXsimPLUS</i>	AA-KN79A-TE
<i>HSC Service Manual</i>	EK-HSCMA-SV
<i>VAXsimPLUS Field Service Manual</i>	AA-KN82A-RE
<i>VAXsimPLUS User Guide</i>	AA-KN80A-TE

Refer to Section 5.19 for RA90/RA92 disk drive error codes and descriptions.

5.1.1 Customer Support Training for the RA90/RA92 Disk Drive

You must have the proper training to efficiently support the RA disk family. This training is available at most Customer Services Training Centers, category A and B sites. Consult with your Customer Services unit managers for training information.

DSA Level I and HSC Level I courses are prerequisites to the RA90 IVIS training.

Although support organizations are available to assist in problem solving, there is no substitute for proper training. Support training resources include DSA Level II and DSA Troubleshooting courses, and the *RA90 Disk Drive Technical Description Manual*.

5.2 RA90/RA92 Troubleshooting Aids

The following aids are available for disk drive troubleshooting:

- VAXsimPLUS (VMS systems) (see Section 5.2.1)
- Host error logs (see Section 5.2.2)
- Drive internal error log (see Section 5.2.4)
- Operator control panel (OCP) fault indicator/error codes (see Section 5.2.5)
- Drive power supply indicator (see Section 5.2.6)

- Drive error reporting mechanisms (see Section 5.2.7)
- Host-level diagnostics/utilities (see Section 5.2.8)

5.2.1 VAXsimPLUS

The VAX System Integrity Monitor (VAXsimPLUS) provides access to VMS error log data. The three VAXsimPLUS manuals needed to operate VAXsimPLUS effectively are listed in Section 5.1.

5.2.2 Host Error Logs

Refer to the appropriate system error logs for error interpretation. The *DSA Error Log Manual* and the *DSA Error Log Pocket Service Guide* contain system error log descriptions for most operating systems.

5.2.3 Extended Status Bytes

Extended status bytes are part of the response to the SDI GET STATUS/TOPOLOGY command or any unsuccessful response to a level 2 command. These bytes are passed through the controller to the host for error logging purposes. Figure 5-1 shows a breakdown of the RA90/RA92 extended drive status bytes. Extended status bytes are described in detail in the sections that follow.

BYTE 01	RESPONSE OPCODE		
BYTE 02	UNIT NUMBER LOW BYTE		
BYTE 03	SUBUNIT MASK		
BYTE 04	REQUEST BYTE		GENERIC DRIVE STATUS BYTE
BYTE 05	MODE BYTE		GENERIC DRIVE STATUS BYTE
BYTE 06	ERROR BYTE		GENERIC DRIVE STATUS BYTE
BYTE 07	CONTROLLER BYTE		GENERIC DRIVE STATUS BYTE
BYTE 08	RETRY COUNT		
BYTE 09	PREVIOUS CMD OPCODE		EXTENDED DRIVE STATUS BYTE
BYTE 10	HDA REVISION BITS		EXTENDED DRIVE STATUS BYTE
BYTE 11	CYLINDER ADDR (LO)		EXTENDED DRIVE STATUS BYTE
BYTE 12	CYLINDER ADDR (HI)		EXTENDED DRIVE STATUS BYTE
BYTE 13	RECOVERY LVL	GROUP NO	EXTENDED DRIVE STATUS BYTE
BYTE 14	ERROR CODE		EXTENDED DRIVE STATUS BYTE
BYTE 15	MFG FAULT CODE		EXTENDED DRIVE STATUS BYTE

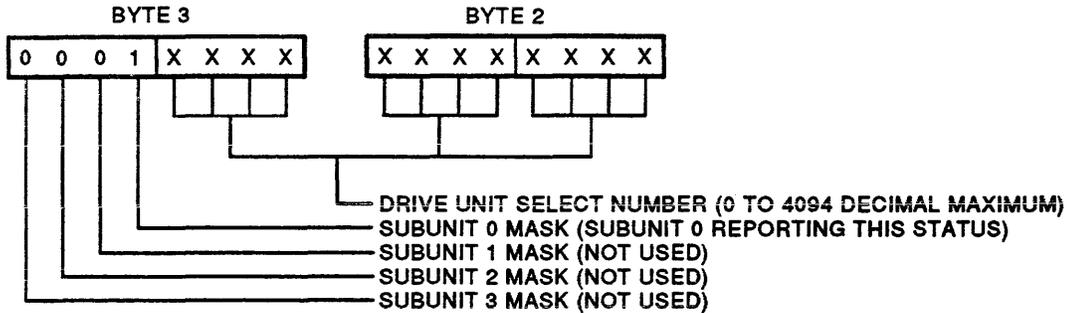
CXO-2157B

Figure 5-1 RA90/RA92 Extended Drive Status Bytes

5.2.3.1 Response Opcode (Byte 1)

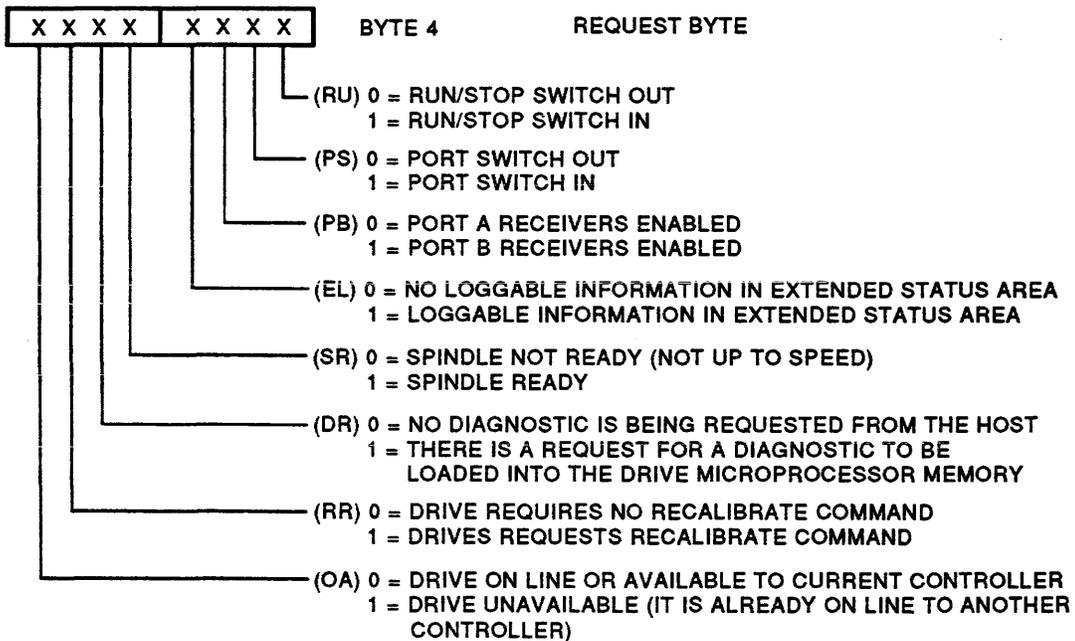
Response Opcode (Byte 1) is the drive-to-controller response opcode and indicates the success or failure of the previous controller-to-drive command. Generally, this is transparent to the user.

5.2.3.2 Unit Number Low Byte (Byte 2) and Subunit Mask (Byte 3)



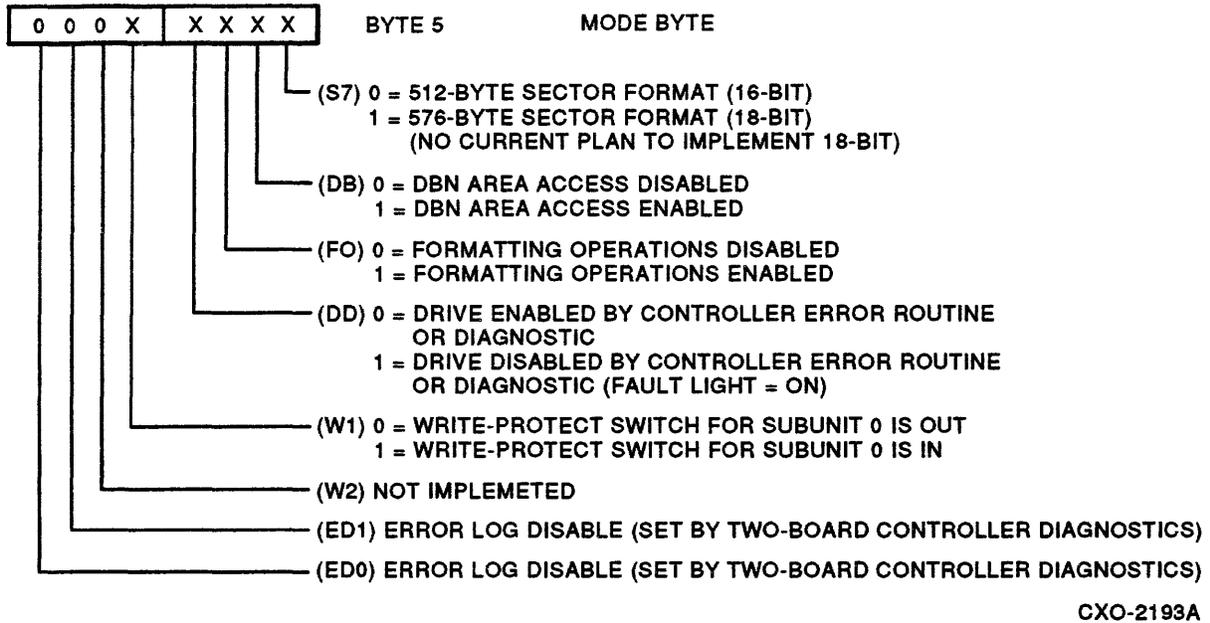
CXO-3017A

5.2.3.3 Request Byte (Byte 4)



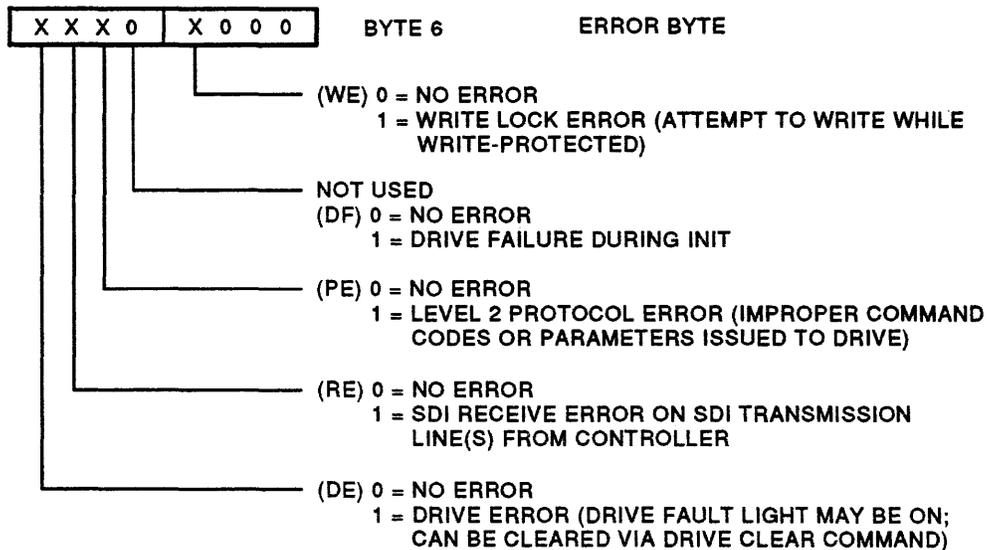
CXO-1281A

5.2.3.4 Mode Byte (Byte 5)



Bits ED1 and ED0 can only be set by two-board controller diagnostics. If either ED1 or ED0 are set (EDx=1), the RA90/RA92 disk drive turns off internal error logging.

5.2.3.5 Error Byte (Byte 6)



The error byte is one of four generic status bytes. Error bits in the error byte are set by the drive for drive-detected errors. The controller clears the bits with the SDI DRIVE CLEAR command. The bits are described as follows:

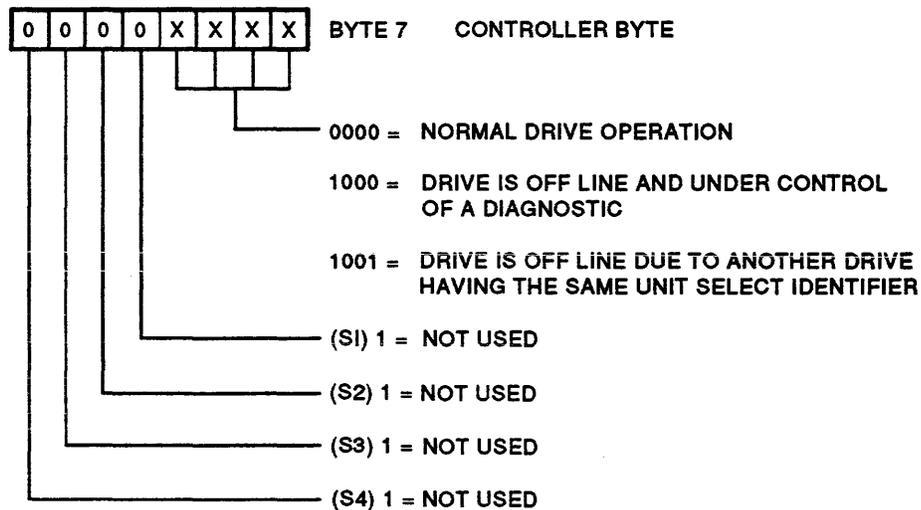
- The DE bit reports any internal drive error that requires explicit controller recovery action other than simple command retransmission or context readjustment.
- The RE bit reports transmission errors detected by the drive.
- The PE bit reports level 2 protocol errors detected by the drive.
- The DF bit indicates the drive did not pass its initialization/diagnostics the last time it was initialized or powered up.
- The WE bit reports the drive received a SELECT TRACK AND WRITE command or a FORMAT command while the drive was write protected.

NOTE

Drive-detected errors fit into one of the five classes described above and are reported as such.

Controller-detected drive errors are logged without any of these bits being set. For example, the drive actuator has positioned itself to a cylinder other than the one the controller requested. The controller detects this failure as a drive positioner error or an invalid header error.

5.2.3.6 Controller Byte (Byte 7)

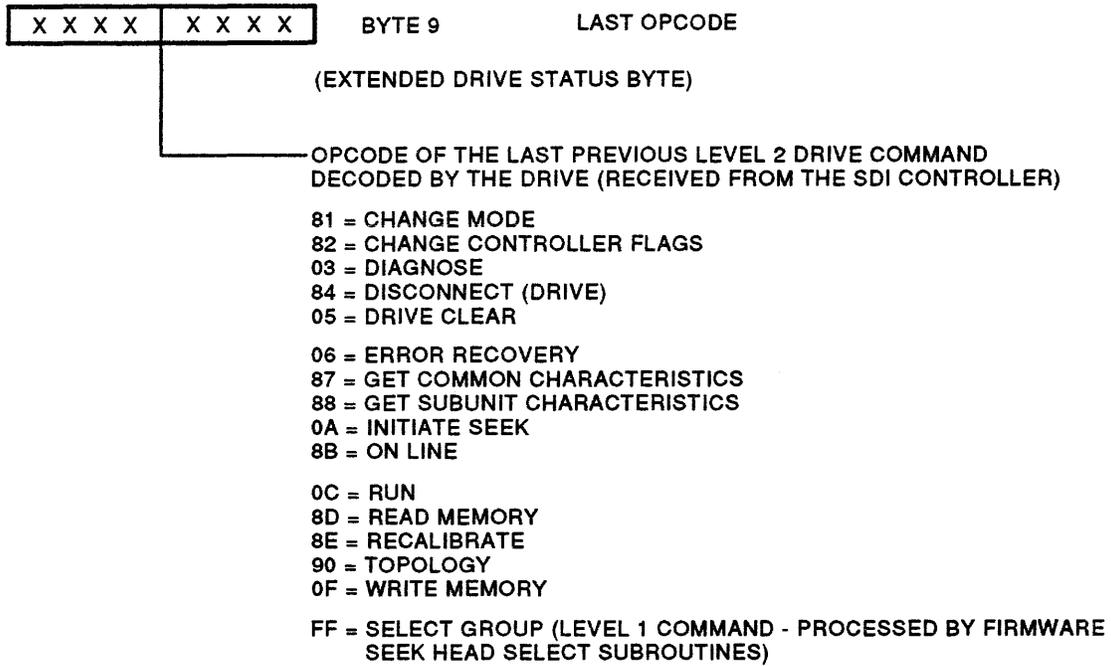


CXO-2158A

5.2.3.7 Retry Count (Byte 8)

Byte 8 is the retry count during the last SEEK or RECALIBRATION command. (The retry count is the number of times the command was retried, internal to the drive, in an attempt to successfully complete the SEEK or RECALIBRATE operation.)

5.2.3.8 Previous Command Opcode (Byte 9)



CXO-1285B

5.2.3.9 HDA Revision Bits (Byte 10)

Byte 10, bits 0 and 1, indicate which vendor heads are used in the HDA. Bit 7 is the UNCALIBRATED bit and indicates the drive failed during drive recalibration.

5.2.3.10 Cylinder Address (Bytes 11 and 12)

Decoding bytes 11 and 12 gives you the cylinder address from the last SDI SEEK command issued to the drive. See Examples 5-1 (for the RA90 disk drive) and 5-2 (for the RA92 disk drive) to determine cylinder address and group (head).

The RA90 implements the following geometry for logical addressing:

The RA90 has 1 logical track = 1 physical track

The RA90 has 1 logical group = 1 logical track

The RA90 has logical cylinder = 13 logical groups

The current cylinder address and current group bytes indicate the cylinder address and group where the read/write heads are positioned. The following formula outlines how to obtain the cylinder head from the logical block number (LBN).

$Cylinder (cyl) = LBN/897 = cyl.fraction (discard\ fraction)$

$Head = (LBN - (cyl * 897))/69 = head.fraction (discard\ fraction)$

LBN to physical cylinder and head number conversion:

If LBN = 23609

Then $23609/897 = 26.32 (discard\ fraction)$

CYL = 26

To find the head, use the following example:

$Head = (23609 - (26 * 897))/69$

Head = 4.16 (discard fraction)

Head = 4

As you can see LBN 23609 = head 4 and physical cylinder 26.

DBN to physical cylinder and track (head on RA90 disk drives) conversion:

$CYL = 2654 + DBN/910 = cylinder.fraction (discard\ fraction)$

$Head = (DBN - ((CYL - 2654) * 910))/70 = head.fraction (discard\ fraction)$

XBN to physical cylinder and head conversion:

$CYL = 2651 + XBN/910 = cylinder.fraction (discard\ fraction)$

$Head = (XBN - ((CYL - 2651) * 910))/70 = Head.fraction (discard\ fraction)$

RBN to convert a RBN to the associated physical cylinder and head, use the following formula:

$CYL = RBN/13 = cylinder.fraction (discard\ fraction)$

Head = RBN - (CYL * 13)

Example 5-1 RA90 Cylinder Address and Group (Head)

5-8 Troubleshooting and Error Codes

The RA92 implements the following geometry for logical addressing:

The RA92 has 1 logical track = 1 physical track

The RA92 has 1 logical group = 1 logical track

The RA92 has logical cylinder = 13 logical groups

The current cylinder address and current group bytes indicate the cylinder address and group where the read/write heads are positioned. The following formula outlines how to obtain the cylinder head from the logical block number (LBN).

$\text{Cylinder (cyl)} = \text{LBN}/949 = \text{cyl.fraction (discard fraction)}$

$\text{Head} = (\text{LBN} - (\text{cyl} * 949))/73 = \text{head.fraction (discard fraction)}$

LBN to physical cylinder and head number conversion:

If LBN = 23609

Then $23609/949 = 24.88$ (discard fraction)

CYL = 24

To find the head, use the following example:

$\text{Head} = (23609 - (24 * 949))/73$

Head = 11.411 (discard fraction)

Head = 11

As you can see LBN 23609 = head 11 and physical cylinder 24.

DBN to physical cylinder and track (head on RA90 disk drives) conversion:

$\text{CYL} = 3104 + \text{DBN}/962 = \text{cylinder.fraction (discard fraction)}$

$\text{Head} = (\text{DBN} - ((\text{CYL} - 3104) * 962))/74 = \text{head.fraction (discard fraction)}$

XBN to physical cylinder and head conversion:

$\text{CYL} = 3101 + \text{XBN}/962 = \text{cylinder.fraction (discard fraction)}$

$\text{Head} = (\text{XBN} - ((\text{CYL} - 3101) * 962))/74 = \text{Head.fraction (discard fraction)}$

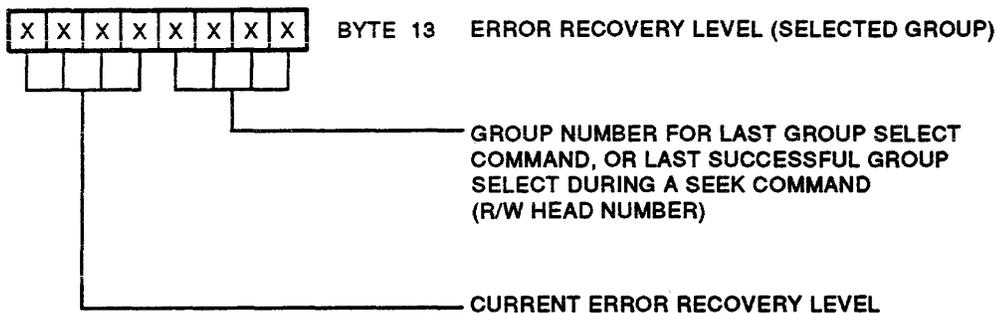
RBN to convert a RBN to the associated physical cylinder and head, use the following formula:

$\text{CYL} = \text{RBN}/13 = \text{cylinder.fraction (discard fraction)}$

$\text{Head} = \text{RBN} - (\text{CYL} * 13)$

Example 5-2 RA92 Cylinder Address and Group (Head)

5.2.3.11 Error Recovery Level (Selected Group) (Byte 13)



CXO-2159A

5.2.3.12 Error Code (Byte 14)

Refer to Section 5.19 for drive error codes and their descriptions.

5.2.3.13 Manufacturing Fault Code (Byte 15)

Byte 15 contains the manufacturing repair code and is used by the repair depot.

5.2.4 Drive Internal Error Log

All drive-detected disk subsystem errors are recorded in the RA90/RA92 drive internal error log. Power-related errors are also recorded. ECC errors are not recorded in the drive internal error log.

Figure 5-2 shows the RA90/RA92 drive internal error log memory layout; Figure 5-3 shows the RA90/RA92 drive internal error log header format; and Figure 5-4 shows the RA90/RA92 drive internal error log descriptor format.

There are three ways to extract the RA90/RA92 drive internal error log:

1. Run DKUTIL from the HSC console or KDM controller (see Section 5.2.4.1).
2. Run utilities for two-board controllers. (Table 5-2 lists the systems that use two-board controllers.)
3. Run drive-resident utility T41 from the RA90/RA92 OCP (see Section 5.2.4.2).

Table 5-2 Two-Board Controller Diagnostics

Monitor	KDA/KDB/UDA
XXDP	ZUDM
VDS	EVRL
MDM	Test drive internal error log utility at the device utility menu

LABEL	BYTE WIDE MEMORY
LOGBUF 0A006H	START OF ERROR LOG HEADER
SAVESET 0A010H	START OF POWER DOWN PAGE; FIRST 8 BYTES ARE DRIVE GENERIC
SAVE0 0A018H	SECOND 8 BYTES ARE DRIVE SPECIFIC
0A025H	LAST BYTE OF HEADER
0A026H	UNUSED
0A02FH	UNUSED
DSCBEG 0A030H	START OF ERROR LOG DESCRIPTORS
0A42FH	LAST BYTE OF LAST DESCRIPTOR
DSCEND 0A030H	END OF DESCRIPTOR MARKER; FROM HERE ON EEPROM IS NOT USED FOR ERROR LOG

CXO-2162A

Figure 5-2 RA90/RA92 Drive Internal Error Log Memory Layout

LOGBUF (ADDRESS LABEL) = 0A006H

WORD 00	FFFB	
WORD 01	SIZE	DEVICE TYPE
WORD 02	ERRORLOG SIZE	
WORD 03	LO ORDER SEEKS SINCE LAST POWERUP	
WORD 04	HI ORDER SEEKS SINCE LAST POWERUP	

SAVESET (ADDRESS LABEL) = 0A010H

WORD 05	LO ORDER CUMULATIVE SEEKS		} POWER DOWN DATA*
WORD 06	HI ORDER CUMULATIVE SEEKS		
WORD 07	LO ORDER TOTAL ELAPSED TIME (MIN)		
WORD 08	HI ORDER TOTAL ELAPSED TIME (MIN)		
WORD 09	OCP SWITCH STATUS	UNIT NUMBER ONES DIGIT	
WORD 10	UNIT NUMBER TENS DIGIT	UNIT NUMBER 100S DIGIT	
WORD 11	UNIT NUMBER 1000 DIGIT	S.SA2 STATUS BYTE	
WORD 12	CUMULATIVE NUMBER OF SPINUPS		
WORD 13	NOT USED = 0000H		
WORD 14	BAD ERROR LOG FLAG	FAULT TABLE POINTER	
WORD 15	POINTER TO DESCRIPTOR ENTRY THAT FAILED		

*MUST BE SAVED AT AN EEPROM PAGE BOUNDRY (XXX0H).

CXO-2160A

Figure 5-3 RA90/RA92 Drive Internal Error Log Header Format

DSCBEG (ADDRESS LABEL) = 0A020H

WORD 00	ERROR TYPE	ERROR CODE		} DRIVE GENERIC INFORMATION
WORD 01	FRU/DRU NUMBER	NUMBER OF ASCII BYTES		
WORD 02	LO NUMBERS SEEKS AT TIME OF ERROR			
WORD 03	HI NUMBER OF SEEKS AT TIME OF ERROR			
WORD 04	ENTRY WRITE COUNT			
WORD 05	NUMBER OF SPINUPS SINCE FIRST POWERUP			} DRIVE SPECIFIC INFORMATION
WORD 06	ERR RCVR LVL	CURR GROUP	TBD	
WORD 07	DESIRED CYLINDER			
WORD 08	LO ORDER TOTAL ELAPSED TIME (MIN)			
WORD 09	HI ORDER TOTAL ELAPSED TIME (MIN)			
WORD 10	ASCII BYTE	ASCII BYTE		
WORD 11	ASCII BYTE	ASCII BYTE		
WORD 12	ASCII BYTE	ASCII BYTE		
WORD 13	ASCII BYTE	ASCII BYTE		
WORD 14	ASCII BYTE	ASCII BYTE		
WORD 15	ASCII BYTE	ASCII BYTE		

CXO-2161A

Figure 5-4 RA90/RA92 Drive Internal Error Log Descriptor Format

5.2.4.1 Running DKUTIL From the HSC Console or KDM70 Controller

Running DKUTIL from the HSC console controller dumps the drive internal error log to the HSC console. The same capability exists for the KDM70 controller.

To display the drive internal error log, enter the DISPLAY ERROR command at the HSC prompt (see the example below).

```

First do:
  DKUTIL> GET Dxxxx (If Drive is capable of being put on line)
OR
  DKUTIL> GET Dxxxx/NOONLINE (If Drive is incapable of being put on line)
THEN
  DKUTIL> DISPLAY ERROR
    
```

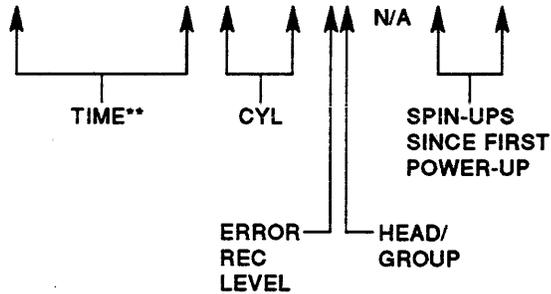
Figure 5-5 shows an example of a formatted drive internal error log. The data in this example will help you determine the time elapsed since a failure occurred.

ERROR LOG ENTRIES FOR DRIVE D090

SELECT STARTING ENTRY LOCATION (1-32) [20]?
 ENTER HOW MANY ERROR LOG ENTRIES TO DISPLAY (0-32) [32]?
 PAUSE AND PROMPT AFTER 10 ERROR LOG ENTRIES [(Y),N]? Y

DRIVE TYPE	MAX#ENTRYS (D)	SEEKS/POWER ON (D)	CUM. SEEKS (D)	CUMULATIVE POWER-ON MINUTES (D)	(H)
RA90	64	328	9065	0000042695	0000A6C7*

ENTRY LOCTN (D)	ENTRY COUNT (D)	ERR TYP (A)	ERR CODE (H)	SEEK COUNT (D)	MFG CODE (H)	DRIVE SPECIFIC HEX DATA BYTE 0-9, RIGHT TO LEFT (H)	DRIVE ERR MESSAGE (A)
20	4	PE	2B	8751	0D	00 00 3F 1C 00 00 00 00 00 17	inv.dmr.num.
19	4	DE	F5	8751	11	00 00 3F 1C 00 00 00 00 00 17	dsp.sek.fit.
18	4	RE	07	8731	0E	00 00 3E 95 05 2C 06 2C 00 15	frm.seq.err.



(D) = decimal
 (A) = ASCII
 (H) = hex

* 0000A6C7 (H) CUMULATIVE POWER-ON MINUTES
 (SUBTRACT) - ** 00003F1C (H) LEFT-MOST FOUR "TIME" BYTES
 (EQUALS) = 000067AB (H) TIME LAPSE SINCE LAST ERROR
 (D) = 26,539 MINUTES

CONVERT HEX TIME LAPSE TO DECIMAL MINUTES, THEN
 CONVERT TO HOURS, THEN
 CONVERT TO DAYS.

CXO-2994A

Figure 5-5 Drive Internal Error Log

The ten bytes of drive-specific hex data printed by the DKUTIL utility are divided by the RA90/RA92 into five data fields. The drive specific hex data fields are:

1. Time (minutes)
2. Cylinder
3. Head/group
4. Undefined
5. Spinups since the last power-up

NOTE

All five data fields represent the drive state at the time of the error.

5.2.4.2 Running the Drive-Resident Utility Dump (T41) From the OCP

Run drive-resident utility T41 to display the drive internal error log. (Refer to Chapter 4 for instructions on how to run this utility.) The drive internal error log is displayed starting with the latest entry and continuing until all entries are displayed. Positions three and two represent the error log entry in decimal. Positions one and zero represent the two-digit LED hex error code. Each entry is displayed for 1.5 seconds. You can start or stop the display using the Run switch.

5.2.5 OCP Fault Indicator/Error Codes

The OCP Fault indicator lights when a hard fault is detected. Select the Fault switch to display an error code. These error codes are described in Section 5.19. Each description includes fault isolation information.

5.2.6 Drive Power Supply Indicator

The drive power supply has a green LED that, when lit, indicates the power supply is operating normally. If the LED is not lit and the drive is experiencing problems, begin troubleshooting in this area. Figure 5-6 shows the location of the green LED.

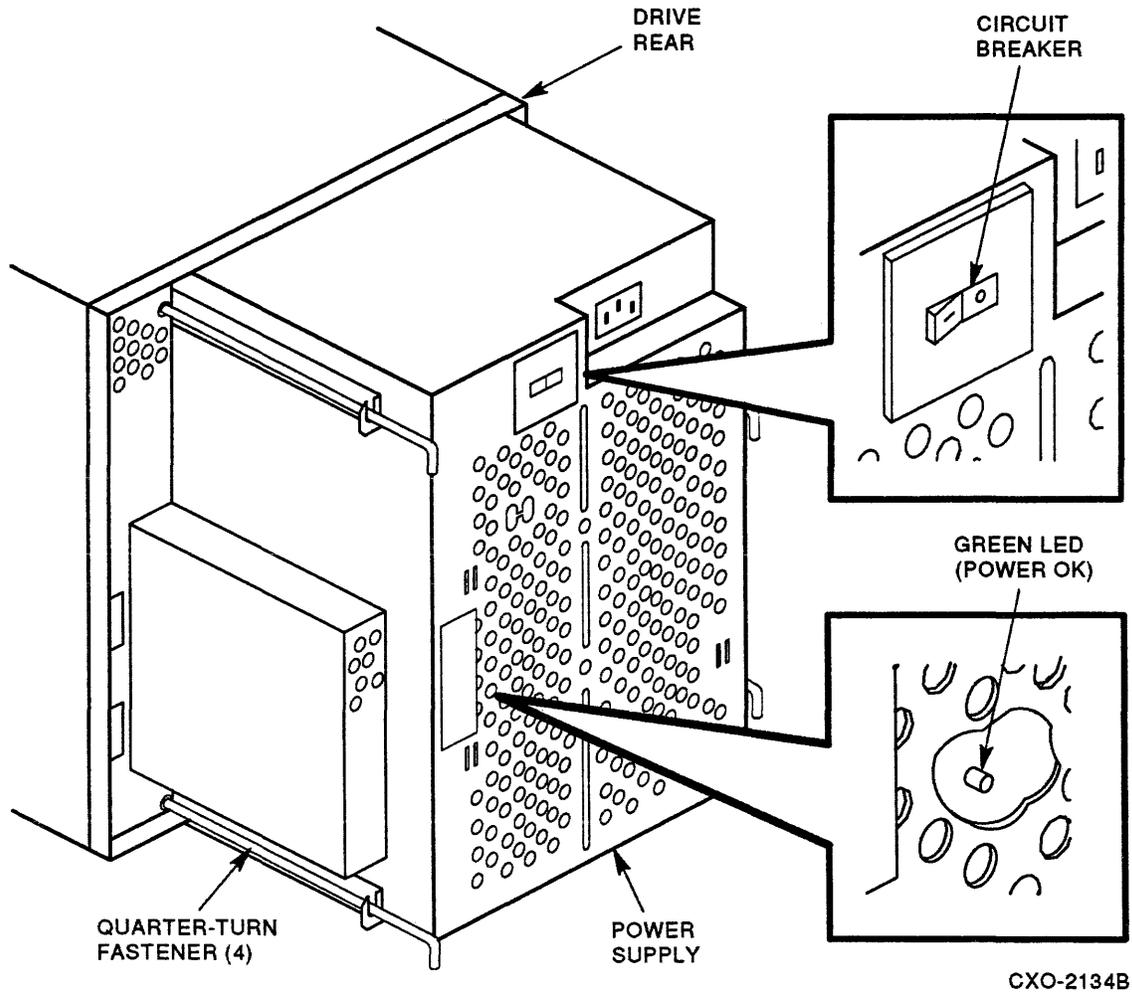


Figure 5-6 Power Supply Indicators

If the green LED appears to be at about half brilliance and the OCP has no display, the power supply is in a crow-bar state. Recycling the circuit breaker may clear the condition.

5.2.7 Drive Error Reporting Mechanisms

The RA90/RA92 detects and reports the majority of real-time errors and faults in the drive, including intermittent failures.

All drive-detected errors are reported to the controller. If error logging is available and enabled, the controller reports errors to the host.

5.2.7.1 Detailed Description of Error Reporting Mechanisms

RA90/RA92 disk drives have five mechanisms available to report error conditions to the controller. The mechanism used is based on the state of the drive, the drive activity at the time of the error, and the error that occurred. The five mechanisms are listed below. As described in this list, it is assumed that a port or ports have been selected from the OCP port select switches.

1. **STOP TRANSMITTING CLOCKS AND DATA OVER ANY SDI LINE**—The drive stops transmitting clocks and data over any SDI line connected to either port if any of the following conditions exist:
 - The drive is off line to the controller.
 - Power is failing.
 - A failure is detected that prevents communication between the drive and the controller.
2. **TRANSMIT CLOCKS BUT NO STATE INFORMATION**—The drive transmits drive clock but does not transmit state (RTDS) information if it is off line to the controller or if it failed resident diagnostics. The only time a drive executes resident diagnostics is at power-up or reset and when an SDI INIT is received by the real time controller state (RTCS) line. If a drive receives an SDI INIT, it executes resident diagnostics verifying processor and communications paths to the controller.
3. **ASSERT ATTENTION IN THE RTDS**—The drive uses the RTDS attention mechanism to report error conditions if the drive is on line to the controller. The RTDS attention mechanism is used when the command timer expires or when one of the generic status bits changes, with the following exceptions: when a generic status bit changes as a result of a correct operation during an SDI level 2 command or an error in an SDI level 2 command occurs.
4. **SEND UNSUCCESSFUL RESPONSE**—An unsuccessful response to an SDI level 2 command is sent to the controller if any of the following conditions exist:
 - The execution of an SDI level 2 command could not be completed successfully. (For example, a level 2 DRIVE CLEAR command was issued but the error condition could not be cleared.)
 - A transmission error occurred during an SDI level 1 exchange and the drive successfully received a valid SDI level 1 end frame.
 - A protocol error occurred.
 - A fault occurred while the drive was executing a topology command.
5. **CONTROLLER RESPONSE TIMEOUT** —This is not a drive mechanism, but it indicates to the controller that the drive has an error condition.

5.2.8 Host-Level Diagnostics and Utilities

If possible, avoid running host-level diagnostics to recreate the symptoms. You only extend the service period. However, under certain conditions you may need to run host-level diagnostics. Refer to Section 5.11.

Do not use host-level diagnostics to verify drive repair; use resident diagnostics tests. Use system-level commands to ensure the drive is on line and operating normally.

5.3 General Troubleshooting Information

The drive internal error log records all drive-detected (DD) faults as error codes. Use the recorded error codes to help isolate faults to a failing or failed FRU. Run the RA90/RA92 disk drive utility program T41, Display Drive Error Log, to extract drive internal error log information.

Real-time faults detected by the disk subsystem are recorded in the host error log of the supporting operating system software. Host error logs contain detailed information on intermittent and hard drive errors and can also be used to isolate the failing field replaceable unit (FRU).

ECC-type errors are detected by controllers and logged in the host (or HSC) level error logs. These errors are not recorded in the drive internal error log. The drive only reports drive-detected errors.

Once a disk drive fault has been isolated to an FRU and repairs have been made, use drive-resident diagnostics to verify proper drive operation.

5.3.1 Drive-Resident Diagnostics Limitations

The following disk functions or areas are not covered by resident diagnostic testing:

1. Customer data areas (are never read or written to during testing).
2. Data paths between the drive and controller.
3. Internal loopback testing (only tests the SDI loopback through the TSID gate array). External SDI testing can be accomplished with resident diagnostic T09 and use of a loopback connector (Digital part number 70-19074-01).

“At-speed” testing of the SDI circuitry is not done. SDI interface testing is accomplished by internally looping the SDI signals within the SDI gate array and TSID. Transformer couplings are not tested.

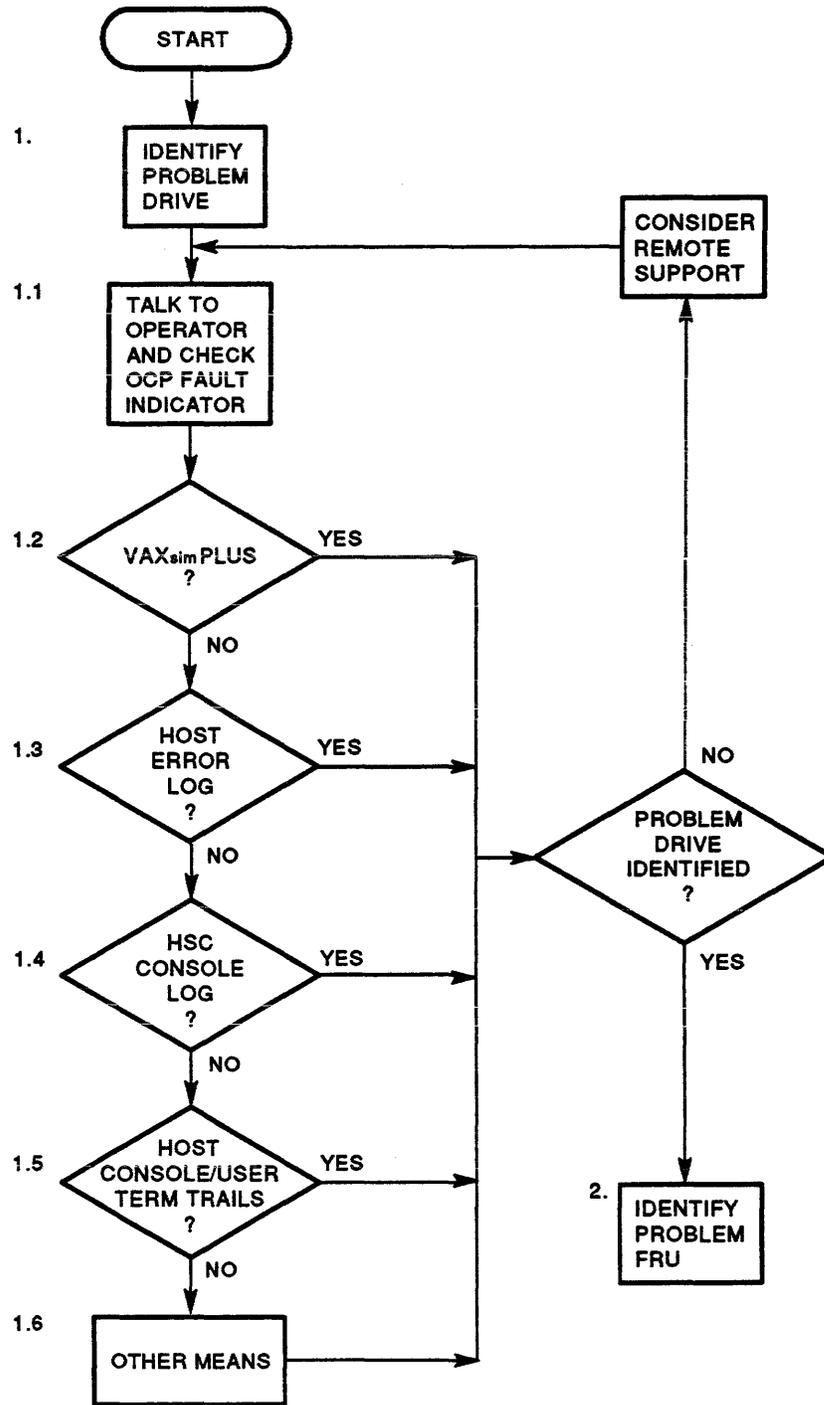
If you suspect media, go to Section 5.8.

Drive-resident diagnostics descriptions are in Chapter 4.

5.4 Step-by-Step Troubleshooting Procedure

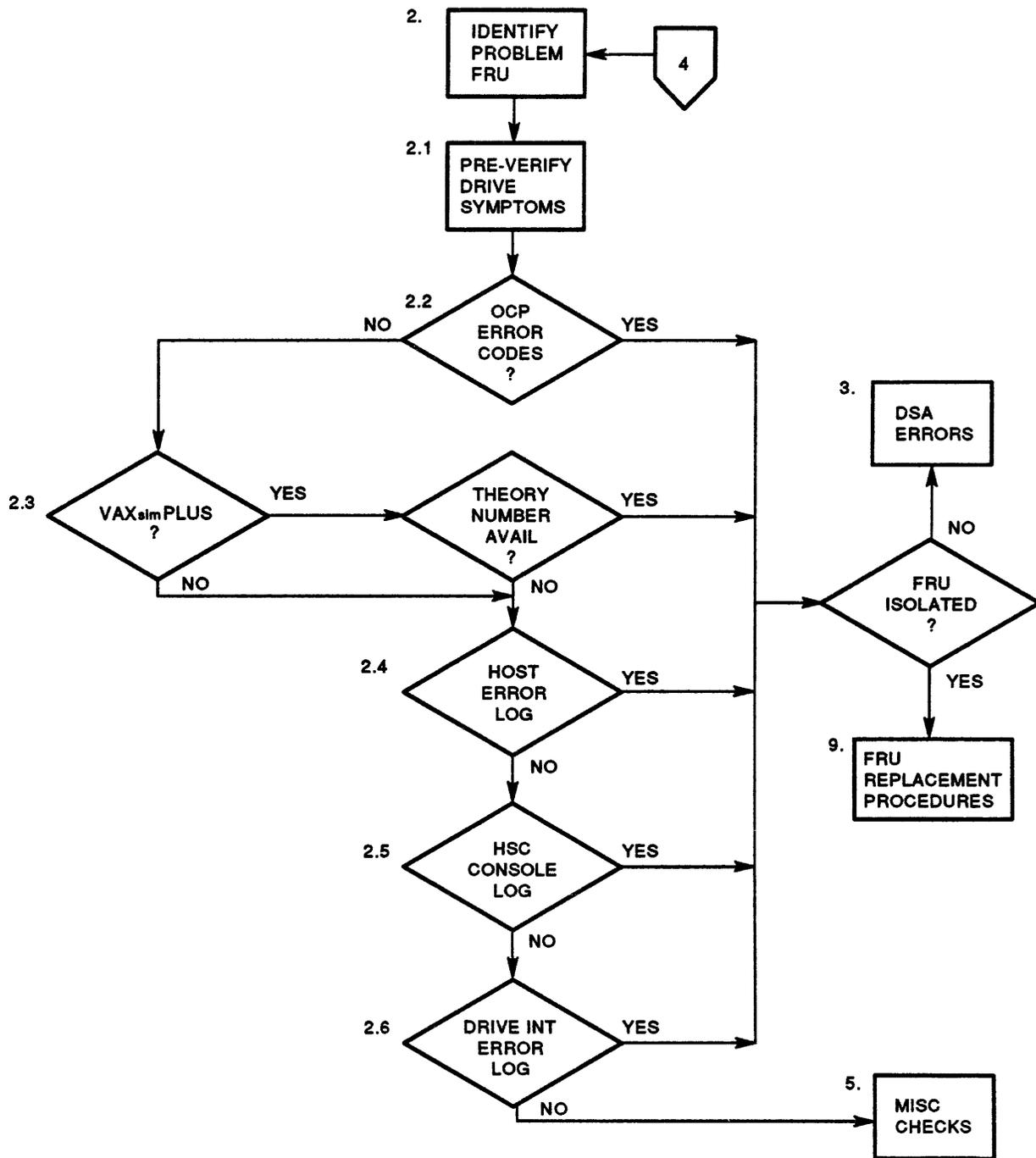
Use this troubleshooting procedure when you are reasonably certain the problem is in a disk drive. Some troubleshooting procedures may require that you follow the entire procedure before isolating the problem. If you have an error code, go to Section 5.19 for a description of the error and an FRU replacement list.

Included in this section is a step-by-step troubleshooting flowchart (Figure 5-7). Each section heading that follows this flowchart contains a number, enclosed within a box, that corresponds to those in the step-by-step troubleshooting flowchart.



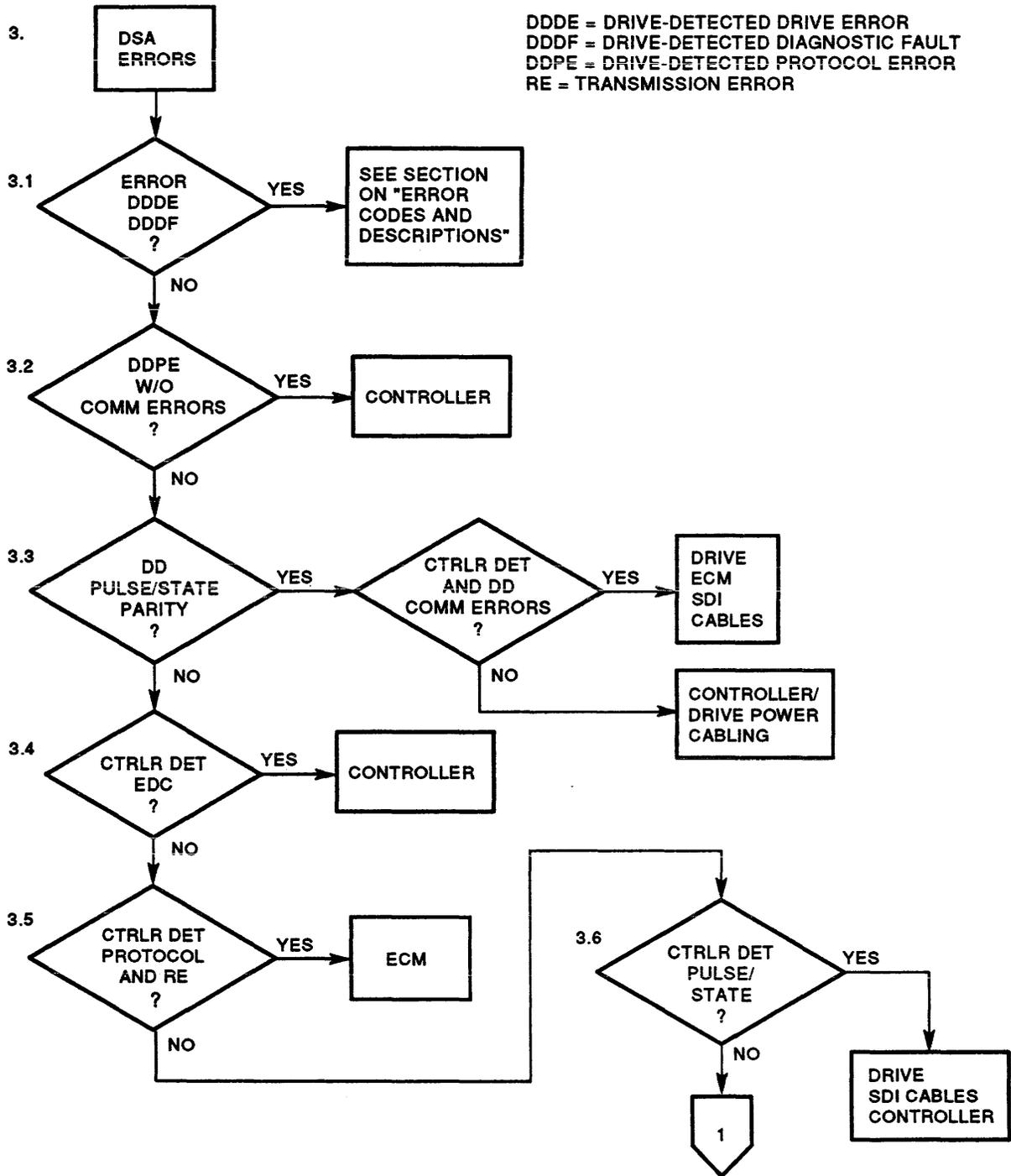
CXO-2163C
Sheet 1 of 6

Figure 5-7 (Cont.) Step-by-Step Troubleshooting Flowchart



CXO-2163C
Sheet 2 of 6

Figure 5-7 (Cont.) Step-by-Step Troubleshooting Flowchart



CXO-2163C
 Sheet 3 of 6

Figure 5-7 (Cont.) Step-by-Step Troubleshooting Flowchart

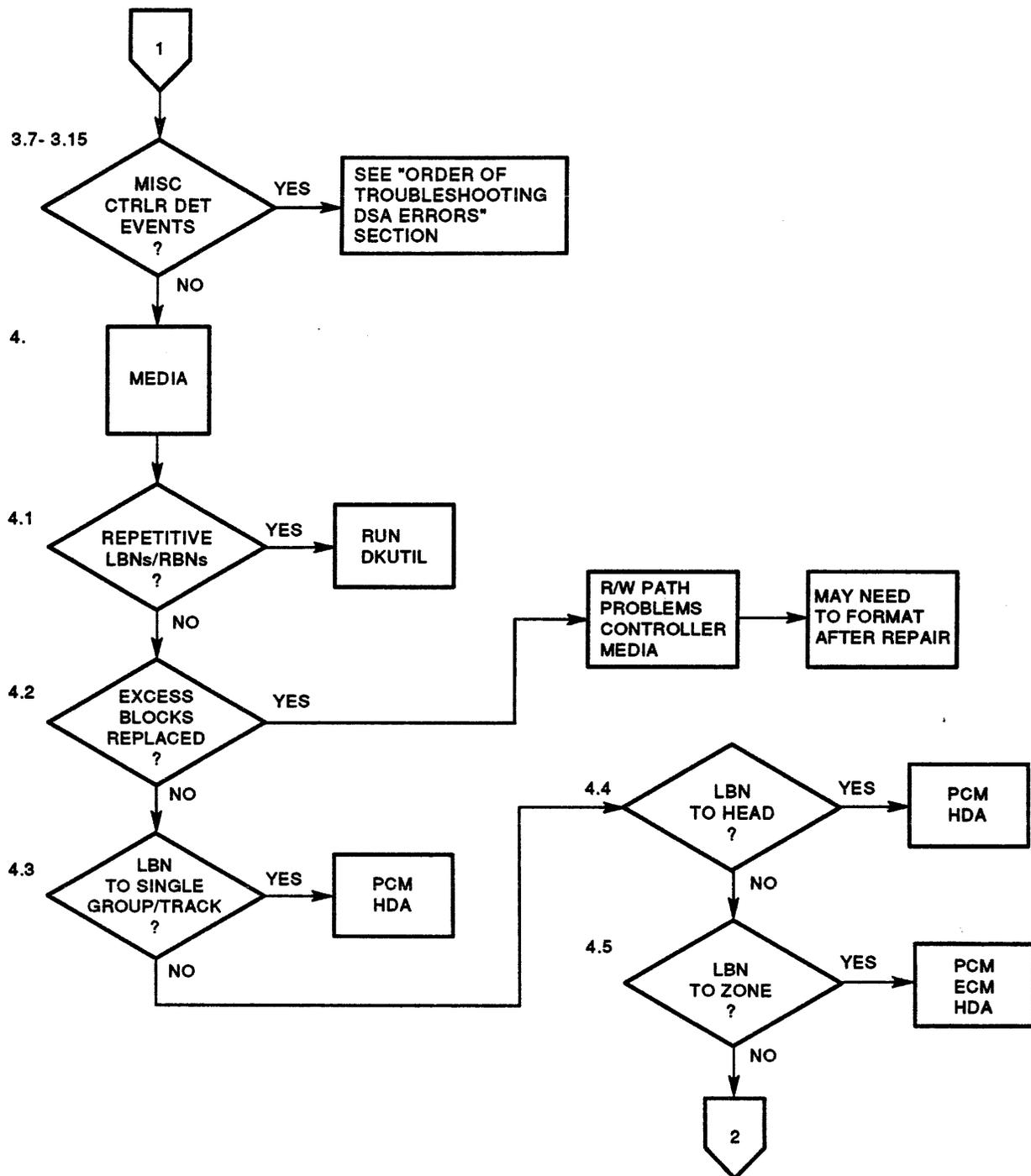


Figure 5-7 (Cont.) Step-by-Step Troubleshooting Flowchart

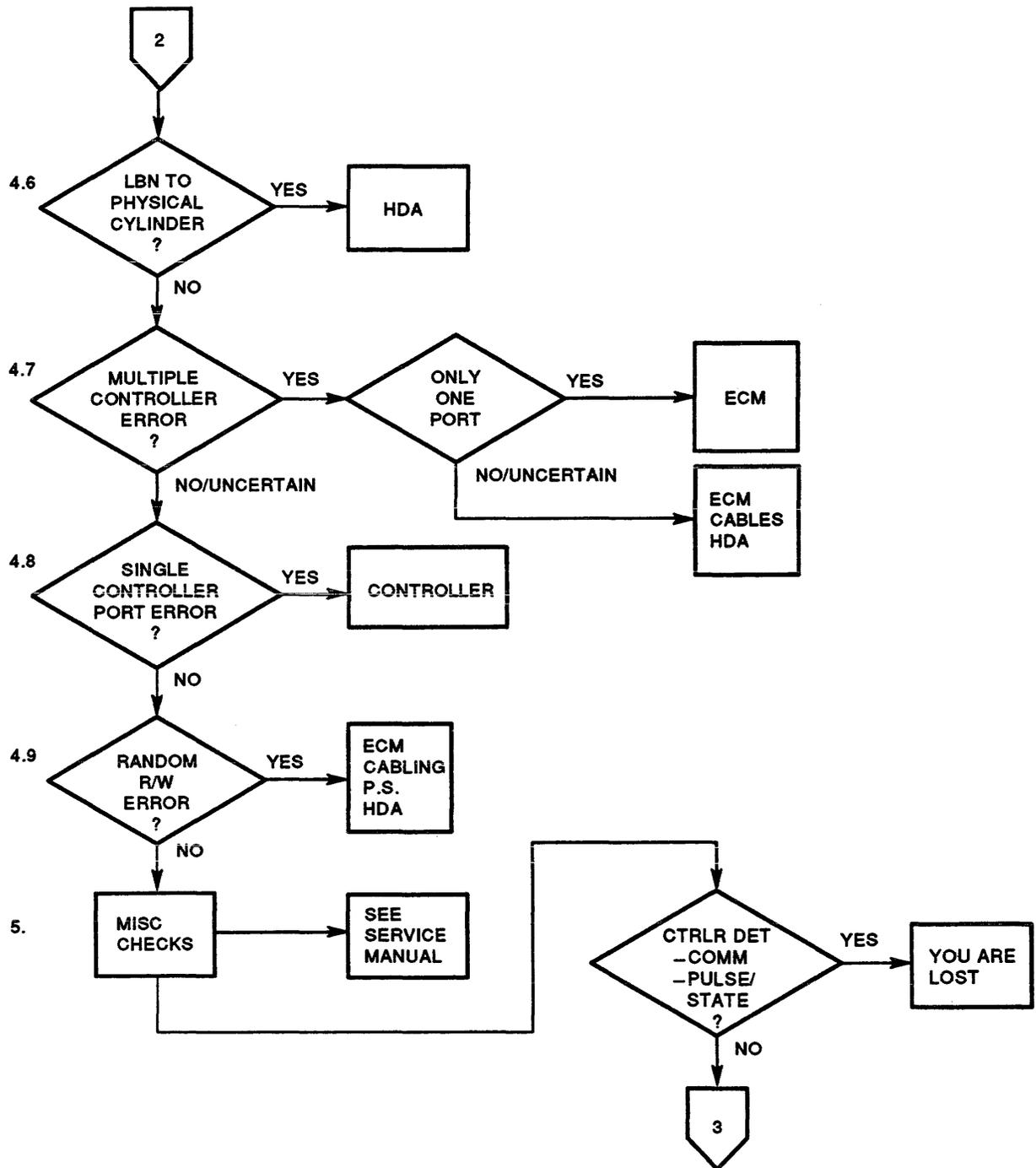
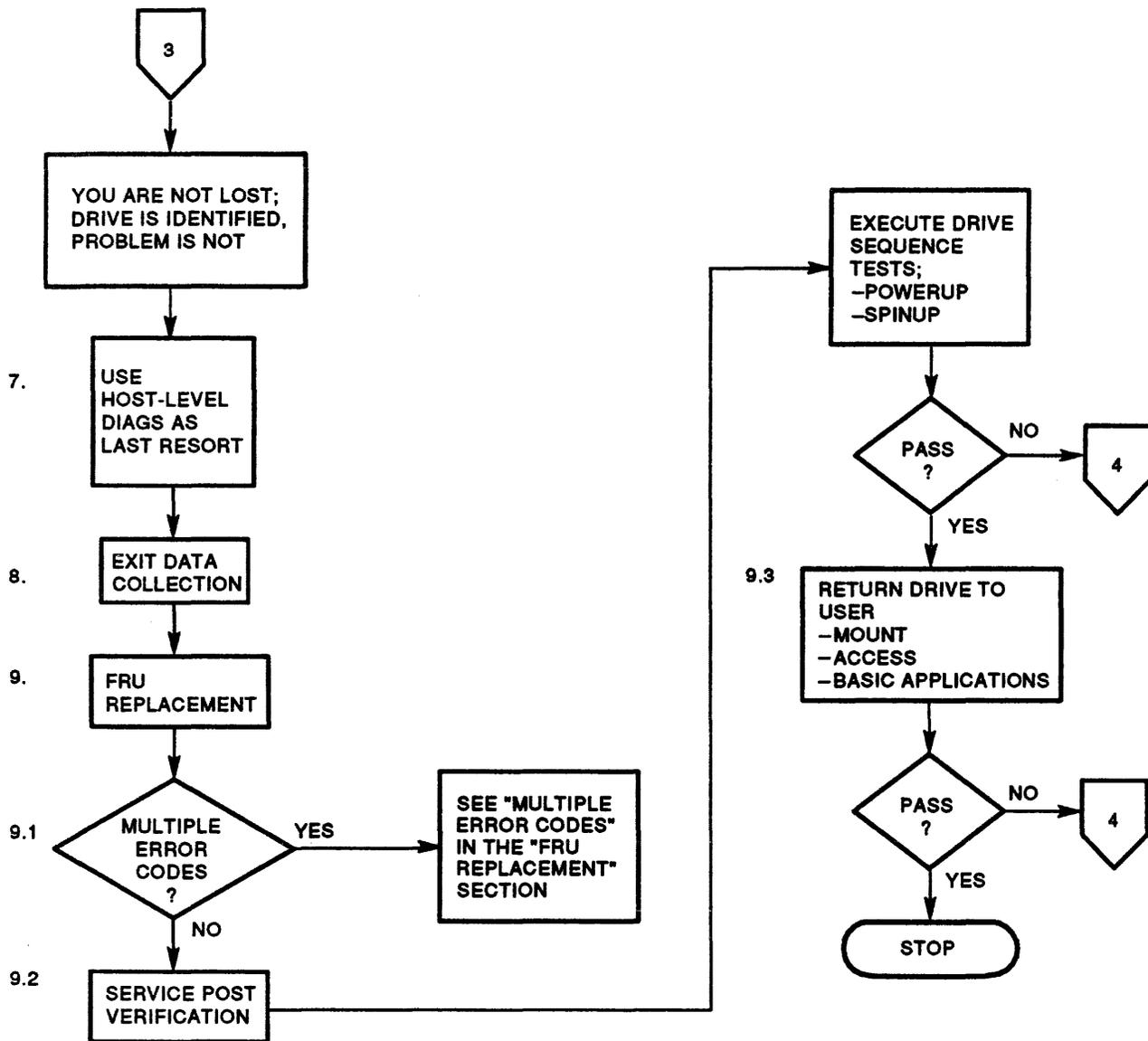


Figure 5-7 (Cont.) Step-by-Step Troubleshooting Flowchart



CXO-2163C
Sheet 6 of 6

Figure 5-7 Step-by-Step Troubleshooting Flowchart

5.4.1 Troubleshooting Worksheet

Develop a worksheet to aid in collecting error data. Identify only those errors being reported against the identified drive. Arrange a piece of wide, line-printer paper with columns identified as follows:

- MSCP Status/Event Code
- Comment Area
- Block Number
- Block Type (LBN or RBN)
- Cylinder
- Group
- Sector
- Drive LED Error
- Drive-Reported Previous/Current Group
- Date/Time of Error

5.5 Identifying the Problem Drive ¶

The cause of local drive error problems generally requires minimum analysis. These problems can be identified by noting that the drive is not performing basic operational functions (power-up, spinup, spindown, and so on), by incorrect lamp indications, or by OCP error codes.

Once you have isolated the problem drive, proceed to Section 5.6.

If you have not isolated the problem drive, refer to Sections 5.5.1 through 5.5.6. These sections describe procedures to use for problem drive identification.

5.5.1 Talking to the System Operator/Checking the OCP Fault Indicator ¶1.1

Discuss drive errors with the system operator/manager and users. Operators or users can provide valuable information concerning system activity at the time of the error (such as applications that were running, disks the data is stored on, affected users, and impact on other applications).

Check the OCP for fault indications.

5.5.2 Using VAXsimPLUS to Identify the Problem Drive ¶1.2

Use VAXsimPLUS to obtain a summary of information that may lead to direct identification of the failing drive. Section 5.1 lists appropriate VAXsimPLUS documentation.

If the problem drive is identified using information obtained with VAXsimPLUS, go directly to Section 5.6.

5.5.3 Using the Host Error Log to Identify the Problem Drive ¶1.3

Study available host error logs. Host error logs provide failing drive and error code information. Use this information to identify failing FRUs.

Refer to the *DSA Error Log Manual* for detailed descriptions of most system-level host error logs.

5.5.4 Using the HSC Console Log to Identify the Problem Drive 1.4

Drives attached to HSC controllers send drive state information to the HSC console log. Use the HSC console log to identify problem drives. Correlate time-of-error information to user operations.

5.5.5 Using the Host Console/User Terminal Trails to Identify the Problem Drive 1.5

If no host error log or VAXsimPLUS resource is available, check host console trails or user terminal trails. These may indicate drive problems and identify the problem drive.

5.5.6 Using Other Means to Identify the Problem Drive 1.6

If no hard fault indications, error logs, or console logs are available to identify the problem drive, refer to Section 5.9.

It is important to identify the failing disk drive before attempting to isolate the failing subsystem component. If more than one drive exhibits the same failure symptoms, examine the possibility of a controller or system problem.

NOTE

Using DSA utilities such as Error Log Dumper (ZUDM/EVRL/MDM/DKUTIL) to dump the RA90/RA92 drive internal error log may identify problem hardware areas. However, there may be a significant negative impact on the availability of hardware and data to the customer. Consider off-line diagnostics only as a last resort.

DSA utilities (Bad Block Replacement or HSC Verify) verify that the logical structures of the user data are correct. Additionally, these utilities check the status of any revectorized blocks, blocks with forced error flags set, blocks marked bad in the RCT area, the number of primary and non-primary replaced blocks, and blocks that exceed symbol error thresholds. User data areas that have flagged forced error conditions are identified as disk areas that cannot be accessed due to media or drive problems.

Transient problems may require the use of off-line diagnostics. EVRL, ZUD, and MDM frequently miss a problem executing in the DBN area of a disk. You may have to exercise the customer data area of the disk to increase the chances of generating an error.

CAUTION

Back up customer data before executing diagnostics on customer data areas of the disk.

Refer to Section 5.11 for host-level diagnostics information.

5.6 Identifying the Problem FRU 2

After identifying the problem drive, you must identify the failing FRU. The following sections describe procedures to use for identifying the problem FRU.

Use the host error log or HSC console log to fill in the troubleshooting worksheet (described in Section 5.4.1). Calculate the logical cylinder, group, and sector from the targeted LBN or RBN and add that information to the worksheet. Drive-reported errors (SDI error packet) include valid extended drive status bytes that call out the logical cylinder, the previous and current group select, and the master drive error code.

After the data is collected, analyze the data to select the most logical replacement FRU. Proceed to Section 5.7 and compare the collected data to determine troubleshooting priority.

5.6.1 Pre-Verifying Drive Symptoms 2.1

After identifying the drive, you should verify drive failure symptoms by performing pre-verification testing of the drive. Pre-verification of drive symptoms using resident diagnostics has the following benefits:

- Establishes a basis for post-verification and:
 - Ensures that no new problems have been introduced.
 - Ensures that a replaced FRU corrected the problems detected during pre-verification testing.
- Establishes a more reliable error code or condition to troubleshoot. Generally, errors detected while performing drive-resident diagnostics have a higher priority than errors or symptoms derived from any source previously mentioned.

To complete pre-verification testing, perform the following steps:

1. Spin up the drive.
2. Execute resident diagnostic test T60 (loop-on-test utility).
3. Execute resident diagnostic test T00 (sequence test).

Examine the drive internal error log and note the type of errors. Compare the generated errors to the error symptoms originally encountered. The following sections help isolate the failure symptoms to the failing FRU.

5.6.2 Using OCP Error Codes to Identify the Problem FRU 2.2

Correlate error codes displayed in the OCP, host error logs, or drive internal error logs to error descriptions given in Section 5.19. Each error description includes a list of suggested replacement FRUs. Use this list to repair the drive. Verify repairs using the post-verification procedures defined in Section 5.13.2.

5.6.3 Using VAXsimPLUS to Identify the Problem FRU 2.3

VAXsimPLUS identifies FRU replacements based upon an analysis of the errors being recorded by the VMS error logging system. VAXsimPLUS identifies the failing FRU through a *theory number*.

The procedure for cross-referencing theory numbers to drive FRUs is determined by individual Digital service areas. Each service area has the responsibility of defining and implementing VAXsimPLUS in line with individual area service goals and strategies.

If VAXsimPLUS identifies a failing FRU, replace the FRU then proceed with post-verification testing. Refer to Chapter 6 for FRU removal and replacement procedures.

5.6.4 Using the Host Error Log to Identify the Problem FRU 2.4

If the system does not support host error logs, or if a host error log cannot be obtained, go to Section 5.6.5

If you are working in a cluster environment, it may be easier to use the HSC console log. The HSC console log is a condensed version of the host error log. Proceed to Section 5.6.5 for information on using the HSC console log.

The following is a data collection step:

Access the host error log. Obtain the drive and controller event (error) codes. Note the LBNs involved in read/write disk transfer errors.

Note the LBN being reported in the data transfer error packet. Also note if any of the following error types have been detected by the controller:

- Data errors
- ECC errors
- Uncorrectable ECC errors
- Header-not-found errors
- Invalid header errors
- Header compare errors
- Format errors
- Data sync timeout errors

Study the SDI error packet of the error log for drive-detected errors and check for the following information:

- Error code
- Drive group number
- Logical cylinder number

For controller-detected (communication) errors, such as protocol or transmission errors, note the controller-reported error code in the status/event code field.

5.6.5 Using the HSC Console Log to Identify the Problem FRU 25

If the disk drive is not attached to an HSC or KDM and no supporting error data is available, go to Section 5.6.6.

The amount of subsystem error information reported by the HSC console log depends upon the HSC error threshold level setting. The HSC SETSHO utility can be set to alter the error threshold level as follows:

- Information
- Warning
- Error
- Fatal

Execute the HSC SHO SYSTEM command to display the error threshold parameter setting. If the error threshold is set sufficiently high (fatal), no error information may be available from the HSC console log. Refer to Section 5.6.6 to continue error analysis.

If the drive is attached to an HSC, check the HSC console log. Use the *HSC Service Manual* to decode the console error log. Obtain status/event codes, drive extended status bytes for the drive LED error codes, and the LBN addresses at the time of the error. Organize the gathered information on the troubleshooting worksheet to help isolate the failing FRU. Proceed to Section 5.7 and compare the collected data to determine troubleshooting priority.

If the information from the HSC console log does not identify the problem FRU, go to Section 5.6.4 to examine the host error log, or Section 5.6.6 to examine the drive internal error log.

5.6.6 Using the Drive Internal Error Log to Identify the Problem FRU [2.6](#)

If the drive is connected to a cluster, it is strongly recommended that you dump the drive internal error log before troubleshooting or attempting FRU replacement.

To extract the RA90/RA92 drive internal error log, use one of the following methods:

- Run DKUTIL from the HSC console or KDM controller (see Section 5.2.4.1).
- Run drive-resident utility T41 from the RA90/RA92 OCP (see Section 5.2.4.2).
- As a last resort, run utilities such as MDM, EVRLL, or ZUDMxx.

NOTE

Off-line diagnostics remove system availability from the user and should only be used as a last resort.

Media problems such as ECC errors are not logged in the drive internal error log. Proceed to Section 5.8 for media errors.

If you cannot access the drive internal error log, verify the physical connection between the drive and the controller. If the drive is attached to an HSC, type a SHOW DISK command at the HSC console to verify that the drives are on line to the controller.

If no errors have been logged, or the drive internal error log is inaccessible, proceed to Section 5.9.

If a host error log or an HSC console trail has been acquired, proceed to Section 5.9.

5.7 Priority Order of Troubleshooting DSA Errors [3](#)

The priority order of troubleshooting DSA errors is important. The following sections describe the importance of each error type and DSA reporting mechanisms.

5.7.1 Drive-Detected Drive Errors and Diagnostic Faults [3.1](#)

Give error codes in this category top priority.

Drive-detected drive errors (DDDEs) appear in host error logs and HSC console logs provided the error threshold is set low enough. DDDEs are also available in the drive internal error log.

Drive-detected diagnostic faults (DDDF) appear in the drive internal error log, although they may be seen at the host level. This error type is top priority.

5.7.1.1 Drive-Detected Protocol Errors Without Communication Errors [3.2](#)

The occurrence of drive-detected protocol errors (such as errors 07, 0C, and so on) without the occurrence of transmission errors (errors 20, 21) indicate a controller problem or an electronic control module (ECM) failure. Troubleshooting must be done on that basis.

The occurrence of drive-detected transmission errors with error codes 08, 09, 0D, 0E, 0F, 10, 16, 19, 1A, 29, 2A, 2B, 2E, or 2F without communication errors generally indicate a controller problem. The drive detects these errors by analyzing packet frames as they are being received. If the drive is at fault (in other words, replacing the controller did not fix the problem), replace the drive ECM module.

5.7.1.2 Drive-Detected Pulse or State Parity Errors [3.3](#)

The occurrence of transient, drive-detected communication errors occasionally causes a protocol error. This is generally a manifestation of communications problems. Determine if the problems occur on the transmit or receive lines from the controller to the drive. Drive error codes associated with pulse or parity errors are 0A, 20, or 21.

If the drive is seeing drive-detected communication errors, then the drive ECM receive circuitry, SDI port transmit circuitry (controller), or SDI cabling is suspect. Reconfiguration might further isolate the problem (use different drive/controller ports and cable combinations).

If the controller is seeing communication errors (these also show up as ECC errors) and the drive is also seeing communication errors, then the whole path (drive to controller) is suspect. It is important to make a distinction between the communication errors and ECC errors. If an SDI subsystem is having communication errors, one of the manifestations (not the cause) is ECC errors. If the communication errors are severe enough, data transfers are halted.

NOTE

Fix communication problems before concentrating on ECC or positioner errors.

Ensure SDI cable connections are secure enough to provide proper electrical and mechanical continuity.

5.7.2 Controller-Detected EDC Error 3.4

NOTE

EDC errors are *not* caused by drives.

EDC is a data protection mechanism to ensure data integrity within a disk controller. In contrast, the ECC mechanism ensures data integrity from the controller through the drive, to the media, and back again. ECC ensures integrity of customer data and the EDC mechanism together.

It is important to note the differences in how controllers implement the EDC mechanism:

- For the KDA/KDB/UDA family of controllers, EDC is generated on a sector of data at the bus interface as the data is initially read from host memory. EDC is verified on a sector basis as the data is written to host memory from the controller memory. Therefore, xDA/xDB controllers generate and check EDC. The microcode engine of the controller performs this check at the bus interface.
- For HSC controllers, EDC is generated on a sector of data at the K.pli port processor module as the data streams in from host memory over the CI bus. EDC then becomes an integral part of the user data as the data is transferred to the HSC data memory. As this data is read out of HSC data memory by the K.sdi modules and transmitted to the drive, user data EDC is regenerated and checked in the K.sdi and compared to the EDC characters appended to the data by the K.pli.

The EDC must check OK, or the write-transfer-to-disk will be aborted. The HSC again requests the data from host memory and again queues the write-transfer-to-disk when data becomes available in the HSC data memory. If the EDC checks OK at the K.sdi on a write-to-disk, the EDC and ECC codes are appended to the data stream and written to disk with ECC ensuring data integrity of the customer data and the EDC code.

For a disk read, the data, as it is read by the K.sdi (over the SDI read/response line), is checked for good ECC, then the data plus EDC characters are stored in HSC data memory. As the data is sent to host memory, the K.pli, while transferring the data to host memory, verifies that good EDC exists for the customer data block but does not transfer EDC characters to host memory. If EDC is bad, the K.pli informs the HSC functional code to again request the same data from the disk.

- For KDM controllers, EDC is generated on a sector of data at the bus interface as the data is initially read from host memory. EDC is verified on a sector basis at the SDI SERDES port interface as the data is written to disk. On a read, EDC is checked by the SDI SERDES at the completion of each sector read (and data correction, if applicable). EDC is checked again as the data is written to host memory from the controller memory.

If EDC errors are detected, the problem is a controller problem. The ECC is protecting the data to and from the disk and checking the integrity of the data at the SDI port module logic.

NOTE

A properly functioning controller always reads bad EDC written to disks. However, if bad EDC is written to a disk (improperly functioning controller), each time the block with bad EDC is read, EDC errors are logged against the drive. Only after the data is restored or rewritten to the disk with good EDC by a good controller will the errors go away.

5.7.2.1 Controller-Detected Protocol and Transmission Errors Without Communication Errors (Status/Event Codes 14B or 4B) [3.5](#)

The troubleshooting process for this type of error is very similar to the discussion in Section 5.7.1.1. It is important to determine that the controller detected protocol errors without basic communications errors such as:

- Protocol errors—A level 2 response from the drive had correct framing codes and checksum but was not a valid response under SDI protocol rules. If the opcode on the read/response line has an odd number of bits, it is an unknown opcode; if the response packet is bad, it is also classified as a protocol error.
- Transmission errors—The controller detected an invalid framing code or a checksum error in a level 2 response from the drive. The UDA50 also returns the same status/event code for controller-detected protocol errors.

Table 5-3 Summary of Controller-Detected Communication Errors

Controller-Detected Communication Errors	Status/Event Code				
	HSC	UDA	KDA	KDB	KDM
Protocol	14B	4B	14B	14B	14B
Invalid frame code, level 2 checksum	4B	4B	4B	4B	4B
Pulse/state parity (wire)	10B	10B	10B	10B	10B

Communication (wire) errors are described in Section 5.7.2.2.

5.7.2.2 Controller-Detected Pulse or State Parity Errors (Status/Event Code 10B) [3.6](#)

The procedure for handling controller-detected communication errors is very similar to the one described in Section 5.7.1.2. The controller detected a pulse error on the state or data line, or the controller detected a parity error in a state frame from the drive. This error is associated with the controller and drive SDI port electronics (including interconnecting cables).

The symptoms indicate a basic (wire) communications problem within the SDI pathway, including drive or controller port electronics. Noise can be injected through the port electronics or the cabling between the controller and the drive. Additionally, bad cables (bent, walked on) or loose connecting hardware (bulkhead connections) can contribute to the problem.

Pulse errors are caused by two consecutive pulses of the same polarity. SDI signal lines use an NRZ transmission technique where no two adjacent pulses can be of the same polarity. This is detected on either the state or read/response line.

A state parity error is the occurrence of bad parity over the length of a single SDI RTDS state frame or SDI read/response frame. This type of error may also result in the detection of ECC errors during data transfer times. This occurs when the read/response line and the write/command line are functioning as the data line.

Controller-detected transmission errors (4B) occur if an invalid framing code or a checksum error is detected during a level 2 response from the drive.

NOTE

The UDA50 also returns this status/event code for controller-detected protocol errors.

5.7.3 Controller-Detected Communication Events and Faults [3.7](#)

Controller-detected communication events include:

- Loss of read/write ready—MSCP Status/Event 8B
- Loss of receiver ready—MSCP Status/Event CB
- Receiver ready collisions—MSCP Status/Event 1AB
- Drive clock dropout—MSCP Status/Event AB
- Failure of drive initialization process—MSCP Status/Event 16B
- Failure of drive to respond to controller-requested initialization—MSCP Status/Event 18B
- SERDES overrun error (in controller)—MSCP Status/Event 2A
- SDI drive command time-out—MSCP Status/Event 2B

Communication systems have faults and event irregularities. Communication faults are events, but not all events are faults. The difference is related to timing between events and system operations occurring at the time of the event.

For example, a loss of read/write ready is an event if no write activity is occurring at the time of the loss. During a write, however, a loss of read/write ready is an error (fault) event.

5.7.3.1 Controller-Detected: LOSS OF READ/WRITE READY (Status/Event Code: 8B) [3.8](#)

The controller event is LOST READ/WRITE READY DURING OR BETWEEN TRANSFERS. This error indicates read/write ready (RTDS status bit) was negated when R/W ready had been previously asserted (indicating completion of a preceding seek) and:

- The controller attempted to initiate a transfer, or
- A R/W ready was found negated at the completion of a transfer

This event usually results from a drive-detected transfer error, in which case an additional error log message may be generated containing the drive-detected error event code.

This error may be symptomatic of a fine track servo problem in the RA90/RA92 disk drive. If there are no other such subsequent error log entries, the loss of fine track was probably responsible for the loss of read/write ready. Examine the drive internal error log for evidence of servo problems.

5.7.3.2 Controller-Detected: LOST RECEIVER READY (Status/Event Code: CB) [3.9](#)

RECEIVER READY (RTDS status bit) was negated when the controller attempted to initiate a transfer, or RECEIVER READY was not asserted at the completion of a transfer. This includes all cases of the controller timeout expiring for a transfer operation (level 1 real-time command).

As a consequence of this condition, the controller performs an SDI INIT then attempts to request a GET STATUS. The extended status error log entry returned in the GET STATUS command may indicate what the problem is.

If no information is being reported by the drive as a part of the error log sequence, approach the problem as a drive ECM failure. Examine the drive internal error log for extended error information.

5.7.3.3 Controller-Detected: RECEIVER READY COLLISION (Status/Event Code: 1AB) [3.10](#)

The controller attempted to assert RECEIVER READY (RTCS status bit), indicating it was ready to receive a drive response. The drive RECEIVER READY (RTDS status bit) was still asserted, indicating it was ready to receive a command from the controller.

This is not an error, but an event within the subsystem. All DSA drives and controllers occasionally log this event. There is no performance impact because of the occasional occurrence of this event. No data corruption is associated with the occurrence of this event if no other SDI bus errors occur at the same time.

Acceptable event rates for RECEIVER READY collisions are less than ten per day, provided the following events are not contributing:

- Broken physical SDI interconnects (plugging and unplugging SDI cables).
- Controller (node) initializations or HSC failovers.

NOTE

The occurrence of RECEIVER READY collisions happens primarily when both Ports A and B are enabled at the drive.

Resolve unacceptable event rates of more than ten a day by replacing either the ECM or controller port interface module, cables, or bulkheads.

5.7.3.4 Controller-Detected: DRIVE CLOCK DROPOUT (Status/Event Code: AB) [3.11](#)

Either data (read/response line) or state clock (RTDS) was missing when it should have been present. This is usually detected through a timeout.

A fatal drive condition can cause the drive to drop the drive clocks. The drive should reassert clocks after performing a drive initialization and establishing clocks to the controller to re-establish communications and state information between the drive and controller. The sequence of getting status and error information then occurs. Analysis of error log message packets usually indicates that the above sequence has occurred.

If such message packets are not being processed or received, it is possible that the condition cannot be detected by the drive. Execute drive SDI loopback tests to try to find subtle SDI problems. The order of emphasis is:

- ECM
- Controller port module
- Cabling (including bulkhead connectors)

5.7.3.5 Controller-Detected: DRIVE FAILED INITIALIZATION (Status/Event Code: 16B) [3.12](#)

The drive clock failed to resume following a controller-attempted drive initialization. This implies the drive encountered a fatal initialization error. It may also indicate the drive was attempting its own initialization or that the drive is looping in an initialization state or routine.

5.7.3.6 Controller-Detected: DRIVE IGNORED INITIALIZATION (Status/Event Code: 18B) [3.13](#)

The drive clock continued running even though the controller attempted to perform a drive initialization. This implies the drive did not recognize the INIT command from the controller. It may also indicate the drive was performing an initialization caused by some drive-detected condition and, in the course of initialization, ignored the controller's attempt to initialize the drive.

5.7.3.7 Controller-Detected: SERDES OVERRUN ERROR (Status/Event Code: 2A) [3.14](#)

SERDES overrun (or underrun) errors indicate that the drive is too fast for the controller or, more typically, a controller hardware fault is preventing the controller microcode from keeping up with data transfers to or from the drive.

Because of the speed with which the RA90/RA92 disk drive handles data transfers, some SDI controller ports may not be able to keep up with data transfers to and from the drive. This speed sensitivity may even show up on drive ports that have successfully run other RA-type disk drives.

There is *not* a universal problem with Digital SDI controller port boards. The controller port boards design supports RA90/RA92 operating speeds.

The SERDES overrun problem manifests itself as transient occurrences of the error or as solid SERDES problems preventing execution of read/write operations to the drive. For all controllers, the SERDES occurrence looks like a single controller port failure and is seldom related to a particular drive port.

5.7.3.8 SDI Drive Command Timeout (Status/Event Code: 2B) [3.15](#)

A controller may report an SDI command timeout when it issues a command to the drive and the drive does not respond within the required timeout period. The timeout period is command-dependent.

SDI command timeouts are associated with Status/Event Code 2B. These events will frequently occur under the following conditions:

- Powering up a drive with one or both port switches depressed, then hitting the Run switch.
- Spinning down a drive with one or both port switches depressed.

Under these two conditions, the SDI command timeout event reports can be ignored. However, under other conditions, you should examine SDI command timeout events by looking at the logged errors around the time of the event. The drive internal error log may also reveal clues to the problem; however, you should verify that the time of the error, as logged in the drive, corresponds to the time of the event.

If the controller is an HSC, verify that the device priority is correctly managed. The RA90/RA92 disk drive's place in the priority scheme is as follows:

```
TA90—highest priority
RA90/RA92
ESE2x
RA82
RA81
RA70
RA80—lowest priority
```

5.8 Media-Related Errors [4](#)

Media and read/write transfer problems manifest themselves in many ways. Symptoms include:

- ECC errors (refer to Section 5.16)
- Uncorrectable ECC errors (refer to Section 5.16.1)
- Header-not-found errors (refer to Section 5.16.1)
- Invalid header errors (refer to Section 5.16.1)
- Header compare errors (refer to Section 5.16.1)
- Format errors
- Data sync timeout errors

Read/write errors may involve the read/write data path or defective media. For the SDI disk subsystem, the read/write data path includes:

- SDI controller read/write data path circuits
- SDI cables and bulkhead connectors
- Disk drive read/write data path hardware
- Disk drive media

Use the following process to analyze read/write transfer errors:

1. Isolate the LBNs associated with the logged transfer errors in the host or HSC error log. If there are many, randomly select 10 to 20. Use the appropriate algorithm to decode targeted LBN numbers to the logical cylinder, group, and head. Refer to Example 5-1 for RA90 LBN conversion, and Example 5-2 for RA92 LBN conversion.
2. Decode the LBNs in question to physical cylinders, tracks, and groups (physical read/write heads).

5.8.1 Repeating LBNs/RBNs 4.1

LBNs or RBNs that consistently recur in the host error log should be replaced. If the controller or system has not marked these for replacement, replace them manually by running HSC DKUTIL, EVRLK, or ZUDLx, and MDM. This is a useful procedure for blocks that consistently report ECC or data errors.

This symptom occurs when the host bad block replacement (BBR) software does not use customer data as a pattern to test the suspect block. The block is initially flagged for replacement. The host executes a test of the block and finds nothing wrong. It does not revector the block, but instead restores the original data back to the block. The user then attempts to access the data and may get another ECC error severe enough to invoke the BBR activity again.

5.8.2 Excessive Number of Blocks Replaced Because of R/W Path Problems 4.2

Read/write data path problems may cause the replacement of a high number of good blocks. This may lead to logical fragmentation of the disk. If this happens, the number of blocks in the RCT recorded as revectorred differs substantially from FCT information. For example, the RCT may show a doubling of replaced blocks occurring over a short period of time. Use EVRLB, MDM, ZUDKxx, or HSC FORMAT to reformat the disk and recover these good blocks.

NOTE

Back up customer data before executing the reformat.

Use the host error log to identify replacement blocks and to show if BBR activity is complete. Use HSC DKUTIL to dump the factory scan (FCT) and RCT areas of the disk. Look for differences in the FCT and what is currently in the RCT. The contents of RCT only show what blocks were replaced; the host error log and HSC console logs supply the time of replacement.

Keep good records in the site management/cluster guide. Include results of VERIFY and BBR scans of each disk. This information helps identify changes in block replacement activity and is part of good site management practices.

5.8.3 LBN Correlation to Single Group/Track 4.3

Consistent failures involving one or two read/write heads usually indicate an HDA failure.

5.8.4 LBN Correlation to Head Groups 4.4

Consistent failures within head groups are usually due to head selection logic within the HDA. The groups are as follows:

RA90 (LA) 70-22951-01 HDA Rev 00	RA90 (SA) 70-27268-01 HDA Rev 01	RA92 70-27492-01 HDA Rev 10
0-3	0-2	0-2
4-7	3-6	3-6
8-11	7-9	7-9
12	10-12	10-12

Replace in the following order:

1. PCM
2. HDA

5.8.4.1 LBNs Correlated to Zone Write Boundaries 4.5

Failures showing no consistency to a group or head may show consistency in write current zones. DSA drives divide the media into different write current amplitude zones. The RA90/RA92 divides the media into four write current amplitude zones as listed in Table 5-4.

Table 5-4 RA90/RA92 Write Zones

Zone	RA90		RA92	
	Cylinder Range	LBN	Cylinder Range	LBN
0	0000-1722	0-1546428	0000-2014	0-1912234
1	1723-2020	1546429-1813724	2015-2363	1912235-2243435
2	2021-2335	1813725-2096289	2364-2731	2243436-2592667
3	2336-2660	2096290-2377747	2732-3112	2592668-2954237

To verify this correlation, you need a substantial number of errors (greater than 100) and knowledge of the user disk space being used. A customer using more than 50 percent of the available disk space is probably accessing all zones of the disk. A disk using less than 25 percent of the disk space may only be accessing a single zone. Knowledge of operating system utilization of disk space is necessary to make this troubleshooting procedure effective.

Zone-related problems encountered with the RA90/RA92 disk drives generally are resolved by replacing the PCM, ECM, or HDA (in that order).

5.8.4.2 LBN Correlation to a Physical Cylinder 4.6

Failures consistently related to a specific cylinder may be the result of a head touchdown. Problems involving servo detection information (dedicated and/or embedded) that prevent head tracking to cylinders usually indicate media corruption. These problems include HDA and ECM electronics. Failures are usually due to specific cylinders in a head crash and may include an area as wide as ten cylinders. One to three cylinders usually indicate servo data failures.

In the RA90/RA92, logical cylinders correlate to physical cylinders.

5.8.5 Multiple Controllers Report Same Error Types 4.7

If multiple controllers report the same error types and only one drive port (after cable swap) reports the error, it is likely an ECM problem.

If multiple controllers report the same error types and both drive ports report the same error, replace drive components in the following order:

1. PCM
2. ECM
3. SDI cabling/interconnects
4. Power source
5. Spindle ground brush
6. HDA

5.8.6 Only Single Controller Port Affected 4.8

If errors occur to a single controller port and both drive ports have been tested to a known good controller interface, then the problem is in the controller or cable.

5.8.7 Isolating Random R/W Transfer Errors 4.9

NOTE

You are here only because the disk drive is experiencing random read/write transfer errors or because your checklist has led you here. If you have not pinpointed the failure, see Section 5.9.

Random physical cylinder and head failures are generally caused by ECM/SDI/SDI-controller interface problems. A faulty spindle ground mechanism or a power supply exceeding noise specifications may also cause a drive to exhibit random errors.

Intermittent read/write problems involving random read/write heads and cylinders may be the result of intermittent failures through the read/write data path. This includes SDI cabling or read/write data path hardware in the controller.

5.8.7.1 Not Defined to a Specific Drive/Controller Port

This is a decision point for the first-time call effort with random read/write errors. If working from a miscellaneous check or action item list, proceed to Section 5.9.

For the RA90/RA92 drive, replace parts in the following order:

1. PCM
2. ECM
3. Cabling (reconfigure)
4. Power supply
5. Spindle ground brush
6. HDA

5.9 Miscellaneous Checks ¶

Miscellaneous checks are provided as an alternative when:

- No host error log is available.
- No HSC console trail is available.
- No errors are logged in the drive internal error log.
- Errors are transient or not reproducible through standalone diagnostics.

If you cannot access the RA90/RA92 drive internal error log from the OCP, replace FRUs in the following order:

1. ECM
2. OCP
3. Power supply

If you cannot access the RA90/RA92 drive internal error log with DKUTIL or EVRLL/ZUDM/MDM, perform the following:

1. Execute resident diagnostic test T00 (drive spun down).
2. Execute resident diagnostic test T00 (drive spun up).
3. Execute external loopback SDI test T09 (use loopback connector Digital part number 70-19074-01).
4. Check drive power supply and indicators. See Section 5.2.6 for the location of power supply indicators and their meanings.
5. Check drive power supply for proper voltages and ripple (noise). See Chapter 1 for power supply operating specifications.
6. Check spindle ground brush for excessive wear.
7. Check the SDI cable by changing the cable.
8. Check the controller port by connecting the SDI cable to another port.

Unreliable power from the power supply, controller, or source power may cause the drive to exhibit a variety of unrelated errors. Ensure source power is within tolerances and follow suggested drive power checks.

If all checks have been made and no problem is found, replace the ECM. The ECM is the most likely FRU to fail, provided the failing drive has been correctly identified.

Use the Customer Support Center for problems beyond the scope of your experience or this manual.

NOTE

For transient disk subsystem errors, running host-level diagnostics on xDA/xDB controllers seldom isolates errors without long run times. This seriously impacts system availability to the customer. Use system-level and drive internal error logs whenever possible.

5.10 Are You Lost? ¶

If you feel that the problem is beyond your capabilities and you have spent too much time trying to isolate it, use available support resources. Digital Customer Services should operate within the Management Action Planning (MAP) guidelines for each respective area of the country/world.

If you are in the process of performing action items, complete those items and reenter the drive fault evaluation phase after collecting new error data.

5.11 Using Host-Level Diagnostics as a Last Resort ¶

There are significant concerns about running standalone diagnostics in troubleshooting RA90/RA92 disk problems. Running standalone diagnostics extends site time and makes the system unavailable to the customer. Customer Services goals are to maximize system or device availability to the customer and minimize repair time. Consider running host-level diagnostics only if you have exhausted all options. Tables 5-5 through 5-7 contain the names of diagnostics that are compatible with the RA90/RA92 disk drives.

CAUTION

Back up customer data before executing diagnostics on customer data areas of the disk. Protection of customer data is your responsibility.

Follow the strategy which is in place to provide quick and accurate diagnosis, repair, and validation. This strategy minimizes the impact on system or device availability.

5.11.1 HSC-Based Diagnostics

Use HSC utilities (DKUTIL) and diagnostics (ILEXER and ILDISK) in a cluster environment. Though the diagnostics are in line and do not cause a loss of system availability, device availability is an issue. With that in mind, examine the drive internal error log prior to running standalone diagnostics.

To execute the in-line tests or utilities, the drive must first be dismounted. The rest of the disk subsystem will not be affected. DKUTIL, ILEXER, and ILDISK do not adversely affect the drive; however, ensure customer data is protected. While running these tests, give errors detected by the drive or controller top priority.

5.11.2 KDM-Based Diagnostics

Use KDM utilities (DKUTIL) and diagnostics (ILEXER and ILDEVO) in a cluster environment. Though the diagnostics are in line and do not cause a loss of system availability, device availability is an issue. With that in mind, examine the drive internal error log before running standalone diagnostics.

To execute the in-line tests or utilities, the drive must first be dismounted. The rest of the disk subsystem will not be affected. DKUTIL, ILEXER, and ILDEVO do not adversely affect the drive; however, ensure customer data is protected. While running these tests, give errors detected by the drive or controller top priority.

5.11.2.1 On Line from VMS

Use the following procedure to access and run on-line programs on a KDM controller. See Section 5.11.2.2 for instructions on accessing and running programs in standalone mode.

NOTE

You cannot run on-line diagnostics, exercisers, and utilities without first running EVRLN.KDM. Follow the procedure shown here.

```

$ RUN SYS$SYSTEM:SYSGEN
SYSGEN> CONNECT FYA0/NOADAPTER
SYSGEN> EXIT

$ SET DEFAULT SYS$MAINTENANCE
$ SET HOST/DUP/SERVER=DUP/LOAD=EVRLN.KDM PUA0/DEVICE
$ SET HOST/DUP/SERVER=DUP/TASK=ILDEVO PUA0/DEVICE

```

5.11.2.2 Running Standalone Programs from the VAX Diagnostic Supervisor

```

DS> ATTACH KDM70 HUB DUx N BR
      | |
      | |_____ BUS REQUEST
      | |
      | |_____ NODE NUMBER

DS> SELECT DUx
DS> RUN EVRLN
EVRLN> RUNL ILDEVO

```

5.11.3 xDA Controller-Based Diagnostics

To run standalone diagnostics or utilities (excluding EVRAE) through any UDA, KDA, KDB controller, the operating system must be shut down and the appropriate diagnostic/supervisor loaded.

Some diagnostics force error conditions to validate the drive's ability to detect error conditions. Error conditions detected by the drives are logged to the drive internal error log as a normal course of operation. Therefore, through several iterations of a standalone diagnostic, the drive internal error log may be overwritten and the real drive-detected errors lost.

For example, running a single iteration MDM on a MicroVAX may result in 13 error events. These events are logged to the drive's internal error log (EEPROM) and may overwrite important error information.

With that in mind, examine the drive internal error log before running standalone diagnostics.

A recent SDI specification change addresses this issue by having the controller disable drive error logging during drive testing. The following diagnostic software releases incorporate the SDI specification changes:

- XXDP—Release 135 (Q3FY88)
 - ZUDG rev C0
 - ZUDH rev C0
- MDM—Release 122 (Q3FY88)
 - NAKDAH
- VDS—Release 31 (Q4FY88)
 - EVRLF version 8.3
 - EVRLG version 8.3

If any errors occur while running disk diagnostics, go to Section 5.6.

If multiple errors occur, go to Section 5.13.1.

If no errors occur, go to Section 5.10 and call remote support.

Table 5-5 VDS-Based Off-Line Diagnostics

Diagnostic	Title
EVRLB	Drive formatter
EVRLF	Tests 1-3
EVRLG	Test 4
EVRLJ	Test 5
EVRLK	Bad block replacement utility (Scrubber)
EVRLI	Drive-resident error log utility
EVRAE	MSCP disk exerciser
EVSBA	VAX autosizer

Table 5-6 MDM-Based Off-Line Diagnostics

Diagnostic	Title
MDM	MicroVAX diagnostic supervisor ¹

¹Currently has a problem identifying drive unit number.

Table 5-7 XXDP-Based Off-Line Diagnostics

Diagnostic	Title
ZUDH ²	Tests 1-3 Test 1: UNIBUS interrupt/address test Test 2: Executes drive-resident diagnostics Test 3: Disk function test (rd/wrt)
ZUDI ²	Test 4: Disk exerciser
ZUDJ	Test 5: UDA/KDA50 subsystem exerciser
ZUDK	Formatter
ZUDL	Bad block replacement utility
ZUDM	Disk-resident error log utility

²Forces errors during run that are logged in the drive internal error log.

5.12 Exiting Data Collection: Action Item List Process

Your goal during the data collection phase is to collect logged subsystem events including:

- Status/event codes from error log packets
- Drive-detected master error codes
- Identified target LBN numbers

When no host or HSC error log information is available, use the drive internal error log or operator/system console trail to identify the problem drive. In some isolated cases (less than one percent), you will have to use a troubleshooting worksheet (described in Section 5.4.1) in place of system logged information. You should leave this phase ready to analyze collected data or with an action item list.

5.13 FRU Replacement

Replace an FRU only after:

- Analysis of VAXsimPLUS directed a replacement FRU based upon its analysis of occurring errors or error rates.
- Analysis of host error logs resulted in a list of error codes with particular emphasis placed on identifying drive-detected error codes. The error codes should predominately be drive error codes. In some circumstances, error codes are generated by the controller.
- Analysis of the HSC console log resulted in a list of drive error codes used in identifying replacement FRUs.
- Analysis of the drive internal error log led to an identification of a replacement FRU.
- Analysis of miscellaneous checks or the process of elimination identified an FRU replacement.

Once an error code has been established from one of the previously mentioned sources, refer to Section 5.19 for error code descriptions and suggested FRU replacement(s).

5.13.1 Multiple Error Codes

If a number of different error codes are detected, consider the following to decide which error code(s) to use for troubleshooting:

- Give error codes obtained from running internal drive diagnostics top priority.
- Select an error code or symptom that indicates the least number of FRUs. Drive-detected errors of this type will have been derived using the least amount of circuitry to isolate the particular failure.
- Select the error code that occurs most often.
- Select the FRU that is most commonly indicated by different error codes.
- Select the FRU that most commonly indicates the same manufacturing code (Section 5.2.3.13).

5.13.2 Service Post-Verification

After replacing an FRU or repairing a drive, execute drive-resident diagnostics. You can do this through power-up and spin-up cycles or by using tests which exercise the repaired FRUs. Compare the results to the diagnostics executed during pre-verification testing (Section 5.6.1).

Post-verification testing accomplishes the following:

- Verifies that no new problems have been introduced when servicing or replacing FRUs.
- Verifies that a repair or replaced part corrected any problems detected during pre-verification testing.

If the same error code(s) occur during post-verification testing, reinstall the original FRU. Continue troubleshooting procedures, or replace the next identified FRU in the appropriate list.

If the diagnostics pass successfully, the problem has most likely been resolved, with the following exception:

- If the original error codes used for FRU isolation were the result of host, controller, or drive internal error log entries (not duplicated by running pre-verification testing), the problem may be due to an intermittent failure. Proceed to Section 5.13.3

If any errors occur, you may want to reinstall the original drive FRU and go to Section 5.6.1.

5.13.3 Return Disk Drive to User 9.3

After checkout is complete, return the disk drive to the user. Have the user exercise the repaired disk drive through customer applications. If customer applications appear to be functioning normally, the call can be closed.

If the drive fails, return to Section 5.6 or call remote support.

If there is a question as to the correct identity of the failing disk drive, return to Section 5.5.

5.14 Performance Issues When No Errors Are Being Logged

Customer complaints of disk performance can require a fair amount of analysis. Often the performance complaints are quite subjective. The following list of questions may help analyze performance complaints:

1. Do the performance issues relate to all or most of the disks?

If so, ensure that system parameters comply with suggested guidelines. Cluster size of disks, working set size parameters, paging parameters, and ACP/XQP-related parameters all can affect performance.

2. Do the performance problems occur during image activation (when a large sized application program is initially started)?

Many layered products require some time to fully activate. This is not a disk problem.

3. Is the performance problem noticed by users of the same image, layered product, or file on the (same) disk?

If the disk is attached to a local controller (UDA/KDA/KDB) but is a VAX node member in a cluster, then request that the file/image/layered software product be moved to a disk on the HSC. Local serving of disks creates bus, VAX, and I/O overhead that impacts performance.

4. Is the performance problem noticed by users of a file/image/layered product that resides on the same disk as the swap and page files?

If so, request the system manager monitor paging and swapping activity. High page/swap rates decrease VMS response and create an I/O bottleneck for the page/swap disk. Request the file/image/layered product be moved to another disk.

In addition to system parameter settings, two areas of the architecture (hardware-related) contribute to actual loss of performance. These include:

1. Nonprimary replacements in a critical file or directory structure, such as the following examples:

- Nonprimary replacement in VMS disk: [000000] INDEXF.SYS
- Nonprimary replacement in a frequently used directory file

The two examples are of files that may affect the perceived performance of a disk. However, the location of a block of data within a file and how the operating system is set up equally affect nonprimary replacement which, in turn, impacts system or disk drive performance.

A nonprimary replaced block in the INDEXF.SYS file of a disk could be very significant if it is in the front of the file. However, if it is the last block within the file, it might not have as large an impact on system performance.

A nonprimary replacement in a block within SYS.EXE that is loaded once by VMS into memory (at startup) and stays resident in memory has no effect on performance. However, if the block is within a portion of SYS.EXE that is frequently brought in by VMS, it could impact performance. A solution is to increase the VMS working set size.

A nonprimary replaced block within a swap or paging file has little performance impact. If the system is doing enough paging and swapping to notice the occurrence of nonprimary replacements, the real problem may be with the user or system working set size. Performance may improve if the system manager adjusts system parameters around paging and swapping.

VMS uses virtual block file structures, not logical blocks. VBNs do not correlate to LBNs. To correlate an LBN to the affected file, contact someone familiar with the operating system file structure, such as VMS ODS-2. Identifying affected files within ODS-2 is very complicated.

2. Difficulty (but success) in achieving fine track following a seek.

The RA90/RA92 disk drive utilities T36, T38, and T39 measure various seek time parameters. Compare measured times to drive specifications in cases where seek time is in question.

Temperature can affect the performance of T36 and T38.

5.15 Troubleshooting VMS Mount Verification

EXE\$MOUNTVER is the VMS executable mount verification process to bring disks back on line after a problem has made the drives inaccessible to a host VAX. It is a very complicated process. If any failure to reinitialize the disk occurs, or if EXE\$MOUNTVER exceeds its allowed timeout period (default 10 minutes), the host logs a mount verification error to the host error log.

5.15.1 VMS Mount Verification

The mount-verification feature of Files-11 disk handling generally leaves users unaware that a mounted disk has gone off line and returned on line (or in some other way has been unreachable and then restored). Mount verification is the default parameter for EXE\$MOUNTVER, with the following exceptions: Disks mounted /FOREIGN and disks mounted /NOMOUNTVERIFICATION do not undergo mount verification except during cluster state transitions.

Drives dual-ported through HSC controllers should never be mounted /NOMOUNTVERIFICATION because this may prevent VMS from failing the drive over to the secondary HSC controller.

EXE\$MOUNTVER sends status messages to OPCOM. Because there are cases when mount verification messages are needed at the operator console and OPCOM might not be able to provide them, mount verification also sends special messages with the prefix %SYSTEM-I-MOUNTVER to the operator console, OPA0.

5.15.2 VMS Problems Surrounding Diagnosis of “Why a Drive Mount-Verifies”

VMS calls EXE\$MOUNTVER if a drive loses contact with the system. (For example, the controller sends a command to the drive but does not get a successful response back within the controller-specific timeout period.) The process verifies that the disk VMS reestablished contact with is the same disk originally connected.

Sending the drive to the mount-verify state involves:

1. The host initiating an MSCP ONLINE command to the drive modifier followed by a GET UNIT STATUS (GUS).

2. The host reading the home block and comparing the volume information (serial number, name, etc.) for the drive before VMS lost contact and after VMS reestablished contact with the drive during mount verification.

This sequence is repeated until success or timeout. This sequence is made evident by the drive having a port light on and the Ready light blinking quite slowly as the controller accesses the FCT for the on line and LBN block for the media ID, effectively doing full-stroke seeks.

The MVTIMEOUT system parameter defines the time (in seconds) allowed for a pending mount verification to complete before it is aborted. This dynamic parameter should always be set to a reasonable value for the typical operations at the site.

NOTE

Do not use values less than the recommended default of 600 seconds (10 minutes).

After a mount verification times out, any pending I/O requests to the volume will fail. Try to execute the DISMOUNT/ABORT command which allows a subsequent mount to be successful if the MV-timer has previously expired. In some extreme cases, drive failures may require a reboot of the controller; some require a reboot of the system.

Entry and exit to or from MOUNT VERIFY are time stamped. VAXcluster time stamps may vary across the cluster nodes due to differences in the TOY clocks and the initial clock times. Slight variations in time stamps do *not* indicate multiple drive or controller failures causing MOUNT VERIFICATION, but rather one drive or controller failure causing every node to enter MOUNT VERIFICATION at their own locally specified time.

Some reasons why a drive enters mount verification:

- Disk drive dropped off line because of:
 - Port switch glitch.
 - Drive fault.
 - Lost communications with controller or cable fault (drive temporarily went away and came back).
- Drive status changed (operator physically did something with the drive).
- Operator changed media (pack) (causes entry but will never complete).
- Someone accidentally pushed the Write Protect switch.

By noting the time duration of the mount verification and other circumstances surrounding the mount verify status, you can determine some valuable troubleshooting information.

How long did the mount verify take?

Less than MVTIMEOUT and the drive eventually succeeded.

A few seconds—implying a glitch or a recoverable fault.

Did the drive appear on another controller after the mount verification? If so, it could be a port-related problem.

Thirty seconds to a minute to remount probably means the drive was spun down and had to be spun back up. Was this due to a drive fault? Did it run its spin-up diagnostics error free?

Infinite time probably means that, along with the drive disappearing, it also changed its media_ID, or it is a different drive, or it continually fails its spin-up diagnostics, or there is a hard fault on the drive.

What happened?

VMS does not log errors during the MOUNT VERIFY process, although it may log some before or after, depending on how the drive failed.

Did the drive see a fault during this period? (Examine the drive internal error log for error information.)

Were any errors logged to the host or HSC console log before or after the mount verify?

Is it always the same drive?

Do any nonexistent drive numbers appear which may characterize a unit select problem?

Was there a last-fail packet from the xDA/xDB shortly after, meaning the controller faulted/initialized as well?

Did all the drives on a port/K/controller fail?

5.15.3 Non-VMS Mount Verification

RSTS 9.x is tolerant of DSA drives dropping off line. It reinitializes the drive and puts it back on line. Most other drives remain off line unless the driver is patched to reissue on line before every command (as RSX does).

5.16 Troubleshooting ECC Errors on RA90/RA92 Disk Drives

Disks are getting bigger and faster. As disk bit and track density increases, the electronics and mechanical components of the subsystem operate under tighter constraints. This means that error recovery mechanisms within the architecture may be called upon more frequently to compensate for these narrow tolerances.

This is one of the significant advantages of a Digital storage solution. Digital integrates into the design of the controller and the drive error recovery attributes that enhance and ensure data integrity and delivery to the user. Plug-compatible manufacturers (PCMs) of storage devices, by not owning the design of both ends of the subsystem (controller and drive), are left with little capacity to implement such techniques.

The RA90/RA92 disk drive has 14 different error recovery mechanisms (reference Appendix B) and, therefore, affords excellent recovery potential for data errors. These error recovery mechanisms provide the margins necessary to protect customer data at increased densities and to ensure that the data is always delivered successfully.

In order to better determine the significance of logged correctable and uncorrectable ECC errors, and for assistance in troubleshooting either, note the discussions and error log examples in the sections that follow.

5.16.1 Uncorrectable ECC Errors—MSCP Status/Event E8

An uncorrectable ECC error is architecturally defined as the occurrence of a controller logging an MSCP status/event E8 as a result of a read data error. There are two uncorrectable ECC error types: hard and soft. Both types are reflected by a single MSCP status/event code.

The next two sections attempt to aid the engineer in determining/distinguishing between whether the status/event was hard or soft and significant or insignificant.

5.16.1.1 Hard Uncorrectable ECC Errors

A hard uncorrectable ECC error is the occurrence of an uncorrectable ECC error that renders the drive unable to recover data through any retry or recovery mechanism. An uncorrectable ECC error is not considered "hard" until all attempts at getting the data are exhausted and the controller has to terminate its attempts.

Example 5-3 shows a VMS error log error packet where the data was lost due to a hard error. The fields of note are emphasized in bold.

```

***** ENTRY          29. *****
ERROR SEQUENCE 3885.          LOGGED ON:          SID 0200620E
DATE/TIME 30-JAN-1989 19:54:03.77          SYS_TYPE 00000000
SCS NODE: PICKUP

ERL$LOGMESSAGE ENTRY KA750 REV# 14. UCODE REV# 98.
I/O SUB-SYSTEM, UNIT _HSC013$DUA36:
    MESSAGE TYPE          0001          DISK MSCP MESSAGE
    MSLG$SL_CMD_REF      AF66000F
    MSLG$W_UNIT          0024          UNIT #36.
    MSLG$W_SEQ_NUM      0054          SEQUENCE #84.
    MSLG$B_FORMAT       02          DISK TRANSFER ERROR
    MSLG$B_FLAGS        E0          BAD BLK REPLACEMENT REQUEST
                                     OPERATION CONTINUING
                                     OPERATION SUCCESSFUL
    MSLG$W_EVENT        00E8          DATA ERROR
                                     UNCORRECTABLE ECC ERROR
    MSLG$Q_CNT_ID       0000F20D
                                     01010000
    .
    .
    .
    MSLG$B_UNIT_SVR     0B          UNIT SOFTWARE VERSION #11.
    MSLG$B_UNIT_HVR     01          UNIT HARDWARE REVISION #1.
    MSLG$B_LEVEL        01          <Last retry level after
    MSLG$B_RETRY        05          <invoking levels 14 through 2.
                                     <Fifth retry was attempted
                                     <at the above retry level
    MSLG$L_VOL_SER     0000036C          VOLUME SERIAL #876.
    MSLG$L_HDR_CODE    000E75BD          LOGICAL BLOCK #947645.
                                     GOOD LOGICAL SECTOR

CONTROLLER DEPENDENT INFORMATION
    ORIG ERR          8010          EDC ERROR
                                     ECC ERROR
    ERR RECOV FLGS    0003          LBN REPLACEMENT INDICATED
                                     ERR LOGGED TO CONSOLE AND HOST
    LV1 A RETRY       00
    LV1 B RETRY       00
    BUF DAT MEM ADR   C41B
    SRC REQ #         03
    DET REQ #         03
*****

```

Example 5-3 VMS Uncorrectable ECC Error Log—Hard

The disk subsystem will attempt to recover from an uncorrectable ECC error by retrying the transfer five times. For an RA90/RA92 disk drive, the controller would then invoke drive recovery level 14 and execute that recovery mechanism up to five times, then invoke drive recovery level 13, and so on, until executing the last recovery level (1).

Note that for UDA controllers, the reported recovery levels from the controller will differ from what the other controllers will report.

5.16.1.2 Soft Uncorrectable ECC Errors

A soft uncorrectable ECC error is the occurrence of an uncorrectable ECC error on the first read attempt; however, a successful recovery level and/or retry was made and the data was read successfully (with eight or less symbols in error). In such a case, the block is flagged as a BBR candidate for testing purposes by the HSC controller (or in case of a UDA/KDA/KDB controller, the host operating system driver).

For uncorrectable ECC errors (MSCP status/event E8), the following items should be considered:

- For the RA90/RA92 disk drive, examine the error log and determine that the `MSLG$_LEVEL` and `MSLG$_RETRY` (for VMS) is being reported as follows:

If the recovery level is reported as 0 and the retry count is =1 for the uncorrectable ECC errors, an occasional error under high I/O rates may be considered normal. The normal recovery will occur on the first retry with a recovery level of 0. If more than a single retry is necessary, and especially if other levels of recovery are necessary, this indicates potentially more serious error conditions, including the legitimate condition whereby a block is going bad and needs replacement.

The RA90 short-arm HDA and the RA92 HDA will show improved (decreased) ECC error rates. The nominal distribution of uncorrectable ECC errors for an RA90 disk drive with a long-arm HDA operating at very high I/O rates should appear as follows:

- Ninety percent of the errors occur in the top five heads (heads 0 through 4).
- One of the heads (in the 0-4 range) will have no errors logged.
- At least three of the top five heads will have errors of this type.
- You should have a sample size of at least 16 uncorrectable ECC errors for examination. If this distribution of errors is not met, then further analysis should be done.

For example, if 10 of the 13 heads are logging these data errors, then consider it a general read path problem and troubleshoot accordingly.

If distribution is to a single head, then consider the likelihood of a defective HDA.

If error log information indicates that data recovery was accomplished by utilizing a drive error recovery level of 7 through 14 (head offset mechanism), then consider HDA replacement (especially if 9A, 9B, or 9C errors are being logged in the drive as well).

- Each error log entry of an uncorrectable ECC error should be followed by a BBR packet (reference Section 5.16.2.1). The MSCP status/event code should reflect a 34, BBR replacement attempted but block tested okay. Blocks in a normal drive will be retired at a very low rate (less than 20 percent of the time) for the normal transient occurrence of uncorrectable ECC errors on RA90 disk drives.

Example 5-4 has three fields of note (emphasized in bold). The first emphasized field denotes the actual MSCP status/event logged (00E8), and a bit-to-text decode denoting that the read error was an uncorrectable ECC error.

The second field of note indicates how the subsystem recovered from the error condition; in this case, a single retry was successful with no special error recovery mechanism being invoked to aid in the recovery of the data.

The third emphasized field is the field within an error log packet that, for an ECC-type MSCP status/event packet, typically has no meaning and will in most all cases indicate zeros. This section of an errorlog packet will, however, contain significant information for the interpretation of MSCP status/event 6B error packets.

```

***** ENTRY          29. *****
ERROR SEQUENCE 3885.          LOGGED ON:          SID 0200620E
DATE/TIME 30-JAN-1989 19:54:03.77          SYS_TYPE 00000000
SCS NODE: PICKUP

ERL$LOGMESSAGE ENTRY KA750 REV# 14. UCODE REV# 98.
I/O SUB-SYSTEM, UNIT _HSC013$DUA36:

MESSAGE TYPE          0001          DISK MSCP MESSAGE
MSLG$L_CMD_REF AF66000F
MSLG$W_UNIT          0024          UNIT #36.
MSLG$W_SEQ_NUM          0054          SEQUENCE #84.
MSLG$B_FORMAT          02          DISK TRANSFER ERROR
MSLG$B_FLAGS          E0          BAD BLK REPLACEMENT REQUEST
                                OPERATION CONTINUING
                                OPERATION SUCCESSFUL
MSLG$W_EVENT          00E8          DATA ERROR
                                UNCORRECTABLE ECC ERROR
MSLG$Q_CNT_ID          0000F20D
                                01010000
.
.
.
MSLG$B_UNIT_SVR          0B          UNIT SOFTWARE VERSION #11.
MSLG$B_UNIT_HVR          01          UNIT HARDWARE REVISION #1.
MSLG$B_LEVEL          00          <NO Drive Recovery Invoked
MSLG$B_RETRY          01          <Single retry was successful!
                                <Minimal impact event
MSLG$L_VOL_SER          0000036C          VOLUME SERIAL #876.
MSLG$L_HDR_CODE 000E75BD          LOGICAL BLOCK #947645.
                                GOOD LOGICAL SECTOR

CONTROLLER DEPENDENT INFORMATION
ORIG ERR          8010          EDC ERROR
                                ECC ERROR
ERR RECOV FLGS          0003          LBN REPLACEMENT INDICATED
                                ERR LOGGED TO CONSOLE AND HOST
                                < For data problems, these
                                <fields should contain 'zeros'.
LVI A RETRY          00
LVI B RETRY          00
BUF DAT MEM ADR          C41B
SRC REQ #          03
DET REQ #          03
*****

```

Example 5-4 VMS Uncorrectable ECC Error Log—Soft

5.16.2 Correctable ECC Errors—MSCP Status/Event Codes 1A8, 1C8, 1E8

Correctable ECC errors are those where the data was read with symbols in error above the drive threshold (6–8 symbols for the RA90/RA92 disk drive). For ECC errors (MSCP status/event codes 1A8, 1C8, and 1E8), consider the following:

- For an RA90 disk drive with a long-arm HDA, an occasional ECC error (including 6–8 symbols in error and soft uncorrectable errors) may be considered normal when the drive has sustained or I/O burst rates of >30 I/Os per second.

The RA90 short-arm HDA and the RA92 HDA show a marked improvement (decrease) in ECC error rates.

The nominal distribution of correctable ECC errors for an RA90 disk drive with a long-arm HDA should appear as follows:

- Ninety percent of the errors occur in the top five heads (heads 0 through 4).
- One of the heads (in the 0–4 range) will have no errors logged.
- At least three of the top five heads will have errors of this type.
- You have a sample size of at least 16 uncorrectable ECC errors for examination. If this distribution of errors is not met, then further analysis should be done.

For example, if 10 of the 13 heads are logging these data errors, then consider it a general read path problem and troubleshoot accordingly.

If distribution is to a single head, then consider the likelihood of a defective HDA.

If error log information indicates that data recovery was accomplished by utilizing a drive error recovery level of 7 through 14 (head offset mechanism), then consider HDA replacement (especially if 9A, 9B, or 9C errors are being logged in the drive as well).

- Each error log entry of an ECC (6–8 symbol) error should be followed by a BBR packet (reference Section 5.16.2.1). The MSCP status/event code should reflect a 34, BBR replacement attempted but block tested okay. Blocks in a normal drive will be retired at a very low rate (less than 20 percent of the time) for the normal transient occurrence of correctable ECC errors on RA90 disk drives.

5.16.2.1 BBR Packet

ECC errors that exceed the drive threshold initiate BBR algorithms. The BBR algorithms are provided to test, verify, and replace (if needed) defective media spots or marginal media/head spot combinations (assuming no data path problems). In those instances where the BBR algorithms do not determine a need for block replacement, it may be due to a transient type error situation, or mechanisms not attributable to actual head/media margins. These above-drive-threshold ECC errors (or uncorrectable ECC errors) may be caused by drive phenomena other than bad media/heads.

The BBR packet, which is generated at the completion of the BBR algorithm, will contain several important clues about the nature of the ECC error. Included in the packet is whether the block tested good or bad, and whether the original data was recovered or restored with the FORCED ERROR flag set, indicating the data was lost.

The following MSCP status/event codes are applicable for a BBR packet:

- MSCP status/event 14—Bad block successfully replaced.
- MSCP status/event 34—Block verified okay; not a bad block.
- MSCP status/event 54—Replacement failure; replace command failed.
- MSCP status/event 74—Replacement failure; inconsistent RCT.
- MSCP status/event 94—Replacement failure; drive access failure.

MSCP status/event B4—Replacement failure; no block available.

MSCP status/event D4—Replacement failure; two successive RBNs were bad.

Example 5-5 illustrates what the status of the BBR replacement algorithm resulted in. In this example, the block in question did go through BBR; however, the block was not replaced. Further in the example, the replace flags demonstrate that the block was not replaced because the block “verified good.” The last segment of the BBR log packet reveals why the block was even tested. In this example, the block was thought to contain a data error with a severity level of “uncorrectable ECC.”

5.17 Troubleshooting Controller-Detected Positioner Errors—MSCP Status/Event 6B

MSCP status/event 6B is a positioner unintelligible header error (also referred to as a positioner error mis-seek). Several considerations must be weighed when troubleshooting the MSCP 6B event. These include:

- For RA90/RA92 disk drives, what is the I/O rate on the drive?
- Is only one SDI path noting the problem?
- Are other errors being logged at or near the same frequency as the MSCP 6B?
- For RA92 disk drives, what is the write-to-read ratio?
- What recovery level/mechanism is the controller using in order to recover from the situation?

With the RA90/RA92 disk drive, if in the examination of the error log, it can be determined that:

- the Level A retry mechanism is successful on first retry, and
- the Level B retry mechanism is not being used (reported Level B retry count = 0), and
- “all” errors are being recovered on a single retry,

then an error rate of six per day may be considered nominal for the RA90/RA92 disk drives operating near or above 30 I/Os per second.

Example 5-6 illustrates a typical RA90 error log on a VMS system. The fields of note are emphasized in bold.

5.17.1 RA92 Disk Drive With MSCP Status/Event 6B

RA92 disk drives may log more occurrences of MSCP status/event 6B than RA90 disk drives in applications during which long sequences of write activity are occurring. This phenomenon, as a contributor to 6B events, was recently discovered and identified. Though it occurs more often with the RA92 disk drive, heavy write-to-read ratios could be a contributor to logged MSCP 6B events by RA90 disk drives.

The problem is occurring within the design of the heads while the head is involved in large sequential write transfers. When the head has to switch back to read (for next header identification), noise can result in the head that essentially disrupts the header signal as it is read. No identifiable damage to the actual header information is exhibited on the media. Customer data is **not** at risk. The noise merely disrupts the read chain momentarily as the header is being read. By the time the next sector comes around, the read chain will have stabilized.

This head phenomenon will result in additional 6B errors being logged when the write-to-read ratios are heavily weighted in favor of writes. Typical VMS environments may not provide this scenario. It has been noted that typical ULTRIX/UNIX applications appear to have a higher mix of write-to-read activity than VMS applications. However, regardless of the operating system, certain applications may increase the potential of this phenomenon occurring when those applications, by their nature, offer heavy write-to-read ratios.

5-50 Troubleshooting and Error Codes

```

***** ENTRY 6., ERROR SEQUENCE 4709. LOGGED ON SID 05283914
ERL$LOGMESSAGE ENTRY  KAS20 REV# E PATCH REV# 28.  UCODE REV# 20.
                      BI NODE # 2.
I/O SUB-SYSTEM, UNIT  _HSC015$DUA36:

  MESSAGE TYPE          0001          DISK MSCP MESSAGE

  MSLG$L_CMD_REF        6BBC000A
  MSLG$W_UNIT           0024          UNIT #36.

  MSLG$W_SEQ_NUM        0002          SEQUENCE #2.

  MSLG$B_FORMAT         09          BAD BLOCK REPLACEMENT ATTEMPT

  MSLG$B_FLAGS          80          OPERATION SUCCESSFUL

  MSLG$W_EVENT          0034          BAD BLOCK REPLACEMENT
                                     BLOCK VERIFIED GOOD

  MSLG$Q_CNT_ID         0000FC15
                          01200000    UNIQUE IDENTIFIER, 00000000FC15(X)
                                     MASS STORAGE CONTROLLER
                                     HSC70

  MSLG$B_CNT_SVR        27          CONTROLLER SOFTWARE VERSION #39.

  MSLG$B_CNT_HVR        00          CONTROLLER HARDWARE REVISION #0.

  MSLG$W_MULT_UNT       0060
  MSLG$Q_UNIT_ID        000003F6
                          02130000    UNIQUE IDENTIFIER, 0000000003F6(X)
                                     DISK CLASS DEVICE (166)
                                     RA90

  MSLG$B_UNIT_SVR       0B          UNIT SOFTWARE VERSION #11.

  MSLG$B_UNIT_HVR       01          UNIT HARDWARE REVISION #1.

  MSLG$W_RPL_FLGS       0000          REPLACEMENT ATTEMPTED, BLOCK
                                     _ VERIFIED GOOD

  MSLG$L_VOL_SER        0000036C    VOLUME SERIAL #876.

  MSLG$L_BAD_LBN        00175A52    BAD LOGICAL BLOCK
                                     _ NUMBER = 1530450.

  MSLG$L_OLD_RBN        00000000
  MSLG$L_NEW_RBN        000056A4
  MSLG$W_CAUSE           00E8          DATA ERROR
                                     UNCORRECTABLE ECC ERROR
*****

```

Example 5-5 VMS BBR Packet

VMS LOGGED MSCP '6B' POSITIONER ERRORS
 ***** ENTRY 1. *****
 ERROR SEQUENCE 2151. LOGGED ON: SID 1105009C
 DATE/TIME 26-JUL-1990 11:12:49.31 SYS_TYPE 00000000

ERL\$LOGMESSAGE ENTRY KA88 REV# 5. CPU 0.
 CPU # 0.

I/O SUB-SYSTEM, UNIT _HSC4\$DUA39:

MESSAGE TYPE 0001

DISK MSCP MESSAGE

MSLG\$L_CMD_REF 56310024
 MSLG\$W_UNIT 0027

UNIT #39.

MSLG\$W_SEQ_NUM 001B

SEQUENCE #27.

MSLG\$B_FORMAT 02

DISK TRANSFER ERROR

MSLG\$B_FLAGS 81

SEQUENCE NUMBER RESET
 OPERATION SUCCESSFUL

MSLG\$W_EVENT 006B

DRIVE ERROR
 POSITIONER ERROR (MIS-SEEK)

MSLG\$Q_CNT_ID 0017F20D
 01010000

UNIQUE IDENTIFIER, 00000017F20D(X)
 MASS STORAGE CONTROLLER
 HSC50

.
 .
 .
 .
 .
 .
 .
 .

CONTROLLER DEPENDENT INFORMATION

ORIG ERR 1800

HEADER COMPARE ERROR
 HEADER SYNC TIMEOUT
 SUSPECTED LOW HEADER MISMATCH

ERR RECOV FLGS 0002

ERR LOGGED TO CONSOLE AND HOST

LV1 A RETRY 01

<---NOTE 1 "A" RETRY

LV1 B RETRY 00

<---NOTE NO "B" RETRIES

BUF DAT MEM ADR C4BF

SRC REQ # 02

DET REQ # 02

Example 5-6 Positioner Mis-Seek MSCP Status/Event 6B

The occurrence of 6B errors caused by this phenomenon has been more pronounced on the KDM/HSC controllers than on the KDA/KDB/UDA controllers. Since experience and engineering evaluation have shown that the occasional occurrence of the MSCP status/event 6B, when recovered on a single retry, is inconsequential, extra error management code has been implemented as follows:

- HSC software released after the 39x series will contain special 6B error management code that will look for this error signature and will not report this event characteristic of the RA90/RA92 product.
- The KDM70 controller with microcode at revision level 2 will also contain this enhanced error management code for 6B errors on RA90/RA92 disk drives.

This phenomenon is being aggressively pursued by Digital and resolution details will be communicated to the field.

5.17.2 Evaluating MSCP 6B Events

When converting some (20–30 LBNs identified as 6B MSCP events) of the target LBN numbers, look for the following:

- Single head but quite random cylinder addresses—consider the HDA.
- Single head but narrow band of cylinder addresses—consider mapping out suspect LBNs with DKUTIL or HDA replacement. To manually force replacement of a perceived bad block, make sure a current disk backup exists.
- Repeating LBNs—consider “mapping” out suspect LBNs with the BBR utility (DKUTIL).
- Random heads (10 of 13 heads)—consider data path including controller SDI module.

Troubleshoot MSCP status/event 6B as follows:

- Update the drive with the latest drive microcode version.
- If errors are only happening on one port, pursue a port path problem, including ECM, SDI cables between drive and bulkhead, cabinet to controller cabinet, and within the controller cabinet and the port interface module in the controller.
- Note whether more than one drive on the requester is reporting consistent 6B events. This would more definitely suggest a port interface problem within the controller.
- If errors are clearly happening on both drive ports, pursue the problem as a drive problem first, when the event rate exceeds the guidelines indicated above and/or customer satisfaction dictates.

5.18 Conclusion

The DSA architecture defines a very reliable and flexible storage subsystem. This subsystem can be maintained efficiently and effectively when consistent and methodical troubleshooting procedures are followed.

Poorly trained or untrained Customer Services engineers are at a serious disadvantage. The cost of supporting incorrectly identified FRUs is very high. Many of the FRU units are expensive to replace. Some very expensive FRUs are not repairable FRUs. The impact to a customer can be substantial. Impacts include:

- Necessity to back up and restore potentially large amounts of data on misdiagnosed HDA replacements.
- Loss of system availability when using standalone diagnostics with controllers such as UDA/KDA/KDB.
- Loss of drive availability when performing extensive subsystem diagnostics using an HSC controller.

- Increased frustration and inconvenience of dealing with repeated calls.
- Loss of confidence in Digital as a quality supplier of storage systems.
- Increased potential of data loss if improper diagnosis is made and the failure mode continues or gets worse.

SERVICE GOAL

The Customer Services engineer's number one goal in service efforts is to correctly diagnose a problem on the first call and replace the correct part so the customer's disk and data availability is minimally impacted.

5.19 Error Codes and Descriptions

This section describes RA90/RA92 disk drive error codes. Included in each error code description is a list of suggested replacement FRUs for repairing drive problems.

Careful analysis of both system and drive internal error logs, along with drive-generated error codes, should lead to problem isolation and correction.

Error codes are listed in hex numerical order starting with error code 01 through error code FD (hex). The general format of the error code listings is as follows:

01 ❶ Spindle Motor Transducer Timeout ❷

Error Type: DE ❸

Error Description: The spindle was given the command to spin up by an SDI command or from the front panel Run switch and no movement was detected by the spindle motor transducer. See error code 13 for possible isolation help before replacing FRUs. ❹

Fault Isolation/Correction: ❺

1. ECM
2. HDA
3. Rear flex cable assembly

Where:

- ❶ 01 is the error code.
- ❷ SPINDLE MOTOR TRANSDUCER TIMEOUT is the error message.
- ❸ DE is the error type.
- ❹ **Error Description:** is a brief summary of the error event.
- ❺ **Fault Isolation/Correction:** is the suggested FRU replacement order for troubleshooting.

01 Spindle Motor Transducer Timeout

Error Type: DE

Error Description: The spindle was given the command to spin up by an SDI command or from the front panel Run switch, and no movement was detected by the spindle motor transducer. See error code 13 before replacing FRUs.

Fault Isolation/Correction:

1. ECM
2. HDA
3. Rear flex cable assembly

02 Spinup Too Slow

Error Type: DE

Error Description: The spindle did not reach 1000 r/min within 20 seconds. See error code 13 before replacing FRUs.

Fault Isolation/Correction:

1. ECM
2. HDA
3. Rear flex cable assembly

03 Spindle Not Accelerating During Spinup

Error Type: DE

Error Description: The spindle did not accelerate above 1000 r/min in the allotted spinup timeout period. See error code 13 before replacing FRUs.

Fault Isolation/Correction:

1. ECM
2. HDA
3. Rear flex cable assembly

04 Spinup Too Long to Lock on Speed

Error Type: DE

Error Description: The spindle did not reach 3600 r/min (± 18 r/min) within 30 seconds. See error code 13 before replacing FRUs.

Fault Isolation/Correction:

1. ECM
2. HDA
3. Rear flex cable assembly

05 Invalid Drive Serial Number Code

Error Type: DF

Error Description: The drive serial number is out of acceptable range or an invalid manufacturing plant code was read by the drive microcode.

Switches are set (or read) incorrectly on the rear flex cable assembly (S1/S2). This is neither a fatal error nor a hard error. Clearing the fault allows the drive to continue operation. The drive serial number is checked during the power-up sequence.

Table 5-8 Serial Number

Bits <19:18>	Mfg	Serial Number Range in Decimal	Max Binary Value Bits <17:00>
0 0	CX	0-262,143	1111111111111111111
0 1	CX	262,144-309,999	001011101011101111
0 1	-	310,000-524,287	1111111111111111111 invalid
1 0	KB	0-262,143	1111111111111111111
1 1	-	0-262,143	1111111111111111111 invalid

Fault Isolation/Correction:

1. Incorrect S1/S2 bits set on rear flex cable assembly
2. Rear flex cable assembly
3. ECM seating problem
4. ECM

06 Microcode Fault

Error Type: DF

Error Description: A hardware/software failure caused the master processor addressing to point to a null EEPROM area.

Fault Isolation/Correction:

1. Reload drive microcode
2. ECM

07 SDI Frame Sequence Error

Error Type: RE

Error Description: Level 1 SDI commands were detected in the wrong sequence. If the same drive is reporting errors from two controllers, start troubleshooting at the drive.

Fault Isolation/Correction:

1. Controller
2. SDI cable
3. ECM

08 SDI Lvl 2 Checksum Error

Error Type: RE

Error Description: The calculated checksum did not compare with the checksum field sent by the controller to the drive for SDI level 2 commands. If the same drive is reporting errors from two controllers, start troubleshooting the drive.

Fault Isolation/Correction:

1. Controller
2. SDI cable
3. ECM

09 SDI Lvl 1 Framing Error

Error Type: RE

Error Description: A sync pattern was detected by the drive on the SDI WRITE/COMMAND line, but no SDI level 1 control message transmission or single frame command was detected.

Fault Isolation/Correction:

1. Controller
2. SDI cable
3. ECM

0A SDI Incorrect Command Opcode Parity Error

Error Type: PE

Error Description: The wrong parity was detected on the opcode byte of a level 1 or level 2 command.

Fault Isolation/Correction:

1. Controller
2. SDI cable
3. ECM

0B SDI Invalid Opcode

Error Type: PE

Error Description: The decoded opcode is not a valid (level 2) SDI opcode.

Fault Isolation/Correction:

1. Controller
2. SDI cable
3. ECM

0C SDI Command Length Error (LVL2)

Error Type: RE

Error Description: This error indicates the controller caused the drive SDI input command buffer to overflow.

Fault Isolation/Correction:

1. Controller
2. SDI cable
3. ECM

0D SDI Invalid Command with Drive Error

Error Type: PE

Error Description: The controller issued an INITIATE SEEK command, an ERROR RECOVERY command, or a RECALIBRATE command while the drive was faulted.

Fault Isolation/Correction:

1. Controller
2. ECM
3. SDI cable

0E SDI Lvl 1 Invalid Select Group Number

Error Type: RE

Error Description: Indications are the controller attempted to select a nonexistent group. For RA90 and RA92 disk drives, group=head.

Fault Isolation/Correction:

1. Controller
2. ECM
3. SDI cable

0F SDI Write Enable on a Write-Protected Drive

Error Type: PE

Error Description: A drive write-protected from the OCP (front panel) was issued a WRITE ENABLE command through an SDI CHANGE MODE command. The OCP switch state has priority over any SDI CHANGE MODE commands.

Fault Isolation/Correction:

1. Disable Write Protect switch
2. Controller
3. ECM
4. OCP

10 SDI Command Length Error (LVL2)

Error Type: PE

Error Description: An SDI command length error, LVL2, indicates the number of bytes expected did not equal the number of bytes received for an SDI level 2 command.

Fault Isolation/Correction:

1. Controller
2. SDI cable
3. ECM

11 Microcode Cartridge Load Occurred

Error Type: Informational Only

Error Description: This logged event indicates that a drive microcode update successfully occurred.

This new event occurred with the introduction of the Etch-F I/O-R/W module. Etch-F revision ECM boards are indicated by revision 1 or later in the IOP and SRV values reported with drive internal test T45. (There are a minimal number of Etch-E revision modules that provide this information.)

Fault Isolation/Correction:

1. Information only

12 Spindle Speed Unsafe Error

Error Type: DE

Error Description: During idle loop, a spindle speed check indicated the drive was not up to speed at 3600 r/min (± 18 r/min). The servo processor will also detect this condition dynamically and have the master processor log this error as well.

Fault Isolation/Correction: Disabling the brake circuit may aid in troubleshooting. The brake can be disabled by opening either pin 4 or 5 of the rear HDA connector. Use the pin extraction tool (P/N 29-26655-00) to avoid breaking pins.

CAUTION

The female pins in the HDA connector are delicate and must be handled with care. When disabling the brake, cover loose pins with electrical tape to prevent them from shorting.

1. Reseat HDA
2. ECM
3. Power supply
4. Brake
5. HDA

13 Spindle Motor Control Fault

Error Type: DE

Error Description: The motor control IC detected a condition that prevented the spindle from getting up to speed.

Fault Isolation/Correction:

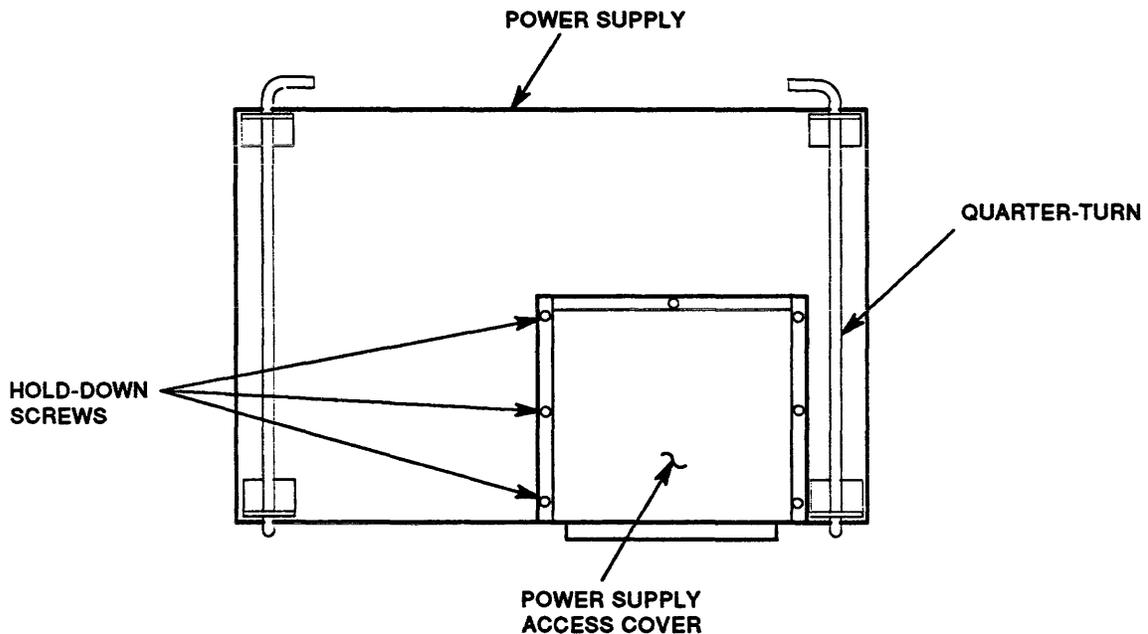
1. Reseat ECM/HDA
2. ECM
3. HDA

A number of checks are made to detect this fault. A failure of any of the following checks results in this error:

1. If no Hall effect is seen within 700 ms after current is applied to the spindle motor.
2. If the SSI chip on the servo module which controls spindle speed rotation is operating at less than 6.8 volts.
3. If the brake circuit is activated at the same time that current is applied to the spindle.
4. If the Hall sensor input from the spindle motor is not occurring at a 700 ms rate.

Additionally, any open condition in the spindle circuitry, including Hall sense phase or spindle motor phase circuitry, causes this error to be asserted.

Although power supply voltages cannot be adjusted, they can be measured by removing the small cover as shown in Figure 5-8 (power supplies bearing a serial number starting with CX only). On the back of the connector, the pin numbers are visible. A very small electrical probe is required to make connection.



CXO-2184B

Figure 5-8 Power Supply Cover Removal

Removal of this cover allows access to the power supply output voltage connector. To remove the power supply cover, use a quarter-inch hex driver. Remove the hold-down screws. Next, use a DVM or oscilloscope to measure the points to ground (black lead) as shown in Table 5-9.

Table 5-9 Power Supply Voltage Measurements

Pin	Wire Color	Voltage Measurement	Deviation
1	Orange	+12 Vdc	±.6 V
2	Black	±12 Vdc (return)	
3	Black	±12 Vdc (return)	
4	Blue	-12 Vdc	±.6 V
5	Red	+5.1 Vdc	±.25 V
6	Red	+5.1 Vdc	±.25 V
7	Red	+5.1 Vdc	±.25 V
8	Red	+5.1 Vdc	±.25 V
9	Black	+5.1 Vdc (return)	
10	Black	+5.1 Vdc (return)	
11	Black	+5.1 Vdc (return)	
12	Black	+5.1 Vdc (return)	
13	Purple	-5.2 Vdc	±.17 Vdc
14	Purple	-5.2 Vdc	±.17 Vdc
15	Brown	-24 Vdc	±2.4 Vdc
16	Brown	-24 Vdc	±2.4 Vdc
17	Brown	-24 Vdc	±2.4 Vdc
18	Black	±24 Vdc (return)	
19	Black	±24 Vdc (return)	
20	Yellow	+24 Vdc	±2.4 Vdc
21	Yellow	+24 Vdc	±2.4 Vdc
22	Yellow	+24 Vdc	±2.4 Vdc
23	Brown	40 kHz H	
24	Blue	-5.2 Vdc (sense)	
25	Black	-5.2 Vdc (sense return)	
26	Orange	DCOK H	
27	Red	OVTEMP H	
28	Blue	POCK H	
29	White	ON/OFF L	

In addition to these measurements, error codes 2D and FF indicate power problems.

Along with the power supply measurements, a number of resistance checks can be made to the HDA. The HDA must first be removed from the drive chassis. Exercise care when handling the HDA so that connector pins are not damaged during measurements. DO NOT jam probes into the connector housing from the front of the connector because it is easy to damage the pins in these sockets. Access the pins from the rear of the connector or use the pin insert/extract

tool (P/N 29-26655-00) to remove pins from connectors for easier measurements. Refer to Table 5-10 to locate opens in the circuits.

Table 5-10 lists pin-to-circuit connections.

Table 5-10 HDA Connector Pin Designations

Pin	Wire Color	Circuit
1	Blue	Positioner lock solenoid (-)
2	Blue	Positioner lock solenoid (+)
4	White	Brake (-)
5	White	Brake (+)
6	Green	S3
7	Violet	S2
8	Flex	Positioner actuator fix (-)
9	Orange	S1
10	Flex	Positioner actuator fix (+)
11	Brown	Hall sensor ground
12	Gray	Spindle motor coil C
13	Red	Hall sensor 5 V input
14	Blue	Spindle motor coil B
16	Black	Spindle motor coil A
Grnd	Yellow	Spindle motor lamination lead exits HDA and is grounded on HDA.

Resistance measurements are checked according Table 5-11.

Table 5-11 HDA Resistance Measurements

(-)Pin to (+)Pin	Circuit	Measured Value
16-14	Coil A - Coil B	1.4 ohm
16-12	Coil A - Coil C	1.4 ohm
14-12	Coil B - Coil C	1.4 ohm
16 - HDA ground	Coil A - ground	20 megohm
14 - HDA ground	Coil B - ground	20 megohm
12 - HDA ground	Coil C - ground	20 megohm
9-7	S1 - S2	20 megohm
9-6	S1 - S3	20 megohm
7-6	S2 - S3	20 megohm
9-13	S1 - Hall 5 V	20 megohm
7-13	S2 - Hall 5 V	20 megohm
6-13	S3 - Hall 5 V	20 megohm
9-11	S1 - Hall ground	≥4.50 megohm

Table 5-11 (Cont.) HDA Resistance Measurements

(-)Pin to (+)Pin	Circuit	Measured Value
7-11	S2 - Hall ground	≥4.30 megohm
6-11	S3 - Hall ground	≥4.50 megohm
11-13	Hall ground - Hall 5V	≈7 megohm
1-2	Positioner lock solenoid	≥30 ohm
8-10	Actuator coil	≥4 ohms

14 Head Offset Margin Event**Error Type: DE**

Error Description: This is not an error condition. Manufacturing sets the enable flag for the detection of this event. If this code shows up in the field, reset the flag by taking the drive off line and powering it down and then up.

Fault Isolation/Correction:

1. Power drive off and back on.

15 Head Offset Out-of-Band Error**Error Type: DE**

Error Description: Head offset has exceeded normal head offset parameters for this drive. This is a serious problem. Data is in danger of being lost. Do not use the drive for further writes. Initiate prompt backup. Head offset errors can result from an over-temperature condition. Check drive airflow and ambient room temperature. If temperature appears to be normal, replace the HDA.

The amount of offset necessary before this error is flagged is $\pm 3/4$ ths of a track. After each offset table rebuild, the servo processor tests each head value against this threshold. If a head exceeds offset limits, the master processor asserts ATTENTION and uses the GET STATUS response to identify which head or heads are involved.

The drive specific bytes of the drive internal error log should indicate which head has marginal offsets.

Fault Isolation/Correction:

1. HDA
2. ECM
3. PCM

16 SDI Invalid Group Select LVL2**Error Type: PE**

Error Description: The controller attempted to select a nonexistent group. A group refers to a head in the RA90 and RA92 disk drives. If the drive is dual-ported and logging this error from both controllers, troubleshoot the drive.

Fault Isolation/Correction:

1. Controller
2. ECM

17 SDI Port A Command/Response Timeout

Error Type: Informational Only

Error Description: The Port A controller did not accept message response data from the drive. This is typically a communications event and not a drive error.

Fault Isolation/Correction:

1. Communications event (typically not a drive problem)
2. Controller on Port A
3. ECM

18 SDI Port B Command/Response Timeout

Error Type: Informational Only

Error Description: The Port B controller did not accept message response data from the drive. This is typically a communications event and not a drive error.

Fault Isolation/Correction:

1. Communications event (typically not a drive problem)
2. Controller on Port B
3. ECM

19 SDI Invalid Format Request

Error Type: PE

Error Description: The controller requested that the drive place itself in 576-byte format. The RA90/RA92 only accepts 512-byte format. This error can also be caused by someone trying to format the drive in 576-byte mode.

Fault Isolation/Correction:

1. Controller
2. ECM

1A SDI Invalid Cylinder Address

Error Type: PE

Error Description: The drive decoded a nonexistent cylinder address during a controller-initiated SEEK command.

This error also occurs when a controller, while running diagnostics, attempts to test the DBN area of the disk without first setting the drive's DB bit.

This error also occurs if an attempt is made to access cylinders beyond the DBN space if the DB bit is set.

Fault Isolation/Correction:

1. Controller
2. ECM

1B Inner Guardband Error

Error Type: DE

Error Description: The drive hardware detected servo inner guardband information instead of servo data information or outer guardband information. The only time the servo head is positioned in the inner guardband area and does not generate an error is during execution of diagnostics.

Fault Isolation/Correction:

1. ECM
2. HDA

NOTE

If an actuator current error or actuator speed error is also indicated, it is probable that the inner guardband error is secondary. Reference the respective actuator error.

1C Outer Guardband Error

Error Type: DE

Error Description: Outer guardband information was decoded when servo or inner guardband information was expected. The only time the servo head is positioned in the outer guardband area and does not generate an error is during execution of a head load operation, a recalibrate, or internal diagnostics.

Fault Isolation/Correction:

1. ECM
2. HDA

NOTE

If an actuator current error or actuator speed error is also indicated, it is probable that the inner guardband error is secondary. Reference the respective actuator error.

1D Illegal Servo Fault

Error Type: DE

Error Description: A servo fault was detected by the GASP array; however, when the master processor examined the register information, the error was invalid.

Fault Isolation/Correction:

1. ECM

1E Power-Up After AC Power Loss

Error Type: Information only

Error Description: Information event noting that the drive performed a power-up sequence after ac power loss. This may be the result of turning the drive power off at the breaker, or loss of ac power to the drive/cabinet.

This new event occurred with the introduction of the Etch-F I/O-R/W module. Etch-F revision ECM boards are indicated by revision 1 or later in the IOP and SRV values reported with drive internal test T45. (There are a minimal number of Etch-E revision modules that provide this information.)

This event is different from the logged event as a result of the power supply being over temperature.)

Fault Isolation/Correction:

1. Information Only

1F Sector Overrun Error

Error Type: DE

Error Description: When a sector or index pulse occurs with either WRITE GATE or READ GATE asserted, an overrun error is asserted. This indicates a write or read operation was attempted through a sector/index boundary.

Fault Isolation/Correction:

1. Controller
2. ECM

20 SDI RTCS Parity Error

Error Type: DE

Error Description: A bit was dropped or picked up in data transferred on the SDI Real Time Controller State (RTCS) line.

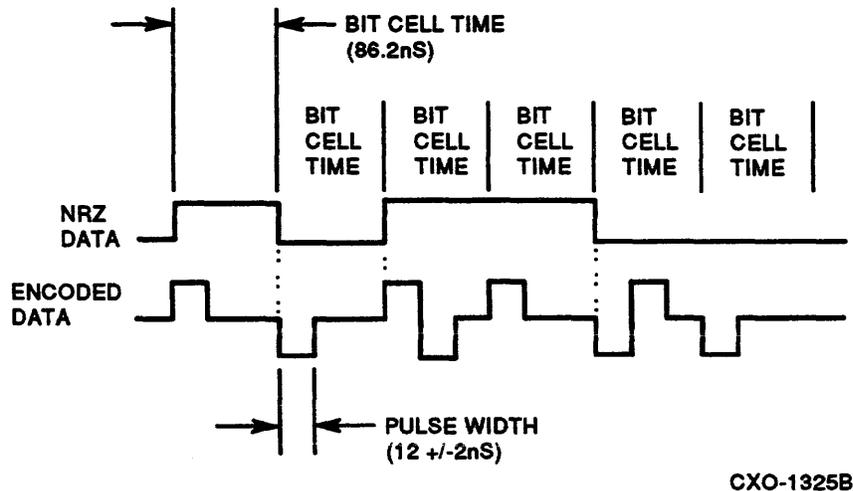
Fault Isolation/Correction:

1. Controller
2. SDI cable
3. ECM

21 SDI Transfer (Pulse) Error

Error Type: DE

Error Description: An extra or missing pulse was detected on the SDI WRT/CMD line or the RTCS line. If this error occurs from both ports and/or more than one controller, troubleshoot the drive. If only one port is involved, troubleshoot the SDI cables or the controller. See Figure 5-9.



CXO-1325B

Figure 5-9 WRT/CMD Data Format

On the WRT/CMD and RTCS lines, a positive transition at the leading edge of a bit cell indicates a one; a negative transition indicates a zero. If the next bit cell contains the same data (a one followed by a one or a zero followed by a zero), the line switches polarity in the middle of the bit cell.

The error is detected by the TSID gate array and is passed to the SDI gate array as a PLS ERR error. A pulse error should only be reported when the drive is executing a data transfer operation. If a pulse error occurs during a TRANSFER command, PLS ERR will set bit 0 of Fault Register 3 of the SDI gate array.

Fault Isolation/Correction:

1. ECM
2. SDI cables
3. Controller
4. Power supply
5. Spindle ground brush

22 Electronic Control Module Over-Temperature Error

Error Type: DE

Error Description: An over-temperature condition exists in the drive. Drive over-temperature conditions result from high room temperature or a dirty air vent inhibiting airflow through the drive. Additionally, a bad blower motor could cause the internal temperature of the drive to increase, but a 2D error is more likely in this case. This over-temperature condition happens when the detector senses 43°C (110°F).

Fault Isolation/Correction:

1. Ambient air temperature is too high
2. Cabinet door air vent needs cleaning
3. Blower assembly
4. ECM

24 Loss of Fine Track During Data Transfer

Error Type: DE

Error Description: A loss of fine track was detected when a read or write operation was ready to begin, but not actually started. This error code is not implemented in microcode revision 7 and later.

Refer to servo event 9A.

Fault Isolation/Correction:

1. Install RA90X-0001 FCO

25 Servo Fault Error

Error Type: DE

Error Description: A servo error was detected but no condition was found that would cause the error condition. The master processor, while in its idle loop, was scanning the servo GASP gate array and discovered error bit(s) set. Valid conditions include:

- Actuator fault
- PLO error
- Actuator over current error

Actuator over speed error
 Track counter error
 Off track error
 Guardband error
 Heat sink 1 error—over-temperature
 Heat sink 2 error—over-temperature

Fault Isolation/Correction:

1. ECM

26 Spindle Speed Error (Servo Processor)

Error Type: DE

Error Description: Spindle is not within $\pm 0.5\%$ of 3600 r/min. The servo processor monitors spindle speed. This error is different from the loss of PLO which can occur separately from the error. Upon detection of the loss of PLO, the master processor examines the servo processor status to determine if it has valid servo-detected error information. If it does, this error is asserted.

Fault Isolation/Correction:

1. ECM
2. Brake
3. HDA

27 Servo Over-Temperature Error at S1

Error Type: DE

Error Description: The thermal sensor (S1) on the servo module detected an over-temperature condition. This results in the master processor spinning the disks down and setting this error condition. If the over-temperature clears, the controller can initialize the drive and try to spin it back up.

Fault Isolation/Correction:

1. Ambient air temperature too high
2. Cabinet door air vent needs cleaning
3. Blower assembly
4. ECM

28 Servo Over-Temperature Error at S2

Error Type: DE

Error Description: The thermal sensor (S2) on the ECM detected an over-temperature condition. This results in the master processor spinning the disks down and setting this error condition. If the over-temperature clears, the controller can initialize the drive and try to spin it back up.

Fault Isolation/Correction:

1. Ambient air temperature too high
2. Cabinet door air vent needs cleaning
3. Blower assembly
4. ECM

29 SDI Invalid Error Recovery Level Specified

Error Type: PE

Error Description: The controller issued an SDI ERROR RECOVERY command with an illegal recovery level. The RA90/RA92 supports 14 error recovery mechanisms. This value is passed to the controller during a GET COMMON CHARACTERISTICS command. The controller in this case asked for a level greater than 14.

Not all controllers report the error recovery levels in the same manner.

Fault Isolation/Correction:

1. Controller
2. ECM

2A SDI Invalid Subunit Specified

Error Type: PE

Error Description: The controller attempted a GET STATUS command to a subunit address other than zero. (The RA90/RA92 is a single unit drive with a subunit address of zero.)

Fault Isolation/Correction:

1. Controller
2. ECM

2B SDI Invalid Diagnose Memory Region Location

Error Type: PE

Error Description: The controller or the operator attempted to execute a nonexistent internal drive test or internal diagnostics while the drive was on line to the controller.

Fault Isolation/Correction:

1. Use valid diagnostic
2. Controller
3. ECM

2C SDI Spindle Not Ready with Seek/Recalibration Command

Error Type: PE

Error Description: A RECALIBRATE or SEEK command was issued to a spun-down disk drive.

Fault Isolation/Correction:

1. Controller
2. ECM

2D Power Supply Over-Temperature**Error Type: DE**

Error Description: A critical over-temperature condition exists in the power supply. This condition is detected by the master processor through the **OVER TEMP L** signal. Within 15 ms of detection, the dc voltages are removed in an orderly fashion. The error is stored in EEPROM and can be read when power is restored to the drive after the over-temperature condition is corrected or the power supply cools down sufficiently to allow power to be reapplied.

Fault Isolation/Correction:

1. Ambient air temperature too high
2. Blower assembly
3. Power supply
4. ECM
5. Rear flex cable assembly

2E SDI Spinup Inhibited by Controller Flags**Error Type: PE**

Error Description: The drive cannot be spun up from the OCP while the drive is in the **AVAILABLE** or **ONLINE** state to the controller.

NOTE

If the Run switch is selected prior to the Fault switch, a 2E led code will be indicated.

Fault Isolation/Correction:

1. Check Run switch
2. ECM

2F SDI RUN Command with Run Switch in Stop Position**Error Type: PE**

Error Description: An SDI RUN command was issued to the drive when the OCP Run switch was in a logical stop state.

Fault Isolation/Correction:

1. Check OCP switch state
2. Controller
3. ECM

30 Write Current and No Write Gate**Error Type: DE**

Error Description: Current was detected at the read/write heads and **WRITE GATE** was not asserted. The PCM provides the current source for the write chips in the HDA. Drive firmware tests for this condition during diagnostics.

Fault Isolation/Correction:

1. ECM
2. PCM
3. HDA

31 Read Gate and Write Gate Both Asserted

Error Type: DE

Error Description: SDI gate array detected that READ GATE and WRITE GATE were asserted at the same time.

Fault Isolation/Correction:

1. ECM
2. Controller

32 Read or Write While Faulted

Error Type: DE

Error Description: A READ or WRITE command was issued to a drive that has a fault condition.

Fault Isolation/Correction:

1. Check error log for fault condition
2. Controller
3. ECM

33 Attempt to Write Through Bursts

Error Type: DE

Error Description: An attempt was made to assert WRITE GATE while the read/write heads were positioned over embedded servo burst information.

Fault Isolation/Correction:

1. ECM
2. Controller
3. HDA

34 ENDEC Encoder Error

Error Type: DE

Error Description: Data to be written to media has been improperly 2/3 encoded.

Fault Isolation/Correction:

1. ECM
2. PCM

35 Write and Write Unsafe

Error Type: DE

Error Description: A problem in the write data path prevented the drive from correctly writing data to the disk surface. One or more of the following conditions cause this error:

- No write data transitions
- No write current
- No SSI 283 (head select chip) selected
- SSI 283 stuck in read mode

The unsafe conditions are wire ORed together and are detected on the PCM.

Fault Isolation/Correction:

1. PCM
2. HDA
3. ECM

36 Write and Servo Uncalibrated

Error Type: DE

Error Description: The firmware routines used to calibrate the read/write heads and the servo system failed to complete successfully. The subsequent write was attempted with the servo uncalibrated.

Fault Isolation/Correction:

1. PCM
2. ECM
3. HDA

37 Write Gate and No Write Current

Error Type: DE

Error Description: WRITE GATE was asserted but no write current was detected at the read/write heads. The PCM sources the current when WRITE GATE is asserted.

Fault Isolation/Correction:

1. PCM
2. ECM
3. HDA

38 Read Gate and Multiple Head Chips Selected

Error Type: DE

Error Description: During a read operation, the master processor determined that more than one head and/or more than one SSI 283 chip was selected.

Fault Isolation/Correction:

1. PCM
2. ECM
3. HDA

39 Write Gate and Off Track

Error Type: DE

Error Description: A loss of fine track was detected when WRITE GATE was asserted. This error code is not implemented in microcode revisions 7 and later. This error code is used exclusively with the dedicated-only servo system found on earlier drives. Refer to error code 9B.

Fault Isolation/Correction:

1. Install RA90X-0001 unless superseded by a later FCO.

3A Write Gate and Write-Protected

Error Type: WE

Error Description: A write-protected drive detected the assertion of WRITE GATE.

Fault Isolation/Correction:

1. Controller
2. ECM

3B Hard INIT Occurred to Drive

Error Type: DE

Error Description: This is not typically an error condition. It is a record of initializations (initializations the controller started by the RTCS logical signal INIT, and initializations started by the drive). Initializations stop mechanical movements, and the drive performs a power-up initialize and reloads the servo processor code.

Examine previous error conditions.

With drive microcode revisions 10 or earlier, if the drive performs a hard initialization on its own (for example, when new drive microcode has just been reloaded), this error entry will be recorded into the EEPROM.

Microcode revisions later than 10 give a new indication of microcode reload. Refer to drive LED code 11.

Fault Isolation/Correction:

1. Look for previous errors
2. ECM
3. Controller

3D HDA Read/Write Interlock Broken

Error Type: DE

Error Description: The cable between the PCM and the ECM is disconnected or broken.

Fault Isolation/Correction:

1. Disconnected ECM-to-PCM cable
2. Bad ECM-to-PCM cable
3. PCM
4. ECM

3E OCP Interlock Broken

Error Type: DE

Error Description: The operator control panel was removed with dc voltages still applied to the drive.

Fault Isolation/Correction:

1. OCP flex circuit connectors
2. Bezel/blower flex circuit/servo module connectors
3. Servo module/ECM connectors
4. OCP
5. ECM

40 SDI Invalid Read Memory Region Error

Error Type: PE

Error Description: The controller issued an SDI level 2 READ MEMORY REGION command to an invalid region of drive read memory.

Fault Isolation/Correction:

1. Operator attempted to write or read a nonexistent or protected memory location.
2. Controller
3. ECM

42 Drive Not On Line/SEEK Command Issued

Error Type: PE

Error Description: The controller issued an SDI level 2 INITIATE SEEK command and the drive was not on line to the controller.

Fault Isolation/Correction:

1. Controller
2. SDI cable
3. ECM

43 TCR and Not Read/Write Ready Fault

Error Type: RE

Error Description: The SDI gate array has decoded a data transfer command from the controller, but the drive is not ready to read/write; or the drive detected a loss of READ/WRITE READY during a data transfer.

Fault Isolation/Correction:

1. Controller
2. SDI cable (poor SDI connection)
3. ECM

44 Format Command and Format Not Enabled

Error Type: RE

Error Description: (A FORMAT ON SECTOR OR INDEX command or a SELECT TRACK AND FORMAT ON INDEX command was decoded by the drive without the format bit (FO) being set in the drive.)

Fault Isolation/Correction:

1. Controller
2. ECM

45 Read Gate and Off Track Both Asserted

Error Type: DE

Error Description: A loss of fine track was detected when read gate was asserted. This error code is not implemented in microcode revisions 7 and later. This error code is used exclusively with the dedicated-only servo system found on earlier drives. Refer to error code 9B.

Fault Isolation/Correction:

1. Install RA90X-0001 unless superseded by a later FCO.

46 Invalid Hardware Fault

Error Type: DE

Error Description: A failure was detected for unused fault inputs to the SDI gate array.

Fault Isolation/Correction:

1. ECM

47 Invalid Disconnect Command/TT Bit Error

Error Type: PE

Error Description: An SDI DISCONNECT command was issued to the drive and the TT modifier bit was in an incorrect state.

Fault Isolation/Correction:

1. Controller
2. ECM

48 Invalid Write Memory Byte Counter/Offset Error

Error Type: PE

Error Description: The drive detected an incorrect number of data bytes to be written in drive memory; or the directed offset into the memory region was incorrect.

Fault Isolation/Correction:

1. Controller
2. ECM

49 Invalid Command During TOPOLOGY Command

Error Type: PE

Error Description: During the execution of an SDI level 2 TOPOLOGY command, the drive received an illegal SDI level 2 command from another controller.

Fault Isolation/Correction:

1. Controller
2. ECM

4A Drive Disabled by Controller (DD Bit Set)

Error Type: Informational Only

Error Description: The controller issued an SDI level 2 CHANGE MODE command to a drive with its DD bit asserted. When the controller asserts the DD bit, it disables the drive from further I/O activity.

Fault Isolation/Correction:

1. Controller (controller error routine determined the drive should be taken out of service)
2. ECM

4B Index Error

Error Type: DE

Error Description: No index pulse was detected for one revolution of the disk.

Fault Isolation/Correction:

1. ECM
2. HDA

4C SDI Invalid Write Memory Region Error

Error Type: PE

Error Description: An SDI level 2 command was issued to a drive-defined invalid memory region.

Fault Isolation/Correction:

1. Operator (attempting to write a nonexistent or protected memory location in drive)
2. Controller
3. ECM

4D Write Gate and Bad Embedded Servo Information

Error Type: DE

Error Description: The servo processor discovered incorrect embedded servo information while WRITE GATE was asserted.

Fault Isolation/Correction:

1. HDA
2. PCM
3. ECM

4F Invalid Select Group (Level 1 Command) - Not Read/Write Ready

Error Type: RE

Error Description: The controller issued a level 1 SELECT GROUP command to a drive when the drive was not read/write ready.

Fault Isolation/Correction:

1. Check OCP for drive state
2. Controller
3. ECM

50 Servo Data Bus Failure

Error Type: DF

Error Description: A communication path to the GASP array failed during resident diagnostic testing.

Fault Isolation/Correction:

1. ECM

51 Sector/Byte Counter Error

Error Type: DF

Error Description: A resident diagnostic failure occurred during testing of the sector counter register or byte counter register.

Fault Isolation/Correction:

1. ECM

52 Servo RAM Test Failure (Low Byte of Address)

Error Type: DF

Error Description: At power-up, the drive-resident diagnostics failed during testing of RAM located on the servo portion of the ECM.

Fault Isolation/Correction:

1. ECM

53 Servo Processor Offset Error

Error Type: DE

Error Description: The servo system failed to offset the heads during error recovery.

Fault Isolation/Correction:

1. ECM

54 Head Select Register Loopback Error

Error Type: DF

Error Description: A drive-resident diagnostic detected a failure in the head select register. The head select register is inside the SDI gate array.

Fault Isolation/Correction:

1. ECM

55 DSP Sanity Timeout After Load

Error Type: DE

Error Description: The servo processor microcode was reloaded from the EEPROM on the I/O-R/W module because of a fault condition. After the microcode was reloaded in servo RAM, the master processor initiated a servo sanity test. The sanity test timed out, indicating a problem with the servo processor.

Fault Isolation/Correction:

1. ECM

56 Servo RAM Test Failure (High Byte of Address)

Error Type: DF

Error Description: A drive-resident diagnostic failed when testing RAM that resides on the servo module.

Fault Isolation/Correction:

1. ECM

57 Master Processor Timer Failure

Error Type: DF

Error Description: A drive-resident diagnostic failed when testing the time count register or output compare register. Both are located internal to the master processor.

Fault Isolation/Correction:

1. ECM

58 Dedicated Head Gain Calibration Error

Error Type: DE

Error Description: The servo processor timed out while attempting to measure and compensate for the gain of the dedicated servo head.

Fault Isolation/Correction:

1. ECM
2. PCM
3. HDA

59 Embedded Servo Offset Calibration Error

Error Type: DE

Error Description: The servo processor timed out during a calibrate of the read/write head offsets. This calibration occurs during all head loads and periodically thereafter.

Fault Isolation/Correction:

1. HDA (most probable, especially if only one head is involved)
2. ECM (10 of 13 heads affected)
3. PCM

5A Embedded Head Gain Calibration

Error Type: DE

Error Description: The servo processor timed out while attempting to calibrate the head gain relative to the read/write head embedded burst information. The drive calculates this gain for each of the read/write heads.

Fault Isolation/Correction:

1. ECM (if most heads show problem)
2. PCM (if most heads show problem)
3. HDA (most probable, especially if only 1 head is involved)

5B Bias Calibration Error

Error Type: DE

Error Description: The servo processor timed out during a bias force adjustment to the actuator.

Fault Isolation/Correction:

1. ECM
2. PCM
3. HDA

5C Incorrect Diagnostic Index or Sector Pulse

Error Type: DF

Error Description: In testing the sector and byte counters, the master processor detected that the sector counter was not working properly.

Fault Isolation/Correction:

1. ECM

60 Read/Write Head Select Failure

Error Type: DE

Error Description: A failure occurred when attempting to select a group (head). When a group selection is requested, logic and firmware in the drive verify that the correct SSI 283 chip and head in the HDA have been selected. This verification takes place during functional operation and in diagnostic mode.

Fault Isolation/Correction:

1. PCM
2. PCM-to-ECM cable
3. ECM

61 Diagnostic Index Sync Timeout Error

Error Type: DF

Error Description: A drive-resident diagnostic failed to detect an index pulse.

Fault Isolation/Correction:

1. ECM
2. HDA

62 Read Test Overall Read Failure (Three or More Bad Heads)

Error Type: DF

Error Description: During the execution of a resident diagnostic read-only test or write/read test, data by three or more heads read from diagnostic cylinders did not compare to the originally written patterns.

The RA90 drive has two diagnostic cylinders (2659 and 2660) located in the inner guardband area of the media. Only the drive can access these two cylinders; they cannot be accessed by the controller. These are not the same cylinders used by the controller to execute controller-based diagnostics (DBN space). Refer to drive-resident diagnostic 17.

Fault Isolation/Correction:

1. Reformat the read-only cylinder by running drive-resident diagnostic 17
2. PCM
3. ECM
4. HDA

63 Read Test Partial Failure (One or Two Bad Heads)

Error Type: DF

Error Description: During the execution of a resident diagnostic read-only test or write/read test, data by one or two heads read from diagnostic cylinders did not compare to the originally written patterns. Refer to error code 62.

Fault Isolation/Correction:

1. Reformat the read-only cylinder by running drive-resident diagnostic 17
2. PCM
3. ECM
4. HDA

64 Cannot Clear IID Error Bits

Error Type: DF

Error Description: Error detection logic internal to the IID gate array cannot be cleared.

Fault Isolation/Correction:

1. ECM

65 Diagnostic Index or Sector Not Detected

Error Type: DF

Error Description: No index pulse was detected during the execution of resident diagnostics that read or write media.

Fault Isolation/Correction:

1. ECM
2. HDA

66 Read Test Servo Failure

Error Type: DF

Error Description: The drive internal diagnostic read or write/read test failed because of an off-track condition.

Fault Isolation/Correction:

1. PCM
2. ECM
3. HDA

67 Cannot Execute Write Test (Read-Only Test Failed or Not Run First)

Error Type: DF

Error Description: This indicates an operator error, not a drive problem.

Service personnel must run the read-only test before attempting to run the write test. Additionally, the read test must be successful before the write/read diagnostic is executed.

Fault Isolation/Correction:

1. Service personnel attempted to execute the write/read diagnostic without first executing the read-only diagnostic.
2. The read-only diagnostic failed and the write/read diagnostic was attempted anyway.
3. ECM

68 This Diagnostic Cannot Execute Without Software Jumper

Error Type: DF

Error Description: A diagnostic or utility was attempted without having first selected the Run/Stop switch. The Run/Stop switch must be selected within 1.5 seconds after initiating certain tests with the Write Protect switch.

Fault Isolation/Correction:

1. Procedural error
2. ECM
3. OCP

69 Unable to Force Compare Error

Error Type: DF

Error Description: The drive failed to force a data compare error during a read-only diagnostic.

Fault Isolation/Correction:

1. ECM

6A Unable to Force No-Sync Error

Error Type: DF

Error Description: The diagnostic firmware was unable to force a no-sync error.

Fault Isolation/Correction:

1. ECM

6B R/W Write/Read Test Overall Failure (Three or More Bad Heads)

Error Type: DF

Error Description: The data read from three or more heads during execution of resident diagnostics was incorrect. The heads are positioned at the drive-reserved diagnostic cylinders during these tests.

Fault Isolation/Correction:

1. ECM
2. PCM
3. HDA

6C R/W Write/Read Test Partial Failure (One or Two Bad Heads)

Error Type: DF

Error Description: The data read from one or two heads was incorrect. The heads were positioned at the drive reserved diagnostic cylinders.

Fault Isolation/Correction:

1. ECM
2. PCM
3. HDA

6D Unable to Force Read Gate and Write Gate Together

Error Type: DF

Error Description: Drive-resident diagnostics were unable to force the simultaneous assertion of READ GATE and WRITE GATE.

Fault Isolation/Correction:

1. ECM

6E Unable to Force Write Gate and Write Protect Error

Error Type: DF

Error Description: A write-protected drive has WRITE GATE asserted but no error was detected.

Fault Isolation/Correction:

1. ECM

6F Diagnostic Write Attempted While Write-Protected

Error Type: DF

Error Description: Either the Write/Read Diagnostic or the Diagnostic Track Format Utility was attempted on a write-protected drive.

Fault Isolation/Correction:

1. Drive write-protected from the OCP
2. Drive write-protected by the controller
3. ECM

70 Servo Processor Spinup Timeout

Error Type: DE

Error Description: The master processor timed out after issuing a SPINUP command to the servo processor.

Fault Isolation/Correction:

1. ECM

71 Recalibrate Timeout Error

Error Type: DE

Error Description: The master processor timed out during a RECALIBRATE command issued to the servo processor.

Fault Isolation/Correction:

1. ECM

72 Servo Processor Seek Timeout

Error Type: DE

Error Description: The servo processor timed out the execution of a SEEK command. This is a gross seek error in that the servo subsystem never sensed that it got even within a cylinder of the desired cylinder within a 100 ms.

Fault Isolation/Correction:

1. ECM
2. HDA

73 Servo Processor Head Switch Timeout

Error Type: DE

Error Description: The master processor timed out before the servo processor responded to a head switch status request.

Fault Isolation/Correction:

1. ECM

74 Offset Timeout Error

Error Type: DE

Error Description: The master processor timed out during an offset check or OFFSET command to the servo processor.

Fault Isolation/Correction:

1. ECM
2. HDA

75 Servo Processor Unload Timeout

Error Type: DE

Error Description: The master processor timed out after issuing an UNLOAD (head) command to the servo processor.

Fault Isolation/Correction:

1. ECM

76 Servo Processor Sanity Timeout

Error Type: DE

Error Description: The master processor timed out while waiting for a response from the servo processor after issuing a SANITY CHECK command.

Fault Isolation/Correction:

1. ECM

77 Head Load Timeout Error

Error Type: DE

Error Description: The master processor timed out waiting for a response from the servo processor after issuing a HEAD LOAD command.

Fault Isolation/Correction:

1. ECM

78 Servo Processor Bias Force Calibration Timeout

Error Type: DE

Error Description: The master processor issued a BIAS CALIBRATION command (diagnostic opcode) to the servo processor. The master processor timed out while waiting for a servo processor response.

Fault Isolation/Correction:

1. ECM

79 Dedicated Servo Calibration Timeout Error

Error Type: DE

Error Description: The master processor timed out waiting for the servo processor to respond to a DEDICATED SERVO CALIBRATION command issued as part of a diagnostic opcode.

Fault Isolation/Correction:

1. ECM

7A Embedded Offset/Gain Calibration Timeout

Error Type: DE

Error Description: The master processor timed out while waiting for the servo processor to respond to an EMBEDDED OFFSET CALIBRATION or EMBEDDED HEAD GAIN CALIBRATION command issued by a diagnostic opcode.

Fault Isolation/Correction:

1. ECM

7B Invalid Test While Spindle Running

Error Type: DF

Error Description: The drive was spun up and the operator selected a diagnostic that can only be run when the drive is spun down. (Certain diagnostics can only be executed on a spun-down drive.) Refer to Chapter 4 for a complete listing of diagnostics and execution requirements.

Fault Isolation/Correction:

1. Spin down drive to run selected tests
2. ECM

7C Gray Code Match Error After Settling

Error Type: DE

Error Description: Head settling on a track normally occurs following a SEEK command. A gray code comparison is made to ensure the heads have settled on the requested track. In this case, the servo was settling within 1/4 track of the desired track (but fine track had not been asserted) when suddenly the servo gray coded information indicated that movement of >1 cylinder has taken place away from the desired target cylinder. Such an occurrence may be related to an intermittent open of the coil actuator circuitry or transient spike in voltage establishing the holding current for the positioner.

Fault Isolation/Correction:

1. ECM
2. HDA

7D Embedded Interrupt Timeout

Error Type: DE

Error Description: The servo processor failed to detect a BURST PROTECT transition (asserted to de-asserted state) as generated from the master processor (ECM).

Fault Isolation/Correction:

1. ECM

7E Fine Track Lost After Settling

Error Type: DE

Error Description: The actuator initially settled on track but has now moved off track and loss of fine track has been declared by the servo subsystem. This condition has persisted for 2 seconds.

Examine head and or cylinder correlation when considering this error. This information should be derivable from the host error log or by doing a complete dump of the drive internal error log with a controller.

Other contributors to this condition might be sustained vibration to the drive unit, HDA runnout condition, or an HDA mechanical resonance problem.

Fault Isolation/Correction:

1. ECM (if totally random cylinders and heads)
2. HDA (first choice if same cylinder(s))
3. HDA (first choice if same head(s))

7F Servo Settling Timer Expired

Error Type: DE

Error Description: The actuator was not able to settle on track within the allotted settling timeout period. The servo system was able to relocate to within 1/4 track of the desired track/cylinder; however, it could not meet the fine track threshold stability criteria within the time allotted (1.8 seconds).

Examine head and or cylinder correlation when considering this error.

Fault Isolation/Correction:

1. ECM (if totally random cylinders and heads)
2. HDA (first choice if same cylinder(s))
3. HDA (first choice if same head(s))

80 Master Processor ROM Consistency Code Mismatch

Error Type: DF

Error Description: The master processor microcode is inconsistent with the microcode stored in EPROM.

Fault Isolation/Correction:

1. Reload microcode
2. ECM

81 Servo Processor Settle State Timeout

Error Type: DE

Error Description: The actuator was not able to settle on track within the allotted settling timeout period.

Fault Isolation/Correction:

1. ECM
2. PCM
3. HDA

82 Servo Processor Coarse Velocity State Timeout

Error Type: DE

Error Description: The servo processor timed out when commanded to move the actuator 256 or more cylinders.

Fault Isolation/Correction:

1. ECM
2. HDA

83 Servo Processor Fine Velocity State Timeout

Error Type: DE

Error Description: The servo processor timed out when commanded to move the actuator less than 256 cylinders.

Fault Isolation/Correction:

1. ECM
2. PCM
3. HDA

84 Servo Processor Seek Direction Error

Error Type: DE

Error Description: Servo processor actuator (positioner) and dedicated servo information indicated that the seek direction was wrong.

Fault Isolation/Correction:

1. ECM
2. HDA

85 Master Processor RAM Test Failure

Error Type: DF

Error Description: The drive-resident diagnostics detected bad RAM internal to the master processor.

Fault Isolation/Correction:

1. ECM

86 Static RAM Failure

Error Type: DF

Error Description: Drive-resident diagnostics detected bad RAM external to the master processor.

Fault Isolation/Correction:

1. ECM

87 Master Processor ROM Checksum Failure

Error Type: DF

Error Description: Drive-resident diagnostics detected bad ROM internal to the master processor.

Fault Isolation/Correction:

1. ECM

88 Master Processor EEPROM Write Violation Error

Error Type: DE

Error Description: EEPROM was addressed and written to while in read-only mode.

Fault Isolation/Correction:

1. ECM

89 Seek Speed Out of Range

Error Type: DE

Error Description: While monitoring the speed of the actuator, the servo processor determined that seek velocity is beyond prescribed speed.

Fault Isolation/Correction:

1. ECM
2. Power supply
3. HDA

8A Servo Processor Inside of Destination Track During Settle State

Error Type: DE

Error Description: Servo processor has determined that the positioner has placed heads inside of the destination track during settle state.

Fault Isolation/Correction:

1. ECM

8B Gray Code Error After Settling With Fine Track

Error Type: DE

Error Description: Head settling on a track normally occurs following a SEEK command. A gray code comparison is made to ensure the heads have settled on the requested track. In this case, the servo was settling within 1/4 track of the desired track and fine track had been asserted when suddenly the servo gray coded information indicated that movement of >1 cylinder has taken place away from the desired target cylinder. Such an occurrence may be related to a significant amount of vibration in the vertical axis of the drive, or electrical transients from the positioner control voltage and holding current circuitry.

Fault Isolation/Correction:

1. ECM
2. HDA

8C Uncalibrated and PLO Error

Error Type: DE

Error Description: A PLO error occurred and the head offsets were uncalibrated.

Fault Isolation/Correction:

1. ECM
2. PCM
3. HDA

8D Polarity Error on Velocity Command During a Multi-Track Seek

Error Type: DE

Error Description: The polarity indication bit in a velocity command profile was clear (zero) during a multi-track seek. This bit should have been set. (This is one of the setup functions the servo processor checks before it executes the digital servo seek profiles.)

Fault Isolation/Correction:

1. ECM

8E Master Processor ROM/EEPROM Consistency Code Mismatch

Error Type: DF

Error Description: Master processor microcode is incompatible with EEPROM microcode.

Fault Isolation/Correction:

1. Reload microcode
2. ECM

8F EEPROM Checksum Failure

Error Type: DF

Error Description: Drive-resident diagnostics detected bad EEPROM external to the master processor. The calculated checksum did not match the stored checksum.

Fault Isolation/Correction:

1. ECM

90 Unable to Force Index Error

Error Type: DF

Error Description: Drive-resident diagnostics were unable to force and/or detect an index error.

Fault Isolation/Correction:

1. ECM

91 No Interrupt Detected During R/W Force Fault

Error Type: DF

Error Description: No interrupt to the master processor was detected by the drive during the read/write force fault diagnostic.

Fault Isolation/Correction:

1. ECM

92 Inner Guardband Without a Servo Fault Set

Error Type: DF

Error Description: The actuator was positioned in the inner guardband area and the inner guardband flag was set; however, a servo fault condition was not detected.

Fault Isolation/Correction:

1. ECM

93 Inner Guardband/Servo Fault: No Interrupt Detected

Error Type: DF

Error Description: The actuator was positioned at a cylinder in the inner guardband area, the inner guardband flag was set, and a servo fault error was detected, but the master processor was not interrupted.

Fault Isolation/Correction:

1. ECM

94 SDI Loopback Test Failure on Both Ports

Error Type: DF

Error Description: Drive-resident diagnostics detected an SDI gate array or TSID gate array failure involving both SDI ports A and B logic. If the drive internal test 09 fails, the failure could be in the hardware external to the SDI/TSID gate array as well. During internal T09, the testing expects SDI loopback connectors to be attached to the ECM or at the cab bulkhead.

Fault Isolation/Correction:

If test number 08 fails:

1. ECM

If test number 09 fails:

1. Loopback connectors are not installed
2. Defective SDI cable
3. Defective bulkhead connector
4. ECM
5. SDI connectors J101 or J102

95 SDI Test Failure: Port A

Error Type: DF

Error Description: A drive-resident diagnostic detected a failure with the SDI gate array or the TSID gate array involving SDI Port A. If the drive internal test 09 fails for this error code, the failure could be in the SDI Port A hardware external to the SDI/TSID gate array as well. During internal T09, the testing expects SDI loopback connectors to be attached to the ECM or at the cabinet SDI bulkhead.

Fault Isolation/Correction:

If test number 08 fails:

1. ECM

If test number 09 fails:

1. Port A loopback connectors are not installed
2. Defective SDI cable (Port A)
3. Defective bulkhead connector (Port A)
4. ECM
5. SDI connector J102 (Port A)

96 SDI Failure: Port B

Error Type: DF

Error Description: A drive-resident diagnostic detected a failure with the SDI gate array or the TSID gate array involving SDI Port B. If the drive internal test 09 fails for this error code, the failure could be in the SDI Port B hardware external to the SDI/TSID gate array as well. During internal T09, the testing expects SDI loopback connectors to be attached to the ECM or at the cabinet SDI bulkhead.

Fault Isolation/Correction:

If test number 08 fails:

1. ECM

If test number 09 fails:

1. Port B loopback connectors are not installed
2. Defective SDI cable (Port B)
3. Defective bulkhead connector (Port B)
4. ECM
5. SDI connector J101 (Port B)

98 Can't Execute Diagnostic/Jumper

Error Type: DF

Error Description: A diagnostic test could not be run because a hardware jumper was not installed. If this error is seen in the field, *do not* attempt to alter jumpers.

Fault Isolation/Correction:

1. Operator (do not attempt to alter jumpers)

9A Positioner Corrected Event During Data Transfer

This is typically an event unless analyzed by VAXsimPLUS to be worthy of correction. Reference expanded discussion of 9A, 9B, and 9C events under error code 9C.

Error Type: DE

Error Description: Heads were not fine positioned or locked on track (relative to the embedded servo information) at the time a read or write operation was ready to start. The drive took necessary procedures to re-establish on-track condition. The drive command was received but READ GATE or WRITE GATE had not yet been asserted.

Fault Isolation/Correction:

1. HDA (if only one head)
2. ECM (if 10 of 13 heads)

9B Write and Positioner Corrected Event

This is typically an event unless analyzed by VAXsimPLUS to be worthy of correction. Reference expanded discussion of 9A, 9B, and 9C events under error code 9C.

Error Type: DE

Error Description: The master processor determined that the selected read/write head moved off track when WRITE GATE was asserted. The condition was corrected. (The read/write heads must be within 57.1 microinches from track centerline.)

Fault Isolation/Correction:

1. HDA (if only one head)
2. ECM (if 10 of 13 heads)

9C Read Gate and Positioner Corrected Event

Error Type: DE

Error Description: The master processor determined that the selected read/write head moved off track when READ GATE was asserted. The condition was corrected. (The read/write heads must be within 57.1 microinches from track centerline.)

TROUBLESHOOTING 9A, 9B, AND 9C:

This is typically an event unless analyzed by VAXsimPLUS to be worthy of correction. For HSC/KDM controllers, event rates of <5 per day may be considered normal for disks that operate with fairly high I/O rates (continually or in significant bursts) provided that the following pattern is noted:

- **Ninety percent of occurrences are with the top five heads (heads 0 through 4).**
- **One of the top five heads will have few if any errors.**
- **No one head in the top five has 90 percent of the errors. (This might point to a track/surface problem.)**

If the event pattern matches this, and the event rate exceeds these guidelines, then HDA replacement may be necessary.

If the event pattern does *not* match this, then further analysis is required.

For KDA/KDB/UDA controllers, event rates should not exceed 16 per day on heavily used disks (I/O rates of 30 per second).

If these events occur over 10 of the 13 heads, then the occurrence may be related to a general servo/read path problem. This is possibly an electronics problem that may not involve the HDA.

If these errors occur primarily on one head, there is strong head/surface correlation and possible HDA replacement is warranted.

The above number of events to be expected was determined by analysis and experience with the RA90 HDA 70-22951-01. With the introduction of the RA92 (HDA 70-27492-01), the number of 9A, 9B, and 9C events has decreased significantly. The phase-in of the RA92 HDA hardware mechanics (resulting in an RA90-compatible HDA 70-27268-01) into RA90 production has substantially reduced the occurrence of these events because of the new design.

Fault Isolation/Correction:

1. HDA (if only one head)
2. ECM (if 10 of 13 heads)

9D Error Log Header Corrupted

Error Type: DF

Error Description: A location in EEPROM containing drive-resident error log identifier information, device type, or descriptor size is invalid.

Fault Isolation/Correction:

1. Attempt to load new microcode
2. ECM

9E Drive Faulted, Test Cannot Run

Error Type: DF

Error Description: Drive-resident diagnostics cannot run while the drive is faulted.

Fault Isolation/Correction:

1. Check fault condition
2. ECM

9F Error Log Check Point Code

Error Type: Informational Only.

Error Description: If drive-resident diagnostic T50 has been used to place a checkpoint between errors in the drive internal error log, a 9F entry will be seen in the drive internal error log. This makes drive troubleshooting easier by placing a null field between errors in the drive internal error log to partition repair activity.

Fault Isolation/Correction:

1. None (read Error Description above)

A0 Unable to Clear SDI Array Safety Status Register

Error Type: DF

Error Description: Drive-resident diagnostics attempted to clear the SDI gate array safety status registers but were unsuccessful.

Fault Isolation/Correction:

1. To isolate the stuck bit, check the preceding error in the drive internal error log storage silo. Base corrective action on the preceding error.
2. ECM

A1 Unable to Force Encoder Error

Error Type: DF

Error Description: Drive-resident diagnostics were unable to force a read/write encoder/decoder (RWENDEC) error.

Fault Isolation/Correction:

1. ECM

A2 Unable to Force Multiple Head Select While Reading

Error Type: DF

Error Description: Drive-resident diagnostics were unable to force read gate and multi-chips error.

Fault Isolation/Correction:

1. PCM
2. ECM
3. HDA

A3 Unable to Force Write Gate and Write Unsafe

Error Type: DF

Error Description: A drive-resident diagnostic was unable to force write gate and write unsafe error conditions.

Fault Isolation/Correction:

1. ECM
2. PCM

A4 Unable to Force Write Current and No Write Gate

Error Type: DF

Error Description: Drive-resident diagnostics were unable to force write current and no write gate error conditions and detect such a condition.

Fault Isolation/Correction:

1. ECM
2. PCM

A5 Unable to Force Write Gate and No Write Current

Error Type: DF

Error Description: Drive-resident diagnostics were unable to force write gate and no write current error conditions.

Fault Isolation/Correction:

1. ECM
2. PCM

A6 Unable to Force Read Gate and Off Track Error

Error Type: DF

Error Description: Drive-resident diagnostics were unable to force read gate and off track error conditions.

Fault Isolation/Correction:

1. ECM

A7 Unable to Force Write Gate and Off Track Error

Error Type: DF

Error Description: Drive-resident diagnostics were unable to force write gate and off track error conditions.

Fault Isolation/Correction:

1. R/W cable to PCM
2. ECM

A8 Unable to Force Read and Write Fault While Writing

Error Type: DF

Error Description: Drive-resident diagnostics were unable to force a read/write-while-faulted error condition.

Fault Isolation/Correction:

1. ECM

A9 Servo Fault/Force Fault Test

Error Type: DF

Error Description: A servo check occurred while the diagnostic firmware was attempting to execute the force fault subtest.

Fault Isolation/Correction:

1. ECM
2. HDA

AB Forced Read and Write Fault While Reading

Error Type: DF

Error Description: Drive-resident diagnostics were unable to force a read/write-while-faulted error condition.

Fault Isolation/Correction:

1. ECM

AD UART Overrun or Framing Error

Error Type: DE

Error Description: The master processor internal UART detected an overrun condition or a framing error condition on data received from the OCP.

Fault Isolation/Correction:

1. OCP
2. ECM
3. Blower/bezel assembly

AE OCP Data Packet Checksum Error

Error Type: DE

Error Description: Data packets transmitted between the master processor and the OCP processor are in error.

Fault Isolation/Correction:

1. ECM
2. OCP
3. Blower/bezel assembly

AF OCP Start Byte is Not a Sync Character

Error Type: DE

Error Description: The first byte the master processor expects in a data packet transfer is a sync character. This error indicates no sync character was received.

Fault Isolation/Correction:

1. ECM
2. OCP
3. Blower/bezel assembly

B0 OCP Invalid Response

Error Type: DE

Error Description: The OCP processor did not acknowledge a command from the master processor.

Fault Isolation/Correction:

1. OCP
2. ECM
3. Blower/bezel assembly

B2 OCP Retransmit Failure

Error Type: DE

Error Description: The OCP processor can request three retransmits from the master processor. This error indicates the OCP requested more than three consecutive retransmit responses.

Fault Isolation/Correction:

1. OCP
2. ECM
3. Blower/bezel assembly

B3 OCP Command Unsuccessful

Error Type: DE

Error Description: An incorrect response was received from the OCP processor after the master processor issued a SEND STATUS command to the OCP.

Fault Isolation/Correction:

1. OCP
2. ECM

B4 OCP Command Timeout

Error Type: DE

Error Description: The OCP processor did not respond to a master processor command within its allotted timeout period. As a result of this error, the master processor logs a B6 error condition into EEPROM and latches B4 into the display.

Fault Isolation/Correction:

1. OCP
2. ECM
3. Blower/bezel assembly

B6 Master Processor UART Loopback Test Failure

Error Type: DF

Error Description: Drive-resident diagnostics were unable to transmit and receive data through the master processor serial communications interface (SCI).

Fault Isolation/Correction:

1. ECM

B8 Master Processor UART Transmitter/Receiver Error

Error Type: DE

Error Description: The OCP failed to transmit or receive data through its master processor serial port.

Fault Isolation/Correction:

1. OCP

B9 OCP-to-Master Processor Communications Timeout Failure

Error Type: OCP Error Code

Error Description: The master processor failed to communicate with the OCP processor within 4 seconds after power-up.

Fault Isolation/Correction:

1. OCP
2. ECM
3. Blower/bezel assembly

BA OCP NMI Timeout Failure

Error Type: OCP Error Code

Error Description: The master processor failed to communicate with the OCP processor within 4 seconds after issuing an initialize request to the OCP processor.

Fault Isolation/Correction:

1. OCP
2. ECM
3. Blower/bezel assembly

BB OCP Processor ROM Checksum Failure

Error Type: OCP Error Code

Error Description: The OCP processor performed a ROM checksum, and the calculated checksum did not match the stored checksum.

Fault Isolation/Correction:

1. OCP

BC Cartridge Checksum Failure

Error Type: DF

Error Description: Invalid microcode was detected in the microcode update cartridge.

Fault Isolation/Correction:

1. Reseat update cartridge (retry T40)
2. Defective cartridge
3. OCP
4. ECM

BD Microcode Update Cartridge Detection Failure

Error Type: DF

Error Description: The microcode update utility (T40) was attempted without an update cartridge in place.

Fault Isolation/Correction:

1. Cartridge is not inserted
2. Defective cartridge
3. OCP
4. ECM

BE Cartridge/EEPROM/Master Processor Consistency Check

Error Type: DF

Error Description: Microcode contained within the cartridge is inconsistent with the microcode in the master processor, EPROM, or EEPROM. The microcode update process is halted to prevent loading incompatible microcode. The product revision matrix documentation shows which codes are compatible.

Fault Isolation/Correction:

1. Reseat update cartridge
2. Replace update cartridge with a compatible cartridge
3. ECM

BF Error Log Write Compare Error**Error Type:** DE

Error Description: Each time the drive writes an error log entry into the error silo, it verifies the data written. The microcode got a data compare error on the page (16 bytes) that was written. This is not a fatal error. Should that particular silo entry be rewritten, it may or may not fail again. This error code is not written to EEPROM but may be displayed at the time of the error if the fault button is depressed.

Fault Isolation/Correction:

1. ECM

C0 Hardware Revision and Microcode incompatibility**Error Type:** DE

Error Description: The microcode has determined that there is an incompatible hardware and/or software combination from the revision information that it has visibility to. The microcode looks at the following hardware revisions in a drive:

- I/O-R/W module hardware revision jumpers
- Servo module hardware revision jumpers
- PCM switch pack (S1-1 through S1-4)
- HDA revision bits information

Most of this hardware revision information can be determined by executing drive internal test T45 (see Chapter 4), then decoding the reported revision information.

The microcode, after checking this internal revision information, will modify the final drive reported hardware revision that is reported to the subsystem and host as the *drive hardware revision*.

Microcode revision 9 was the first release that checked for HDA revision. Subsequent microcode revisions have been expanding on the compatibility testing. With the RA92 (microcode revisions 20 and later), a significant amount of revision checking/testing is necessary for the microcode to properly configure itself as to the type of drive (RA90 vs RA92), type of HDA (short arm vs long arm), type of format (RA90 vs RA92), and type of ECM (70-22942-01 vs 70-22942-02).

To determine *TOTAL* compatibility, you must verify:

- Code compatibility to ECM
- Code compatibility to HDA
- ECM compatibility to HDA
- PCM and HDA compatibility
- PCM switch pack setup.

Reference the compatibility tables in Chapter 3.

With microcode revisions 20 and later, the C0 LED error is a very significant fault to the drive and must be resolved. The error type was redefined to a drive error.

Fault Isolation/Correction: If the HDA has just been replaced, replace it again with a compatible revision or load compatible drive microcode in the ECM.

If the drive HDA and microcode were operational before the failure, then revision bits are now being detected in error. This will require careful troubleshooting. A series of tables in the *RA90/RA92 Disk Drive Pocket Reference Card* have been prepared to assist in the determining and resolving of this error condition. Additional tables are provided in Chapter 3.

1. If the HDA has just been replaced: load compatible microcode
2. If the PCM has just been replaced: check PCM switch pack S1-1 through S1-4 for correct switch settings. Refer to the *RA90/RA92 Disk Drive Pocket Reference Card* and the tables in Chapter 3.
3. If the ECM has just been replaced: check microcode compatibility. Refer to the *RA90/RA92 Disk Drive Pocket Reference Card* and the tables in Chapter 3.
4. R/W cable
5. PCM
6. ECM

C1 Outer Guardband Detected After HEAD LOAD Command

Error Type: DF

Error Description: The GASP gate array detected outer guardband after a HEAD LOAD command.

Fault Isolation/Correction:

1. ECM

C2 Inner Guardband Detected After HEAD LOAD Command

Error Type: DF

Error Description: The GASP gate array detected inner guardband after a HEAD LOAD command.

Fault Isolation/Correction:

1. ECM

C3 Seek to Outer Guardband Failed

Error Type: DF

Error Description: The servo processor was issued a SEEK command to the outer guardband area of the disk but failed the seek.

Fault Isolation/Correction:

1. Clean cabinet air vent grill
2. ECM
3. PCM
4. Blower/bezel assembly
5. HDA

C4 Seek to Outer Guardband Not Detected**Error Type:** DF**Error Description:** The servo processor was issued a SEEK command to the outer guardband area of the disk, but the OGB flag was not detected.**Fault Isolation/Correction:**

1. ECM

C5 HDA and ECM Incompatibility**Error Type:** DF**Error Description:** The microcode has determined that the reported HDA type and ECM type are incompatible. Specifically, the incompatible combination is an old ECM type (70-22942-01) and an RA92 HDA.

Microcode revision 25 was the first release to check specifically for this error. Previous microcode revisions (revision 9 and later) will report this condition as error code C0.

Fault Isolation/Correction: If the HDA or ECM has just been replaced, make sure compatible part numbers have been used.

If the PCM has just been replaced (part of the HDA FRU assembly), make sure switches S1-1 through S1-4 are set correctly. (See Chapter 3 or compatibility tables in the *RA90/RA92 Disk Drive Pocket Reference Card*.)

If HDA, PCM, ECM and drive microcode were operational before the failure, then the switch pack S1 on the PCM and/or the I/O-R/W and servo revision jumpers are now being detected in error. This will require careful troubleshooting. See drive error code C0 for additional troubleshooting information.

1. R/W cable
2. PCM (check S1 switch pack setting)
3. ECM (replace with P/N 70-22942-02)

C6 PLO Failure**Error Type:** DE**Error Description:** The voltage controlled oscillator (VCO) is not synchronized to the dedicated servo information read from the media.**Fault Isolation/Correction:**

1. ECM
2. PCM
3. HDA

C7 Seek to Inner Guardband Failed**Error Type:** DF**Error Description:** The servo processor was issued a SEEK command to the inner guardband area of the disk but failed the seek.

Fault Isolation/Correction:

1. ECM
2. PCM
3. HDA

C8 Inner Guardband Not Detected After Seek to Inner Guardband

Error Type: DF

Error Description: A SEEK command, issued to the servo processor to seek to the inner guardband area, failed to detect the inner guardband flag.

Fault Isolation/Correction:

1. ECM
2. HDA

C9 Analog Loop Test Failure

Error Type: DE

Error Description: The D/A and A/D circuitry did not respond correctly while tested in a loop. The servo processor performs the analog testing on these circuits.

Fault Isolation/Correction:

1. ECM
2. PCM

CA Media Not Spinning

Error Type: DF

Error Description: Selected drive-resident diagnostics could not be executed because the drive was spun down.

Fault Isolation/Correction:

1. Spin up drive
2. ECM

CC Servo Processor Recalibrate Failed

Error Type: DE

Error Description: A RECALIBRATE command issued to the servo processor failed.

Fault Isolation/Correction:

1. ECM
2. PCM
3. HDA

CD Track Counter (Gray Code)

Error Type: DE

Error Description: During coarse positioning, both gray code bits (X and Y) changed during the same servo frame; or the same gray code changed (X or Y) during two consecutive servo frames.

Fault Isolation/Correction:

1. HDA
2. ECM

CE EEPROM Write Cycle Timeout

Error Type: DE

Error Description: During an EEPROM write operation, a location in EEPROM could not be written within 20 milliseconds.

Fault Isolation/Correction:

1. ECM

CF Invalid Data in EEPROM

Error Type: DE

Error Description: Error information in EEPROM was found to be invalid.

Fault Isolation/Correction:

1. ECM

E0 Spindle Rotation Not Detected

Error Type: DE

Error Description: The servo system has not detected Hall sensor signal transitions. This indicates either the spindle motor is not turning or the Hall sensor circuitry has failed. An open motor coil (or drive circuitry) will show this symptom if that particular phase is needed to start the spindle drive. See error code 13 before replacing FRUs.

With microcode revisions 19 and earlier, this error was *spindle speed unsafe*—basically the same error detection.

After microcode revision 20, this error is simply *failure to detect that the spindle has performed any motion*. The servo monitors the hall sense S1 signal (reference error code 13). If it detects any transition on this specific motor control signal, then this check is okay.

Fault Isolation/Correction:

1. ECM
2. Rear flex cable assembly (visually inspect for damage (HDA removal necessary); the rear flex cable assembly should be neatly dressed along the sides of the chassis at the rear)
3. Servo-to-spindle motor interconnect
4. Brake failure (on/open all the time)
5. HDA
6. Rear flex cable assembly

E1 Spindle Speed Out Of Range

Error Type: DE

Error Description: Spindle speed is monitored initially by input from the Hall sensors inside the HDA spindle motor. Improper spindle speed, as detected by the Hall sensors, may prevent proper speed control until the PLO frequency lock range is attained. Once the spindle speed is within the PLO range, the servo system begins to look for servo data in which to lock its frequency to. This error implies that the drive is unable to establish spindle speed rotation within the range required (RA90=3600 rpm, RA92=3405 rpm).

An open failure of a spindle motor coil winding, or a motor drive circuitry failure, or a bad hall sense S1 or S2 circuit will cause this type of error. See error code 13 for measurement points and troubleshooting aids before replacing FRUs.

Fault Isolation/Correction:

1. Rear flex cable assembly (visually inspect for damage (HDA removal necessary); the rear flex cable assembly should be neatly dressed along the sides of the chassis at the rear)
2. ECM
3. Continuity checks (refer to Table 5-10)
4. HDA

E2 A/D or D/A Converter Insane

Error Type: DE

Error Description: The servo processor detected a failure in its A/D or D/A converters during a precheck before the head load was initiated.

Fault Isolation/Correction:

1. ECM
2. If you load microcode revision 13 (or earlier) into a 70-22942-02 (RA92-compatible) ECM, a solid E2 error will be seen upon drive spinup.

E3 Excessive Positioner Current During Test

Error Type: DE

Error Description: The servo processor detected a failure in the power amp circuitry that indicates a shorted condition.

Fault Isolation/Correction:

1. ECM

E4 Open Circuit Detected During Power Amp Toggle Test

Error Type: DE

Error Description: An open was detected in the power amp circuitry during a head load sequence. Power is applied to the positioner in a toggle fashion during the head load sequence.

Reference error code 13 for information that may be useful for isolating an open circuit of the actuator. An ohmmeter measurement might verify this condition at the HDA.

Fault Isolation/Correction:

1. Rear flex cable assembly (visually inspect for damage (HDA removal necessary); the rear flex cable assembly should be neatly dressed along the sides of the chassis at the rear)
2. ECM
3. HDA

E5 Overcurrent Detected During Actuator Test

Error Type: DE

Error Description: The servo processor detected an overcurrent condition before attempting a head load process.

Fault Isolation/Correction:

1. ECM

E6 Track Counter Clear Failure

Error Type: DE

Error Description: The track counter failed to clear indicating establishment of cylinder 0. This is the final phase of the head load/RTZ process that must be accomplished.

Loss of PLO during this portion of the head load/RTZ process will also cause this error. See the note in the error description for error code E8.

Fault Isolation/Correction:

1. ECM (most likely)
2. PCM
3. HDA

E7 Illegal Zone Detected

Error Type: DE

Error Description: The servo system is executing a head load or RTZ operation.

For microcode revisions 19 and earlier, the order of band detection is: outer guardband, data area, then inner guardband area.

For microcode revisions 20 and later, the order of band detection that the servo system is looking for is OGB, data area, then back to OGB. In this case (without an E9 error), the servo system could not re-establish finding the OGB area (the second time). The servo system will spend up to one second trying to re-establish the OGB area.

Loss of PLO during this portion of the head load/RTZ process will also cause this error. See the note in the error description for error code E8.

Fault Isolation/Correction:

1. ECM (most likely)
2. HDA
3. PCM

E8 Outer Guardband Timeout

Error Type: DE

Error Description: Servo is in the outer guardband (OGB) of the disk and wants to be able to detect this region by looking for the OGB pattern from the dedicated servo information. At this time, however, the servo cannot establish PLO lock and faults. Interruption of the servo data stream is likely. Up to 3.4 seconds is allocated to trying to find servo data.

NOTE

PLO Loss During Head Load/RTZ: The PLO coming unlocked is a fairly serious error to a servo system. It causes all the servo information to become unreadable. There are now four different codes for the PLO being unlocked, depending on when it happens:

- At the beginning of RTZ, if unable to establish lock, an E8 is reported.
- Midway through the RTZ, if lock is lost while scanning the disk for the OGB, an E7 is reported.
- Late in the RTZ, while going from the OGB to cylinder 0, lost lock results in an E6.
- During normal track following and seeking, lost lock causes an EC.

These are the error codes reported by the servo and logged in the error log while functional I/O code is running. Diagnostic I/O code may log (and the OCP may display) the I/O's error code of C6 for a PLO failure.

Fault Isolation/Correction:

1. ECM
2. PCM
3. HDA

E9 Gray Code Timeout During the Turnaround State

Error Type: DE

Error Description: No gray code transitions were detected during a hold sequence. The drive is attempting a head load (NRZ), is in the OGB, and has PLO locked, reading its OGB position. At this point, the servo is attempting to move forward to look for track crossings and the eventual detection of the data area of the disk. However, the servo cannot get the positioner to move. The servo will spend up to 3.4 seconds trying to move the positioner.

A sticky (dragging) actuator lock pin or faulty actuator lock solenoid will also cause this error.

Fault Isolation/Correction:

1. HDA (positioner lock solenoid failure—see error code 13)
2. Rear flex cable assembly (visually inspect for damage (HDA removal necessary); the rear flex cable assembly should be neatly dressed along the sides of the chassis at the rear)
3. ECM

EA Gray Code Timeout During Outer Guardband State

Error Type: DE

Error Description: No gray code transitions were detected during a head load sequence.

Fault Isolation/Correction:

1. Visually inspect rear flex cable assembly
2. HDA (positioner lock solenoid failure—see error code 13)
3. ECM

EB Sector Pulse Timeout During Sync-Up State

Error Type: DE

Error Description: An index pulse was detected but no sector pulse was detected in the data area of the disk. Heads may not be positioned over the data area.

Fault Isolation/Correction:

1. ECM
2. HDA

EC Servo Fault and PLO Fault Bit Set In GASP

Error Type: DE

Error Description: The servo fault and PLO fault bits are both set in the GASP, but it was noted by the servo processor that the PLO had come unlocked. Similar to error code 25, however, the servo processor did see the PLO deassert, which in turn caused the servo fault bit to set.

Fault Isolation/Correction:

1. ECM
2. PCM
3. HDA

ED Servo Watchdog Timeout

Error Type: DE

Error Description: The digital signal processor (DSP) was not interrupted on time by the GASP. Possibly, the servo clock signal is not present or is not being detected properly. The timeout is 820 microseconds.

Fault Isolation/Correction:

1. ECM

EE Servo Digital Signal Processor Reset

Error Type: DE

Error Description: The Servo DSP has been reset. As a result, the profiles for the drive have not been loaded by the master processor. The DSP is sane, but has not been told what type of HDA is present in the drive—it may be an RA90 long arm, RA90 short arm, or an RA92. Therefore, the servo will not load its servo tables or move the actuator. This is an unusual error condition. The master processor should have reinitialized the drive characteristics into the servo system.

Fault Isolation/Correction:

1. Turn drive power off and on
2. ECM

EF Head Unload Failed

Error Type: DE

Error Description: The servo processor responded with an error condition to a HEAD UNLOAD command.

Fault Isolation/Correction:

1. ECM
2. HDA

F0 Servo Microcode Update Failed

Error Type: DE

Error Description: The servo processor did not send a SUCCESSFUL acknowledgment when the master processor attempted to load external servo processor RAM with new microcode. When the drive powered up, a microcode update occurred or a servo timeout took place. The master processor did a compare of EEPROM to RAM microcode. The data did not compare.

Fault Isolation/Correction:

1. I/O-R/W to servo cable connection
2. ECM

F1 Command to Servo Processor Timed Out

Error Type: DE

Error Description: The master processor attempted to issue an UNLOAD command to the servo processor; however, the command timed out during its execution.

Fault Isolation/Correction:

1. ECM

F3 Servo Spinup Failed

Error Type: DE

Error Description: The master processor issued a SPINUP command to the servo processor and the servo processor responded with an error condition.

Fault Isolation/Correction:

1. ECM
2. Brake assembly
3. HDA

F4 Servo Spindown Failed

Error Type: DE

Error Description: The master processor issued a command to spin down the drive. The servo processor responded with an error condition.

Fault Isolation/Correction:

1. ECM

F5 Seek Failed

Error Type: DE

Error Description: The servo processor returned an error condition in response to a **SEEK** command from the master processor.

NOTE

T65 does not check for out-of-range values. Do not exceed the maximum specified input values. Also, the last cylinder parameter must always be equal to or greater than the first cylinder parameter. If an invalid cylinder value is entered, a (servo) Seek Failed error (F5) occurs.

Fault Isolation/Correction:

1. HDA
2. ECM (if 10 of 13 heads)

F6 Head Switch Failed

Error Type: DE

Error Description: The servo processor responded with an error condition to a **HEAD SWITCH** command initiated by the master processor.

Fault Isolation/Correction:

1. HDA
2. ECM (if 10 of 13 heads)

F7 RTZ Failed

Error Type: DE

Error Description: The master processor issued a **RETURN TO ZERO (RTZ)** command to the servo processor, and the servo processor responded with an error condition.

Fault Isolation/Correction:

1. ECM
2. HDA

F8 Head Load Failed

Error Type: DE

Error Description: The master processor issued a **HEAD LOAD** command to the servo processor, and the servo processor responded with an error condition and no specific error information with it, or the head load timed out.

Fault Isolation/Correction:

For microcode revisions 19 or earlier:

1. ECM (if 10 of 13 heads)
2. PCM
3. HDA

For microcode revisions 20 or later:

1. ECM

F9 Diagnostic Command Failed

Error Type: DF

Error Description: The servo processor responded with an error or a timeout condition to a DIAGNOSE command issued by the master processor.

Fault Isolation/Correction:

1. ECM
2. PCM
3. HDA

FA Servo Processor Failed Seek to DGN Write Cylinder

Error Type: DF

Error Description: A seek to the diagnostic (DGN) write/read cylinder failed while under diagnostics control.

Fault Isolation/Correction:

1. ECM
2. PCM
3. HDA

FB Servo Processor Failed Seek to DGN Read Cylinder

Error Type: DF

Error Description: A seek to the diagnostic (DGN) read-only cylinder failed while under diagnostics control.

Fault Isolation/Correction:

1. ECM
2. PCM
3. HDA

FD EEPROM Checksum Error

Error Type: DF

Error Description: An incorrect checksum was detected in one of the EEPROMs.

Fault Isolation/Correction:

1. Reload microcode
2. ECM

Removal and Replacement Procedures

6.1 Introduction

This chapter describes the removal and replacement procedures for RA90 and RA92 disk drive components. No tools are needed to remove or replace the six major field replaceable units (FRUs) that make up the RA90/RA92 disk drive. However, tools are required for the removal and/or replacement of some drive components. A tools checklist is included to identify these tools. Tools are also identified in procedures where needed.

Figure 6-1 shows an exploded view of the RA90/RA92 disk drive.

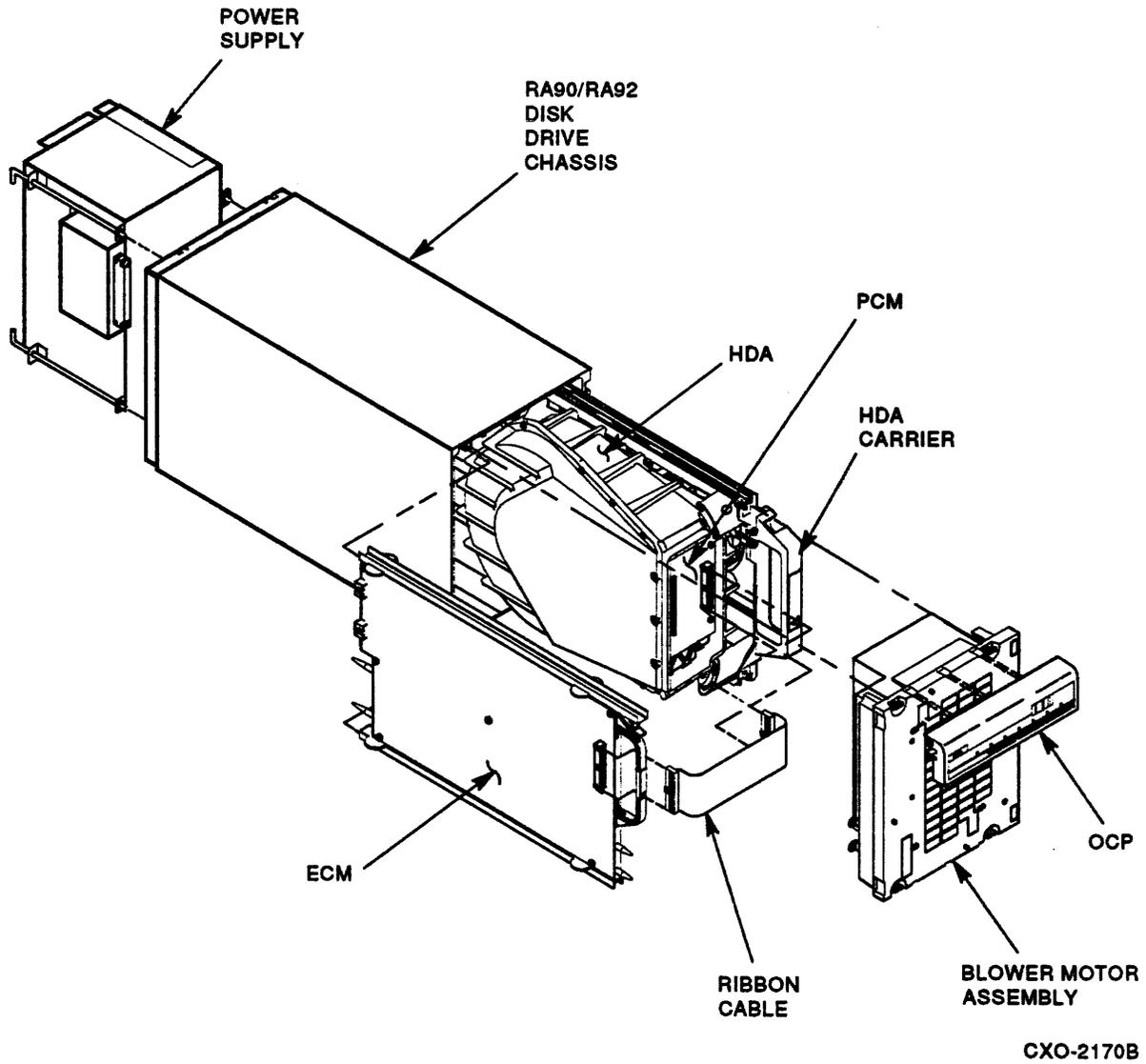
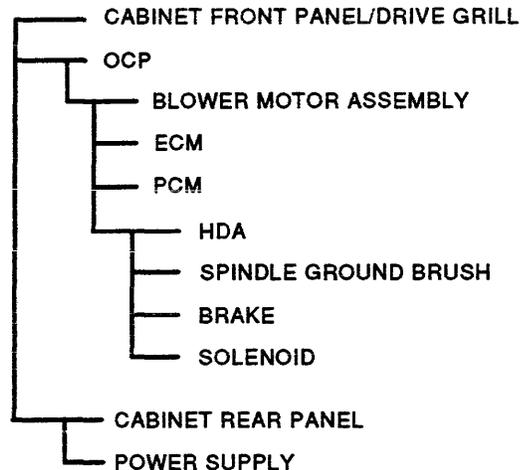


Figure 6-1 RA90/RA92 Disk Drive — Exploded View

6.2 Sequence for FRU Removal

Remove RA90/RA92 FRUs in the following sequence:



CXO-2200A

Figure 6-2 FRU Removal Sequence

Use care when removing and replacing drive components. Never force fit drive modules or components. Generally, a steady, firm pressure and the correct alignment ensures proper seating of drive components. If you encounter resistance during FRU removal or replacement, check for bent pins, obstructions, or improper alignment of parts.

6.3 Electrostatic Sensitivity

Drive components and FRUs are highly sensitive to electrostatic shock. Use proper ESD methods when handling drive components. (Refer to Section 1.4, Electrostatic Protection.)

6.4 Power Precautions

Since hazardous voltages are present in this equipment, it is recommended that only trained service personnel attempt to service this equipment.

WARNING

Always remove power from the unit before removing or replacing any internal part or cable. Bodily injury or equipment damage may result from improper servicing.

6.5 Tools Checklist

Most RA90 and RA92 disk drive repairs can be performed without the use of tools. However, the following tools are required during some procedures:

- 5/32 Hex wrench
- 1/16 Allen wrench
- 3/32 Allen wrench
- 5/32 Allen wrench
- 3/16 Allen wrench

- Pliers
- Needlenose pliers
- Medium Phillips screwdriver
- Flat-blade screwdriver

6.6 Removing/Replacing Cabinet Front and Rear Access Panels

Procedures contained in this chapter require the removal of cabinet front and rear access panels. Panel removal and replacement procedures follow.

6.6.1 Removing/Replacing the Front Access Panel

To remove the cabinet front access panel (refer to Figure 6-3):

1. Use a hex wrench or flat-bladed screwdriver to unlock the two quarter-turn fasteners at the top of the panel. Turn the fasteners counterclockwise.
2. Grasp the panel by its edges, tilt it toward you, and lift it up about 2 inches. Remove the panel and store it in a safe place.

To reinstall the front access panel:

1. Lift the panel into place and lower it straight down until the tabs on the panel's lower edge engage the slots in the cabinet support bracket.
2. Holding the panel flush with the cabinet, use a hex wrench to lock the quarter-turn fasteners. Turn the fasteners clockwise.

6.6.2 Removing/Replacing the Rear Access Panel

To remove the cabinet rear access panel (refer to Figure 6-4):

1. Use a hex wrench or flat-bladed screwdriver to unlock the two quarter-turn fasteners at the top of the panel. Turn the fasteners counterclockwise.
2. Tilt the panel toward you and lift it up to disengage the pins at the bottom.
3. Lift the panel clear of the enclosure and store it in a safe place.

To reinstall the rear access panel:

1. Lift the panel into place and fit the pins into the holes at the top of the I/O bulkhead.
2. Push the top of the panel into place and use a hex wrench to lock the quarter-turn fasteners. Turn the fasteners clockwise.

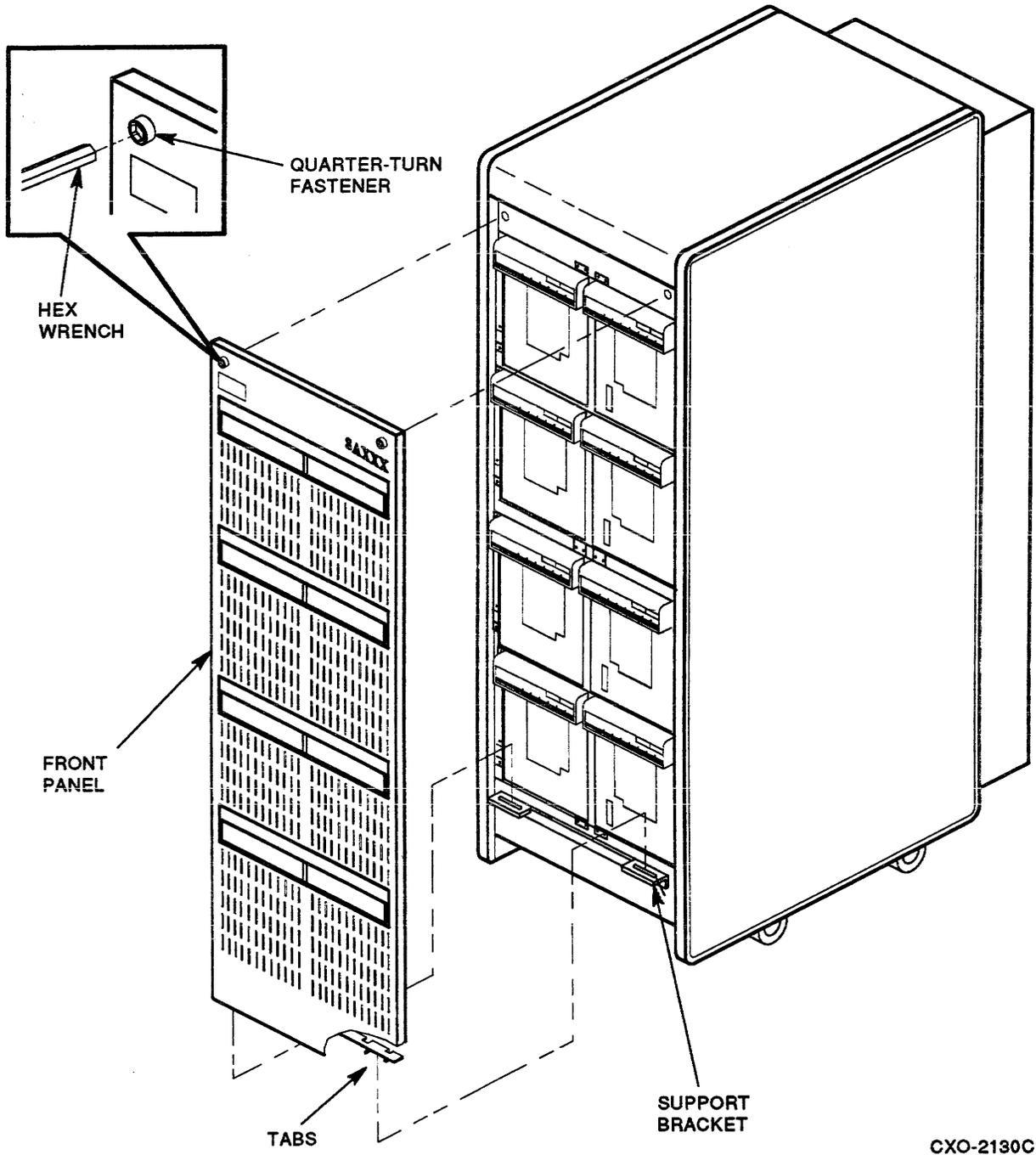


Figure 6-3 Front Access Panel Removal

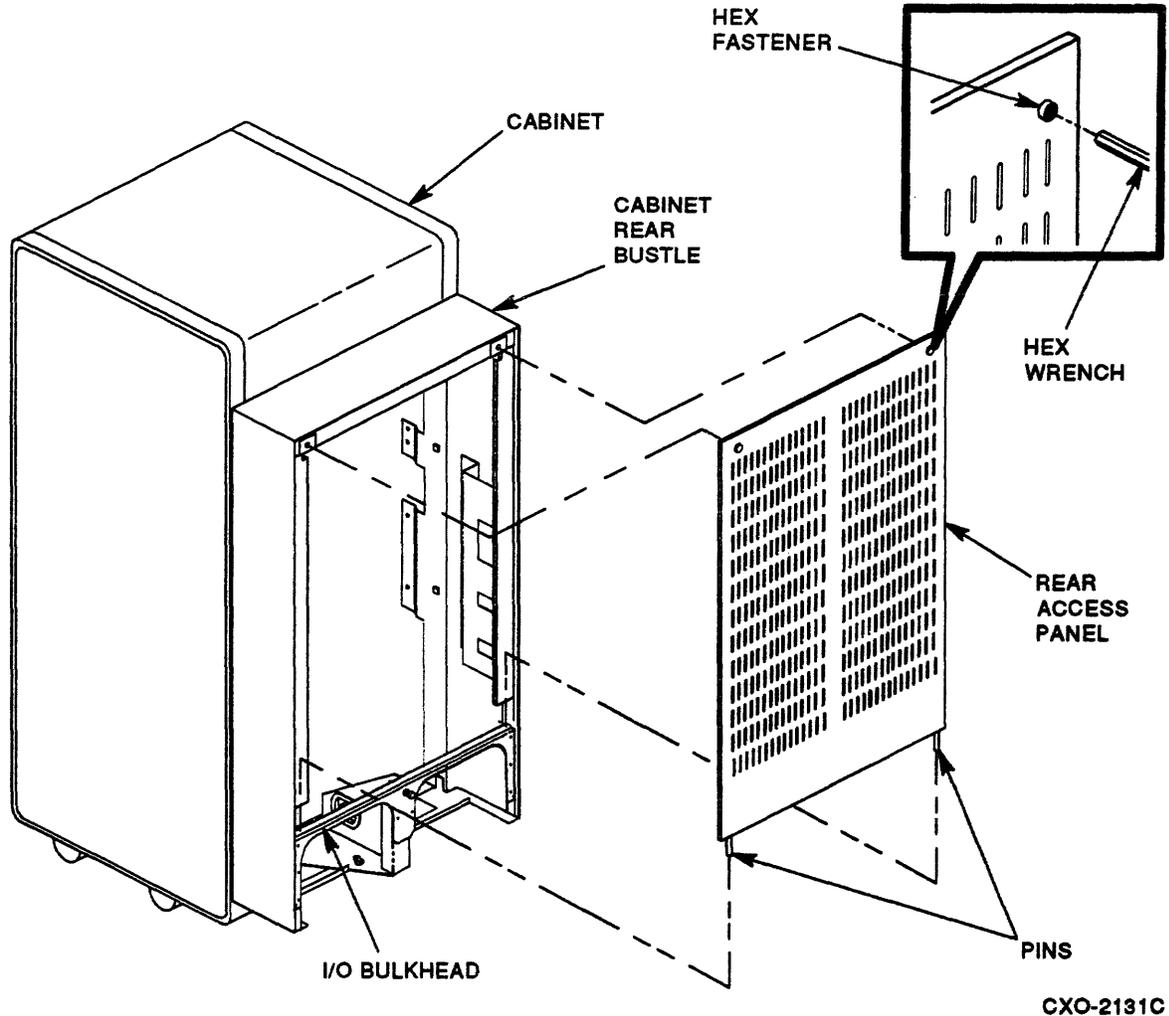


Figure 6-4 Rear Access Panel Removal

6.7 Removing the Operator Control Panel

The operator control panel (OCP) is secured to the bezel/blower assembly by the OCP-to-blower connector and by flexible metal retention clips.

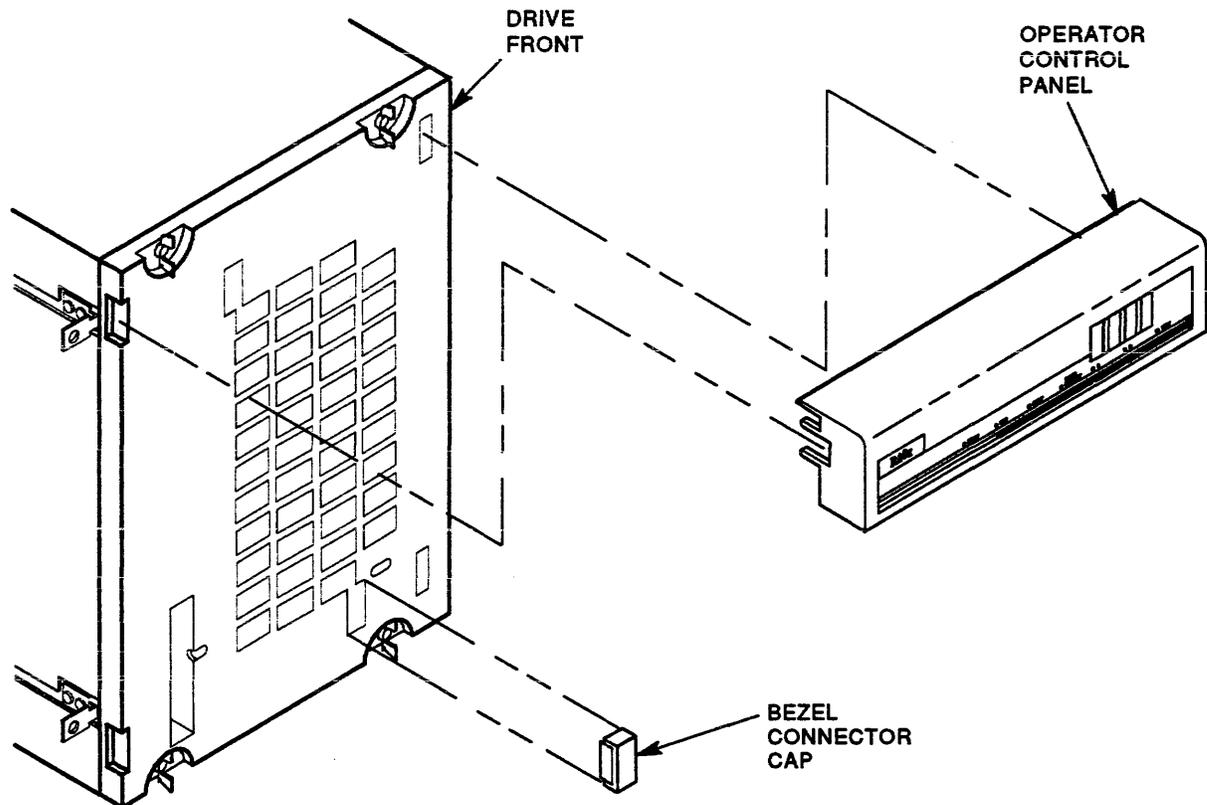
NOTE

Note the orientation of the OCP before removing.

To remove the OCP (refer to Figure 6-5):

1. Remove power from the drive.
2. Grip the OCP in the middle and gently pull it towards you.
3. Note OCP-to-blower connector orientation.

Reverse this process to replace the OCP. (Check for bent pins before replacing.)



CXO-2172C

Figure 6-5 OCP Removal

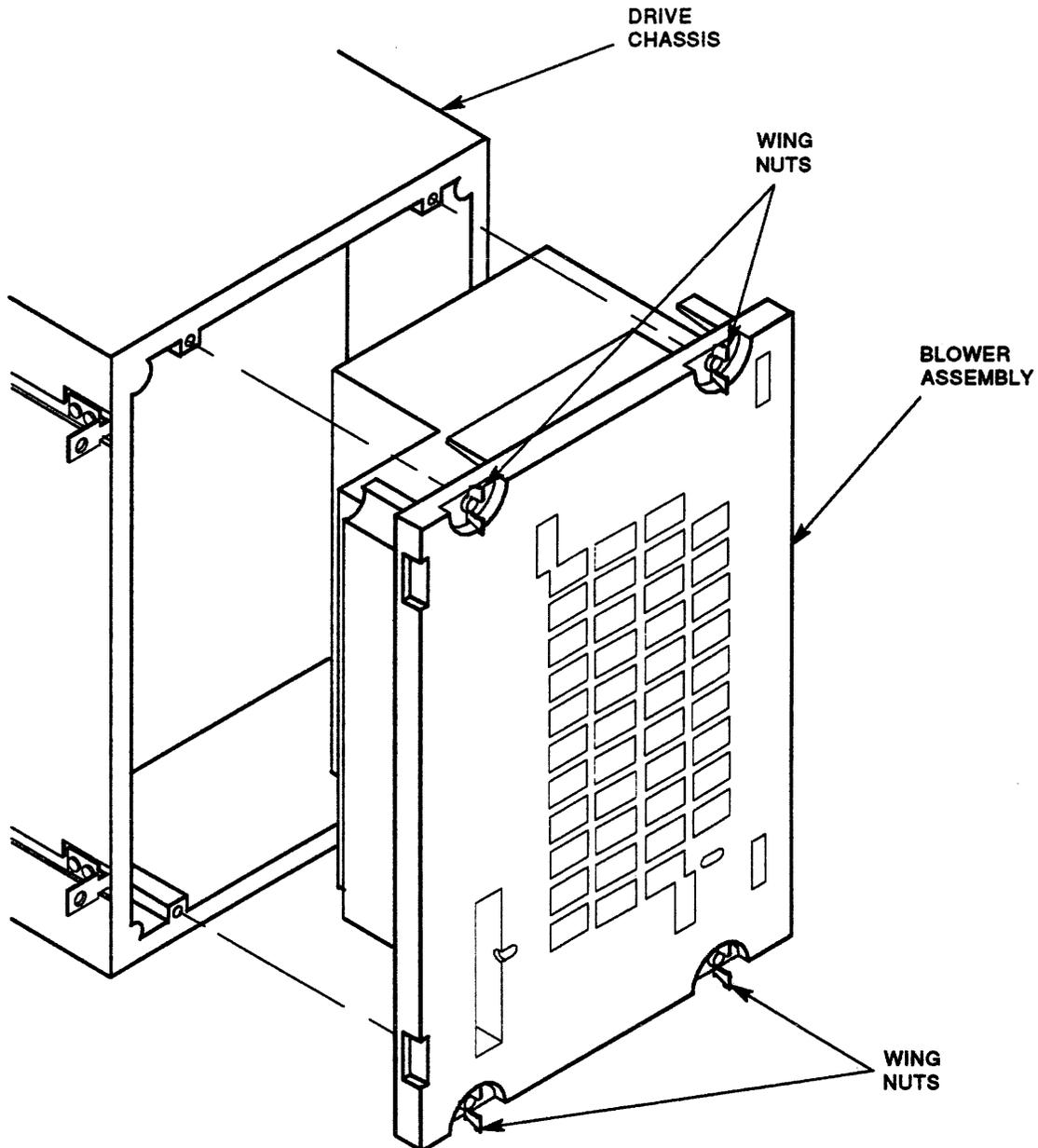
6.8 Removing the Blower/Bezel Motor Assembly

Although the bezel and blower motor assembly are removed as one unit from the drive chassis, the bezel and blower motor assembly are two separate units. The blower motor assembly is the FRU.

Pay particular attention to the blower motor orientation and blower motor-to-ECM connection.

To remove the blower motor assembly (refer to Figure 6-6):

1. Remove power from the drive.
2. Remove the OCP (refer to Section 6.7).
3. Note blower motor orientation before removing.
4. Locate the four wing nuts.
5. Rotate lower then upper wing nuts counterclockwise to loosen.
6. Grasp the assembly sides and pull the assembly toward you.



CXO-2173B

Figure 6-6 Blower Motor Assembly Removal Sequence

To replace the blower motor assembly:

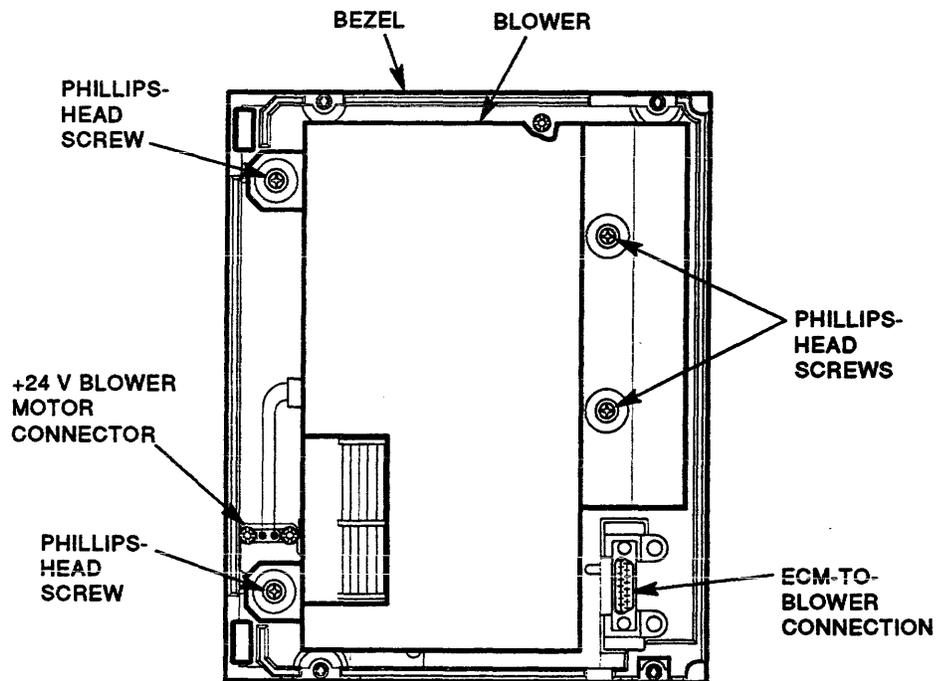
1. Ensure a good connection exists between the blower motor assembly and the ECM.
2. Check for proper connector alignment.
3. Use steady, gentle pressure to replace the blower motor assembly. Do not force the blower assembly into position. If resistance is encountered, check for bent pins.
4. Tighten the upper and lower wing nuts in a clockwise direction.

6.8.1 Separating the Bezel and Blower Motor Assembly

Use the following procedure to separate the blower motor assembly from the bezel (refer to Figure 6-7):

1. Place the assembly grill-side down.
2. Locate and disconnect the +24 V blower motor connector (red and black leads).
3. Locate the Phillips-head screws; loosen and remove.
4. Separate the bezel and blower motor assembly.

Reverse this procedure to reconnect the bezel and blower motor assembly. Return the assembly to the chassis.



CXO-2174B

Figure 6-7 Bezel and Blower Motor Assembly Separation

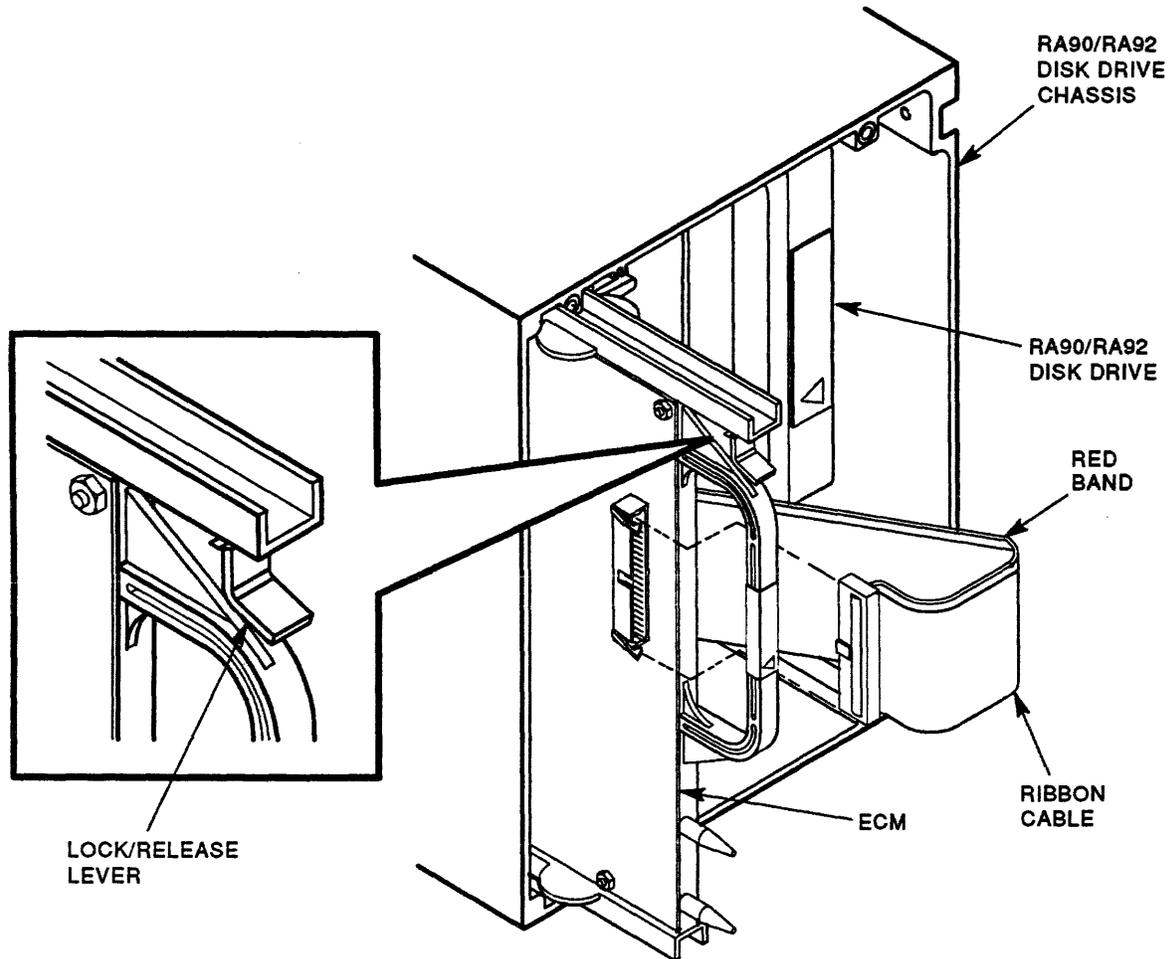
6.9 Removing the Electronic Control Module

Ensure proper grounding before beginning this procedure. To remove the electronic control module (ECM) (refer to Figure 6-8):

1. Remove power from the drive.
2. Remove the OCP (refer to Section 6.7).
3. Remove the blower motor assembly (refer to Section 6.8).
4. Remove the ribbon cable from the preamp control module (PCM).
5. Locate the lock/release lever on the side of the ECM.
6. Grasp the ECM handle and apply pressure to the lock/release lever with your thumb.

NOTE

Do not use extreme force when applying pressure to the lock-release lever. Only firm, steady pressure is required to remove the ECM.



CXO-2176C

Figure 6-8 ECM Removal

7. Pull the ECM toward the front of the chassis.
8. If resistance is encountered, apply a small amount of back pressure to the ECM and, at the same time, apply pressure to the lock release lever. Pull the ECM toward the front of the chassis.

Reverse this procedure to replace the ECM. Apply firm (not excessive) pressure until the carrier latch engages its detent. Reconnect the ECM-to-PCM ribbon cable.

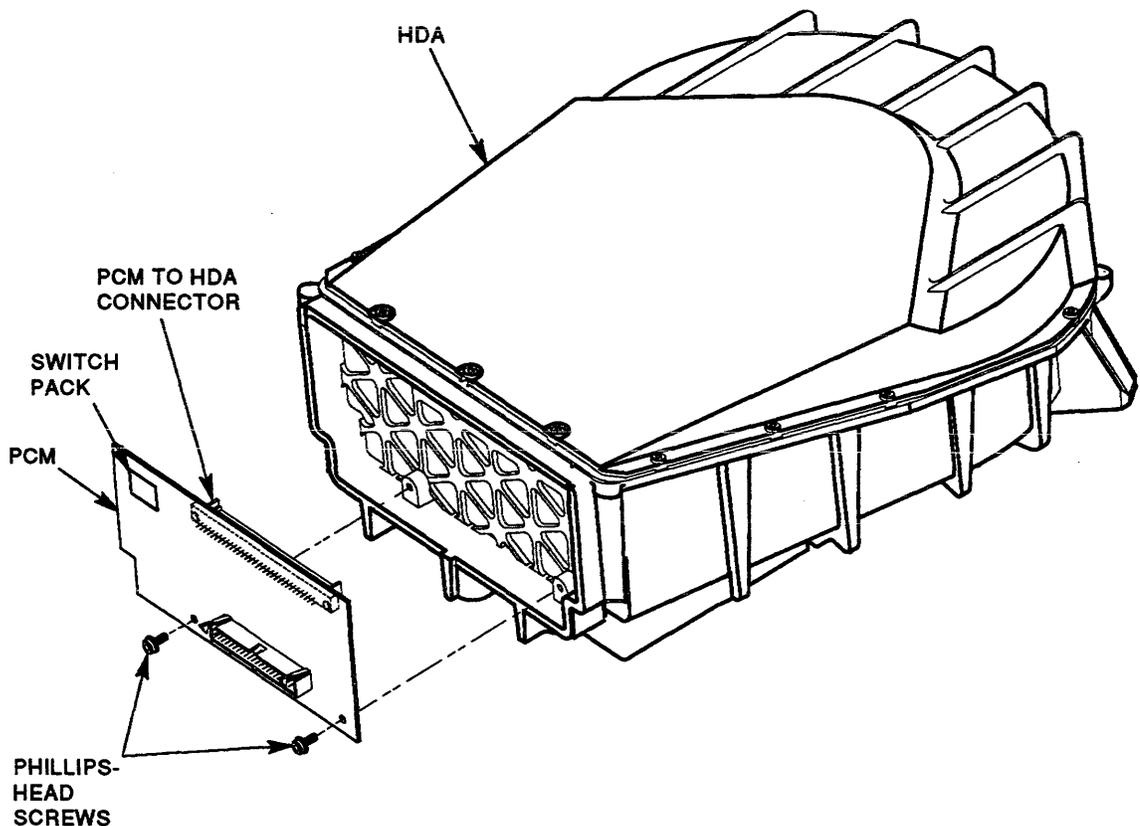
NOTE

Do not force the ECM. If necessary, remove and examine rear connector pins to verify nothing is bent or jammed. In very extreme cases, it may be necessary to remove the SDI cables from the rear of the drive before inserting the ECM.

6.10 Removing the Preamp Control Module

It is not necessary to remove the HDA in order to remove the preamp control module (PCM).

Refer to Figure 6-9 while performing this procedure. Ensure proper grounding before beginning PCM removal.



CXO-2175B

Figure 6-9 PCM Removal

1. Remove power from the drive.
2. Remove the OCP (refer to Section 6.7).
3. Remove the blower motor assembly (refer to Section 6.8).
4. Remove the ribbon cable from the PCM.
5. Remove the Phillips-head screws securing the PCM to the HDA.
6. Note the orientation of the PCM-to-HDA connector. Place your fingers on the sides and near the PCM-to-HDA connector. Use steady, firm pressure to dismount the PCM from the HDA.

Reverse this procedure to replace the PCM. Ensure proper alignment between the HDA and PCM-to-HDA connectors. (Check for bent pins prior to reinstalling.)

6.11 Removing/Replacing the Head Disk Assembly

This section documents the procedures for removing and replacing the HDA. Use extreme care during HDA removal/replacement procedures to prevent damage to the HDA.

As with all static-sensitive components, ensure proper grounding when handling. Place components on a grounded, anti-static work surface. Prior to installation, a replacement HDA must be thermally stabilized.

WARNING

The thermal stabilization procedure is *mandatory*. Failure to thermally stabilize this equipment could cause premature equipment failure.

6.11.1 Removing the HDA

Run tests T43 and T44 before replacing the HDA, to capture seek and spinup information. Record this information on the red tag when returning the HDA.

Run tests T53 and T54 to clear stored parameters from the old HDA.

WARNING

An HDA weighs 15 kilograms (33 pounds). Use both hands during this procedure.

The positioner/head assembly must never be rotated in a counterclockwise direction. Damage to the media and heads could occur.

Place the HDA on a grounded, anti-static work surface after it has been removed. Use proper grounding techniques when working with drive components.

To remove the HDA (refer to Figure 6-10):

1. Remove power from the drive.
2. Remove the OCP (refer to Section 6.7).
3. Remove the blower motor assembly (refer to Section 6.8).
4. Remove the ribbon cable from the HDA.
5. Locate the baseplate latch assembly.
6. To unlock the HDA from the drive chassis, grasp the baseplate latch assembly and pull up and turn until the lock is in its top position.
7. Grasp the HDA carrier handle and pull the HDA toward the front of the drive.
8. Place one hand under the HDA as you remove it from the drive chassis.

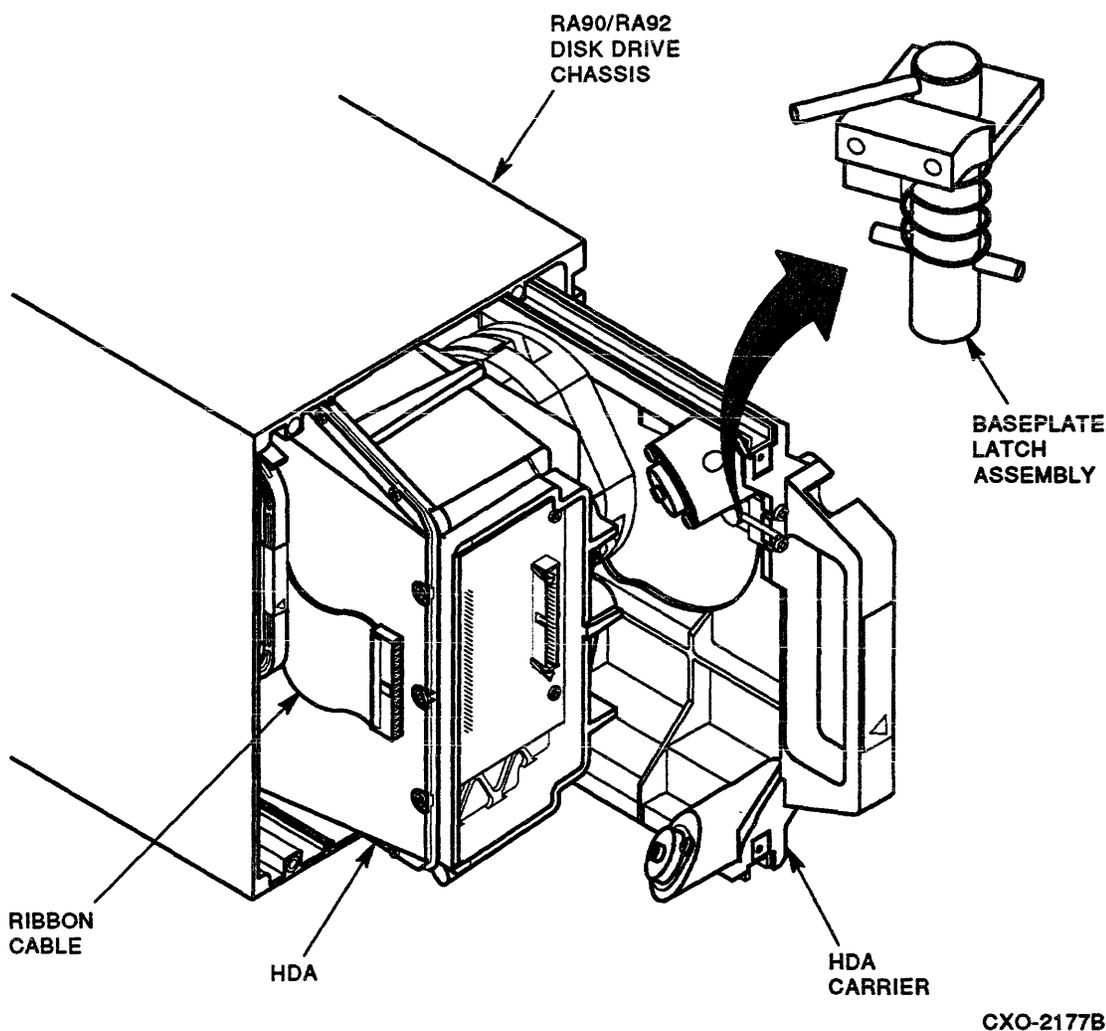


Figure 6-10 HDA Removal

9. If resistance is encountered, attempt to carefully reinsert the HDA and try this procedure again. It may be necessary to apply a small amount of back pressure before the HDA can be removed from the chassis.
10. Place the HDA on a grounded, anti-static work surface.

6.11.2 HDA Thermal Stabilization Procedure

The replacement HDA must be thermally stabilized before its moisture barrier bag is opened.

Prior to installation, a replacement HDA must be stored at a temperature of 16°C (60°F) or higher for a minimum of 24 hours. The HDA may be stored in the computer room or in another storage room under controlled temperature conditions. If stored in another storage room, the HDA must sit for an additional hour in the computer room in which it will be installed.

CAUTION

Under no circumstances should the HDA be left overnight in an uncontrolled temperature environment where cold temperatures could occur (for example, in a car) and then opened/installed without a 24-hour thermal stabilization period.

6.11.3 Replacing the HDA

After the thermal stabilization criteria has been met, open the HDA box and carefully cut the heat-sealed end of the moisture barrier bag. Remove the desiccant from the moisture barrier bag and the HDA from the foam bag. Save all HDA packing material to repackage the failing HDA.

Use the following procedure to install the replacement HDA:

- Slide the HDA into the chassis until the spring-loaded latch locks into place.

WARNING

When reinserting the HDA into the drive chassis, take care not to pinch your fingers. There is limited clearance between the HDA handle and chassis edges.

- Turn the baseplate latch assembly until the latch drops into place and the HDA is secure. To ensure the HDA is secure, try sliding the drive in and out of the chassis.
- Reconnect the ECM-to-PCM ribbon cable.
- Run tests T53 and T54 to clear stored (replaced) HDA-related information.

Return the defective HDA in the replacement HDA's shipping package. Place desiccant inside the moisture barrier bag before folding and sealing the package. Tape the red tag to the outside of the sealed HDA package.

6.11.4 Separating the HDA and Carrier

A number of repairs require separating the HDA and carrier. Use the following procedure to accomplish this:

1. Remove the HDA from the chassis and set it carrier-side up on a grounded, anti-static work surface (Section 6.11.1).
2. Locate the rear HDA connector and remove the retaining C clips shown in Figure 6-11.

NOTE

Remove the C clips by pressing against the spring-loaded rear HDA connector and, at the same time, using a small, flat-bladed screwdriver or small needlenose pliers to loosen and remove the clips.

3. Remove the rear HDA connector.
4. Use a Phillips screwdriver to remove the two screws securing the HDA carrier to the damper bracket assembly.
5. Completely loosen but do not remove the four Torx-head screws with a Torx T-15 screwdriver. Refer to Figure 6-11 for the location of the Torx-head screws.

Reverse this procedure to reassemble the HDA and the carrier.

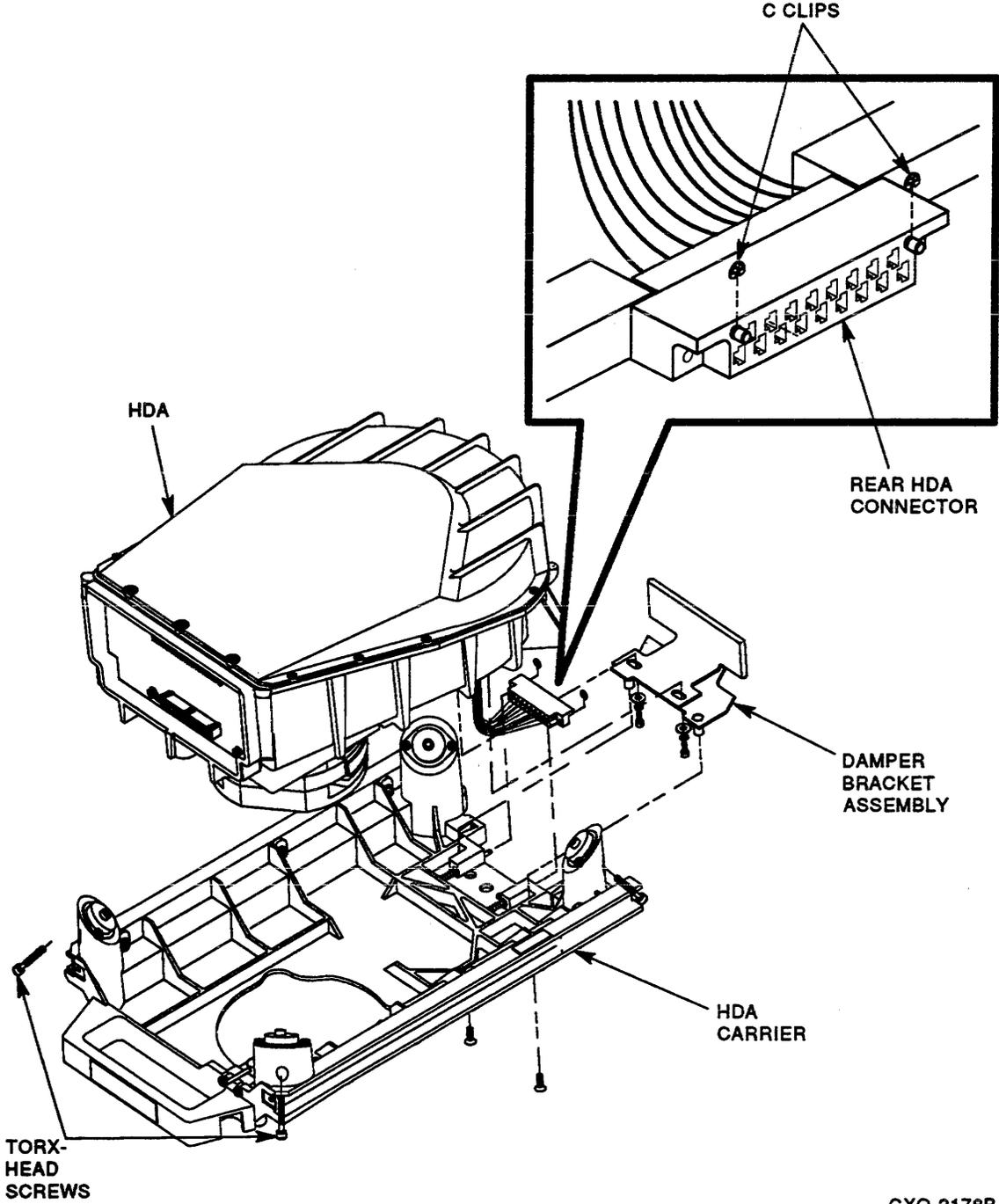


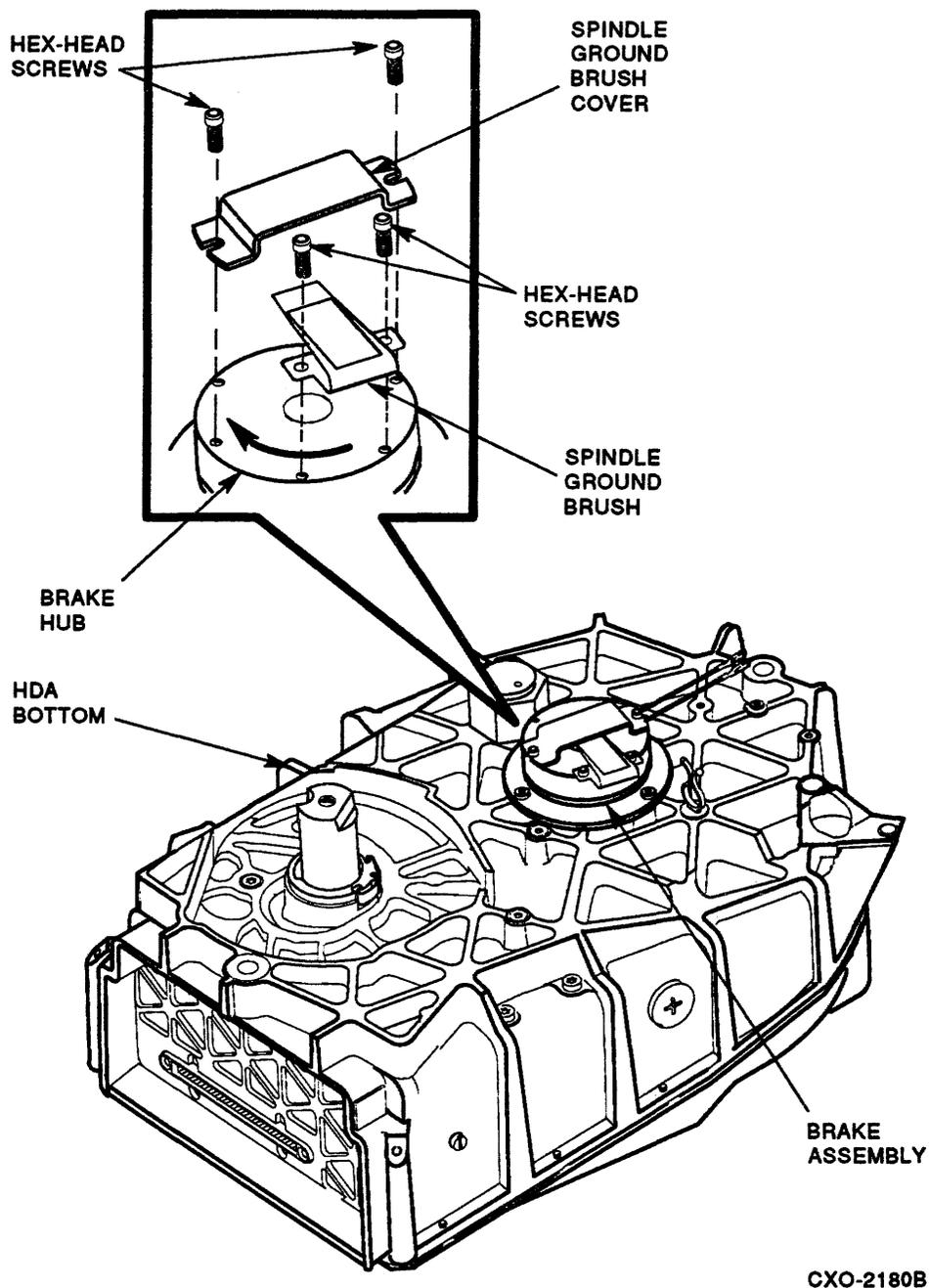
Figure 6-11 HDA Carrier Separation

CXO-2178B

6.11.5 Removing the Spindle Ground Brush

This section documents the procedure for removing and replacing the RA90/RA92 spindle ground brush. Because handling the HDA is necessary, extreme caution must be used.

Refer to Figure 6-12 during this procedure.



CXO-2180B

Figure 6-12 Spindle Ground Brush Removal

1. Remove power from the drive.
2. Remove the OCP (refer to Section 6.7).
3. Remove the blower motor assembly (refer to Section 6.8).
4. Disconnect the ribbon cable from the PCM.
5. Remove the HDA from the chassis (Section 6.11.1) and set it on a grounded, anti-static work surface, carrier-side up.
6. Locate the rear HDA connector and remove the retaining C clips shown in Figure 6-11.

NOTE

Remove the C clips by pressing against the spring-loaded rear HDA connector and, at the same time, using a small, flat-bladed screwdriver or small needlenose pliers to loosen and remove the clips.

7. Remove the rear HDA connector.
8. Use a Phillips screwdriver to remove the two screws securing the HDA carrier to the damper bracket assembly (refer to Figure 6-11).
9. Loosen the four Torx-head screws with a Torx T-15 screwdriver. Refer to Figure 6-11 for the location of the Torx-head screws.
10. Separate the HDA and carrier (refer to Section 6.11.4).
11. Locate and remove the spindle ground brush cover shown in Figure 6-12.
12. Locate and remove the spindle ground brush by removing the two hex-head screws that hold it in place.

Replace the ground brush then reassemble the HDA and drive assemblies.

6.11.6 Removing the Brake Assembly

This section documents the procedures for removing and replacing the RA90/RA92 brake assembly. Because handling the HDA is necessary, extreme caution must be used.

You will need a contact extraction tool (Digital Part Number 29-26655-00) to perform this procedure. Refer to Figures 6-12, 6-13, and 6-14 while performing this procedure.

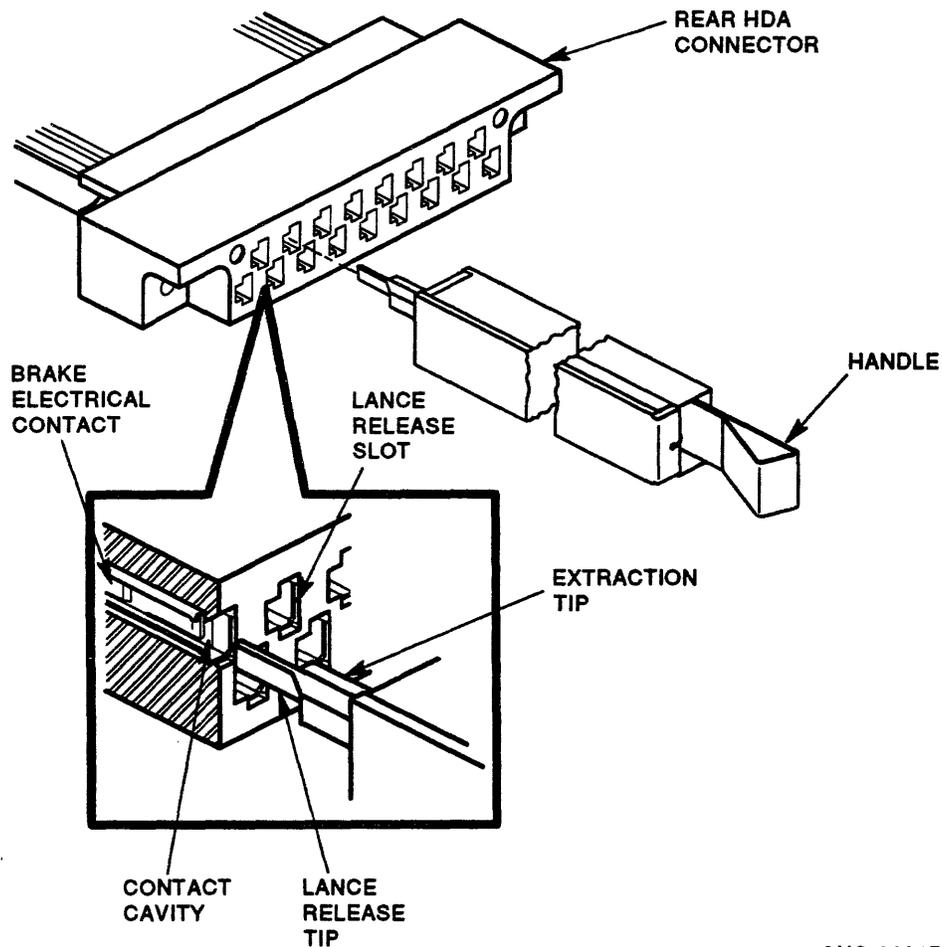
CAUTION

Never rotate the actuator or positioner shaft counterclockwise. HDA damage could occur.

1. Remove power from the drive.
2. Remove the OCP (refer to Section 6.7).
3. Remove the blower motor assembly (refer to Section 6.8).
4. Disconnect the ribbon cable from the PCM.
5. Remove the HDA from the chassis (Section 6.11.1) and set it on a grounded, anti-static work surface, carrier side up.
6. Locate the rear HDA connector and remove the retaining C clips shown in Figure 6-11.

NOTE

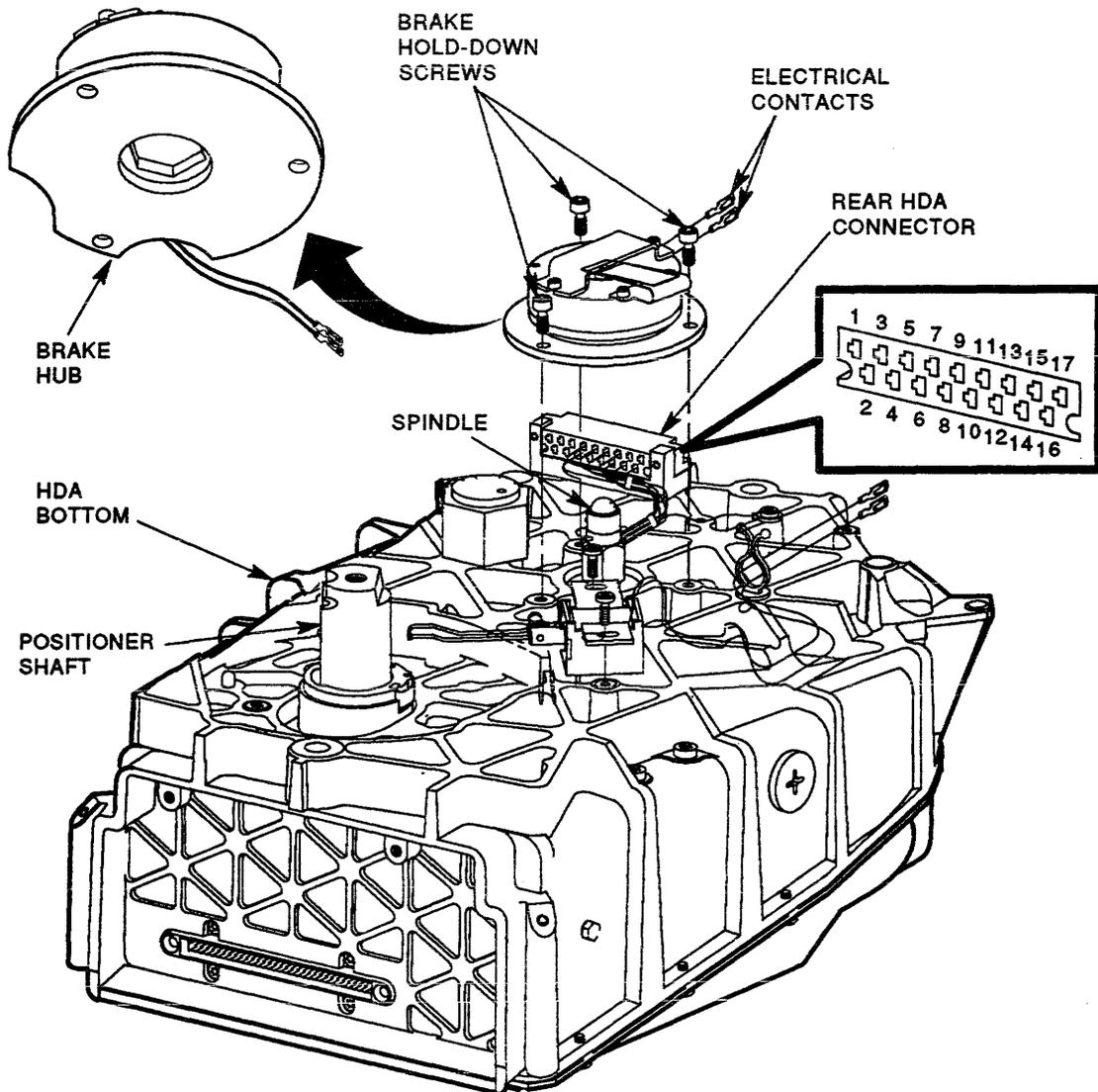
Remove the C clips by pressing against the spring-loaded rear HDA connector and, at the same time, using a small, flat-bladed screwdriver or small needlenose pliers to loosen and remove the clips.



CXO-2181B

Figure 6-13 Contact Extraction Tool

7. Remove the rear HDA connector.
8. Use a Phillips screwdriver to remove the two screws securing the HDA carrier to the damper bracket assembly (refer to Figure 6-11).
9. Loosen the four Torx-head screws with a Torx T-15 screwdriver. Refer to Figure 6-11 for the location of the Torx-head screws.
10. Separate the HDA and carrier (refer to Section 6.11.4).
11. Locate and trace the brake electrical contacts to the rear HDA connector.
12. Extract the brake electrical contacts (contacts 4 and 5) from the rear HDA connector using the contact extraction tool from the kit.
13. Align the contact extraction tool with the front of the connector. Align the lance release tip with the lance release slot, making sure to align the tip with the contact cavity. Refer to Figure 6-13.



CXO-2997A

Figure 6-14 RA90/RA92 Brake Assembly Removal/Replacement

14. Push the lance release tip in until the locking lance (metal tip inside contact pin) is released from the slot.
15. Hold the connector firm and push the handle of the contact extraction tool forward. The contact should back out of the rear of the connector.
16. Remove the contact extraction tool and pull the brake contact from the back of the connector.
17. Locate and remove the spindle ground brush cover (refer to Figure 6-12).
18. Locate and remove the spindle ground brush.
19. Use a 5/32 Allen wrench to remove brake hold-down screws (refer to Figure 6-14).
20. Note the hex shape of the spindle and matching hex shape of the brake hub.

21. Orient the brake hub to the spindle and fit them together. *Do not rotate spindle counterclockwise.*
22. Secure the brake to the baseplate with the brake hold-down screws. Refer to Figure 6-14.
23. Replace the spindle ground brush.
24. Reinstall the spindle ground brush cover.
25. Insert brake electrical contacts into slots 5 and 6 in the connector. (Ensure a secure fit by tugging on leads.)
26. Reassemble the HDA to the HDA carrier.
27. Attach the rear HDA connector and C clips.
28. Reassemble the drive.
29. Install the HDA into the drive chassis.

6.11.7 Spindle Lock Solenoid Failure

This section covers solenoid failures. The solenoid is not a replaceable FRU; however, its failure prevents the heads from loading and data from being recovered.

To preclude the loss of data because of a solenoid failure, this procedure allows you to bypass the solenoid long enough to recover the data and back it up onto another disk drive or tape unit.

CAUTION

Attempt this procedure only under the worst possible situations; that is, if customer backup data is not current or work in progress must be recovered. After performing this procedure and recovering the data, replace the HDA according to Section 6.11.3.

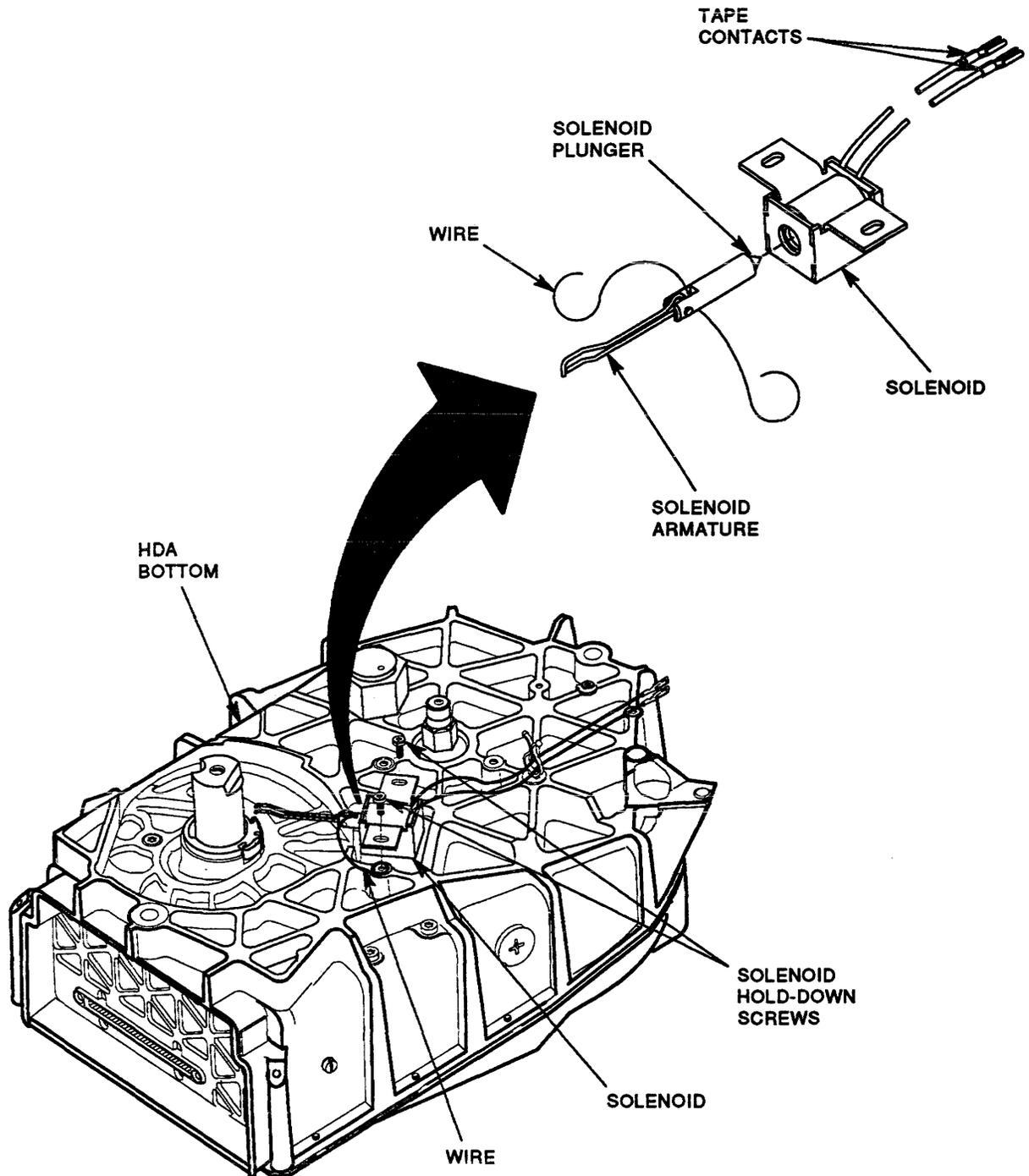
Refer to Figure 6-15 while performing this procedure.

1. Remove power from the drive.
2. Remove the OCP (refer to Section 6.7).
3. Remove the blower motor assembly (refer to Section 6.8).
4. Remove the HDA from the chassis (Section 6.11.1) and set it on a grounded, anti-static work surface, carrier side up.
5. Locate the rear HDA connector and remove the retaining C clips shown in Figure 6-11.

NOTE

Remove the C clips by pressing against the spring-loaded rear HDA connector and, at the same time, using a small, flat-bladed screwdriver or small needlenose pliers to loosen and remove the clips.

6. Remove the rear HDA connector.
7. Use a Phillips screwdriver to remove the two screws securing the HDA carrier to the damper bracket assembly.
8. Loosen the four Torx-head screws with a Torx T-15 screwdriver. Refer to Figure 6-11 for the location of the Torx-head screws.
9. Separate the HDA and carrier (refer to Section 6.11.4).
10. Locate the solenoid (refer to Figure 6-15).



CXO-2179B

Figure 6-15 Disabling the Solenoid for In-Field Data Recovery

11. Disconnect the electrical leads from the solenoid and place electrical tape over the lead contacts to prevent shorting.
12. Loosen and remove the positioner lock solenoid hold-down screws with a T-15 Torx wrench.
13. Remove the solenoid and set it aside.
14. Reinstall the solenoid hold-down screws to the baseplate and tighten slightly.
15. Loop a piece of 20-gauge wire (or equivalent) approximately 6 inches long through the solenoid armature as shown in Figure 6-15.
16. Secure one end of the wire around one of the solenoid hold-down screws and tighten the screw securely onto the wire.
17. After looping the wire through the solenoid armature, gently pull the solenoid plunger away from the positioner/actuator assembly until it stops (approximately a quarter inch).
18. Loop the loose end of wire around the second hold-down screw and tighten the screw securely onto the looped wire.

CAUTION

Ensure both sides of the wire are secure and that the solenoid plunger is held back. The aim of this procedure is to recover customer data. If the solenoid plunger slips back, it will cause the solenoid armature to allow the positioner/actuator assembly to lock. Data recovery will then be unsuccessful.

Reassemble the HDA, carrier, and drive.

After data has been recovered, replace the HDA according to the HDA replacement procedure in Section 6.11.3. When returning the old HDA from the field, also return the failed solenoid.

6.12 Removing the Power Supply

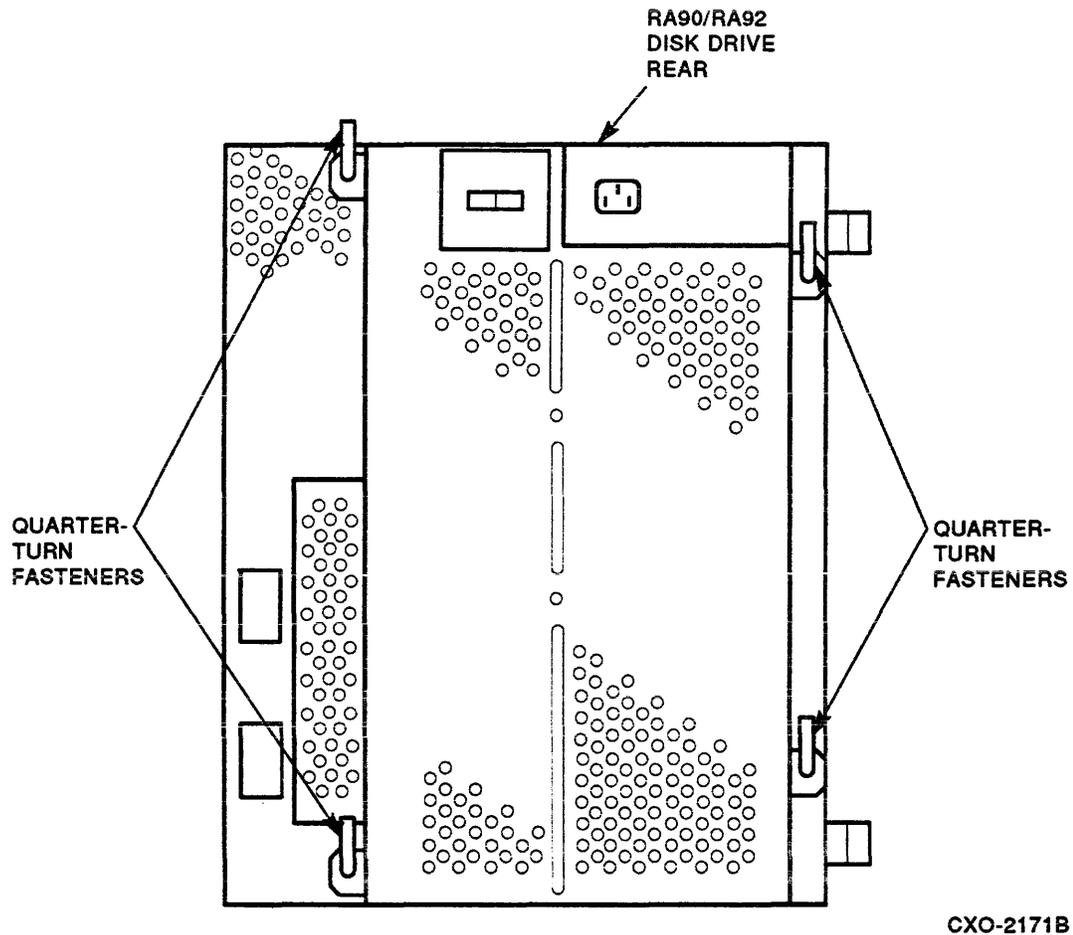
This section documents the procedures for removing and replacing the RA90/RA92 power supply.

Ensure you have removed power from the correct drive. Proceed with caution whenever working with high voltages. Refer to Figure 6-16 while performing this procedure.

WARNING

When removing and replacing drive components, take care not to pinch your fingers. There is limited clearance between the HDA handle and chassis edges.

1. Spin down the drive.
2. Turn off the drive circuit breaker to remove power from the drive.
3. Note port cable connector locations when removing the power supply.
4. Remove the power cord from the rear of the drive.
5. Remove other cables that may interfere with the power supply removal.
6. Loosen the bottom two quarter-turn fasteners by turning in a counterclockwise direction.
7. Support the bottom of the power supply with one hand.
8. Loosen the top two quarter-turn fasteners by turning in a counterclockwise direction.
9. Remove the power supply.



CXO-2171B

Figure 6-16 Power Supply Removal

CAUTION

The power supply weighs approximately 6.8 kilograms (15 pounds). It must be supported when being removed from the drive.

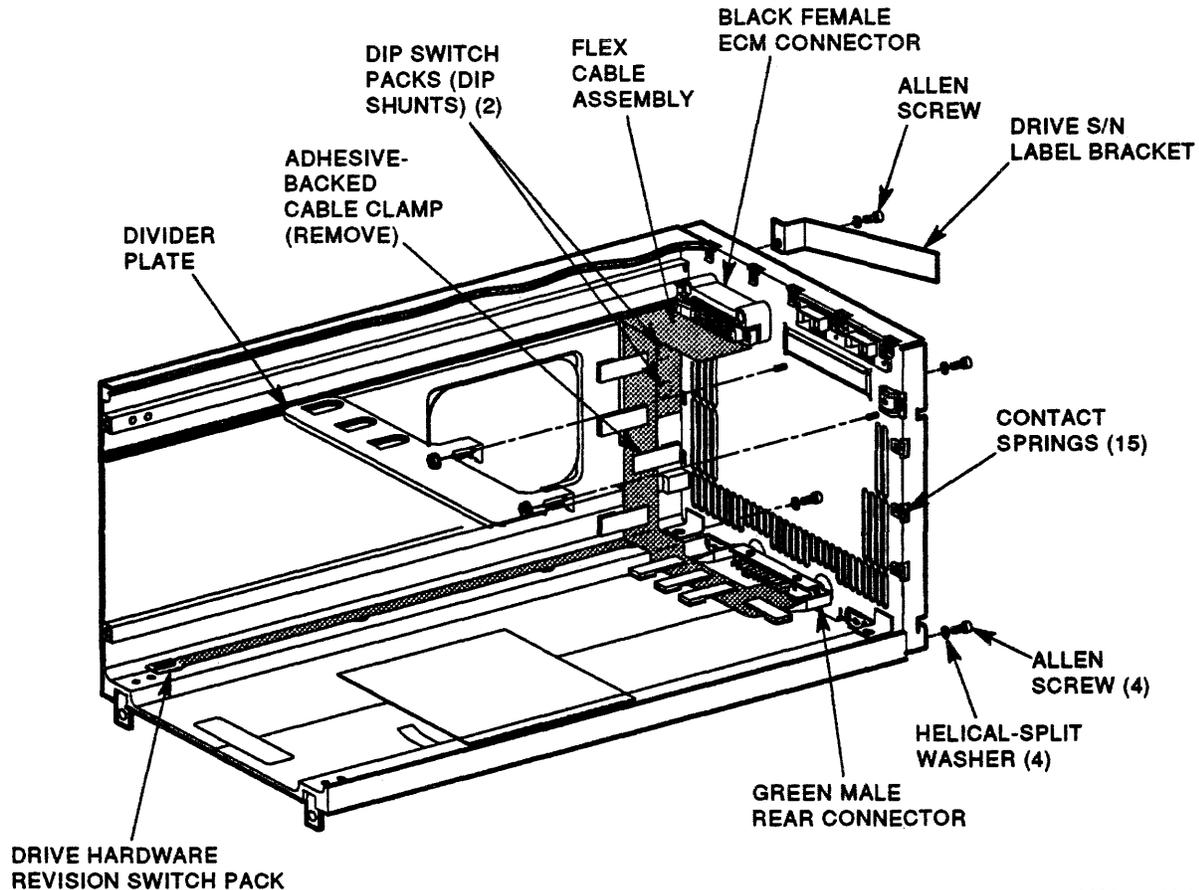
Reverse this process to replace the power supply. Check the line voltage selector switch to ensure you have the correct voltage for your area.

6.13 Removing/Replacing the Rear Flex Cable Assembly

This section documents the procedures for removing and replacing the RA90 and RA92 rear flex cable assembly. To facilitate the removal of the rear flex cable assembly, first remove the drive HDA, power supply, and ECM. After these drive components have been removed, remove the drive chassis from the cabinet and place it on a grounded, anti-static work surface.

To remove the rear flex cable assembly (refer to Figure 6-17):

1. Loosen the four Allen screws holding the rear panel assembly to the drive chassis.
2. Remove the 15 contact springs. Set the contact springs aside.
3. Remove the four Allen screws and set the rear panel assembly aside. (Set aside the drive serial number label bracket.)



CXO-2990A

Figure 6-17 Rear Flex Cable Assembly Removal

The next step requires the removal of the rear flex cable assembly. There are a number of adhesive-backed cable clamps used to secure the rear flex cable assembly in place. The cable clamps all open toward the rear of the drive with one exception; locate and remove this "one" cable clamp to facilitate removal of the rear flex cable assembly. (See Figure 6-17 for the location of this clamp.)

4. Remove the two Allen-head screws that secure the green male rear connector to its bracket.
5. Remove the two C clips that secure the black ECM female connector to its bracket.
6. Remove the rear flex cable assembly.

The next step requires the replacement of the rear flex cable assembly. Lay the replacement rear flex cable assembly out next to the one being replaced. Set the dip switches on the new rear flex cable assembly to the exact settings from the replaced one. By hand, bend the rear flex cable assembly 90 degrees in the same places as the original assembly.

NOTE

Future flex cable assemblies may use dip shunt switch packs rather than dip switch packs. A shunt open = switch open or off.

7. Place the rear flex cable assembly on the rear panel assembly with the two connectors on their proper brackets.
8. Secure the green male rear connector to its bracket with the two (previously removed) Allen-head screws.
9. Secure the black female ECM connector to its bracket with the two (previously removed) C clips.
10. Replace the previously removed adhesive-backed cable clamp.
11. Loosely attach the rear panel assembly to the rear of the drive chassis.
12. Replace the 15 contact springs.
13. Secure the rear panel assembly by tightening the Allen screws.
14. Return the drive chassis to the cabinet.
15. Return the drive components to the drive chassis.

6.14 Media Removal Service for Customers

The on-site media removal and disposal service is an exclusive Digital Customer Services offering.

The following tools are needed to remove drive media from the HDA. Digital part numbers for these tools are listed in Table 6-1:

1. 1/16 Allen wrench
2. 3/32 Allen wrench
3. 5/32 Allen wrench
4. 3/16 Allen wrench
5. Torx size T-15 wrench
6. Torx size T-15 socket wrench
7. Pliers
8. Diagonal cut pliers
9. Needlenose pliers
10. Medium Phillips screwdriver
11. Flat-bladed screwdriver

Table 6-1 Digital Part Numbers for Recommended Tools

Technical Description	Part Number
Ballpoint hex screwdriver blade, 1/16"	29-26111-00
Ballpoint hex screwdriver blade, 3/32"	29-26113-00
Ballpoint hex screwdriver blade, 5/32"	29-26117-00
Ballpoint hex screwdriver blade, 3/16"	29-26118-00
Pliers, diagonal cutters, 4"	29-19328-00
Pliers, long needlenose	29-13461-00
Socket, Torx T-15	29-27275-01
Screwdriver, Torx T-15	29-22772-00
Screwdriver blade, Phillips # 1	29-11001-00
Screwdriver blade, slotted, 3/16"	29-10988-00
Screwdriver blade, Torx T-15	29-22772-00
Screwdriver blade, Torx T-10	29-26947-01

To remove the media from the HDA (refer to Figures 6-18 and 6-19):

1. Remove the PCM from the HDA and store it in an ESD bag for return to Customer Services Logistics. Use proper ESD procedures.
2. Remove the four Torx head screws, or three Torx head screws and one medium Phillips-head screw that secure the PCM plug to the HDA chassis.
3. Remove the HDA from the drive chassis (refer to Section 6.11.1).
4. Separate the HDA and carrier (refer to Section 6.11.4).
5. Use a Phillips screwdriver to remove the actuator counterweight located at the end of the positioner shaft.
6. Use a 3/8-inch open-end wrench or a pair of medium-sized needlenose pliers to hold the 3/8-inch nut on the positioner motor assembly located near the center of the shaft. This is a locking nut for an expander bolt holding the positioner coil assembly to the positioner shaft. Hold the nut and, at the same time, loosen the 3/32 Allen screw with a 3/32 Allen wrench. Turn counterclockwise until the 3/32 Allen screw, the 3/8-inch nut, and expander bolt assembly can be removed.
7. Use a medium-sized Phillips screwdriver to remove the three retaining screws holding the positioner motor assembly to the HDA baseplate.
8. Cut the flex leads from the positioner motor to the HDA electrical socket with diagonal cutters.
9. Firmly grasp the positioner motor assembly at the end of the positioner shaft and lift up. If you have difficulty sliding the positioner motor assembly off the end of the positioner shaft:
 - Loosen the four crash stop Allen screws using a 5/32 and 1/16 Allen wrench. Turn screws in a counterclockwise direction.
 - Reattempt to remove the positioner motor assembly from the positioner shaft.

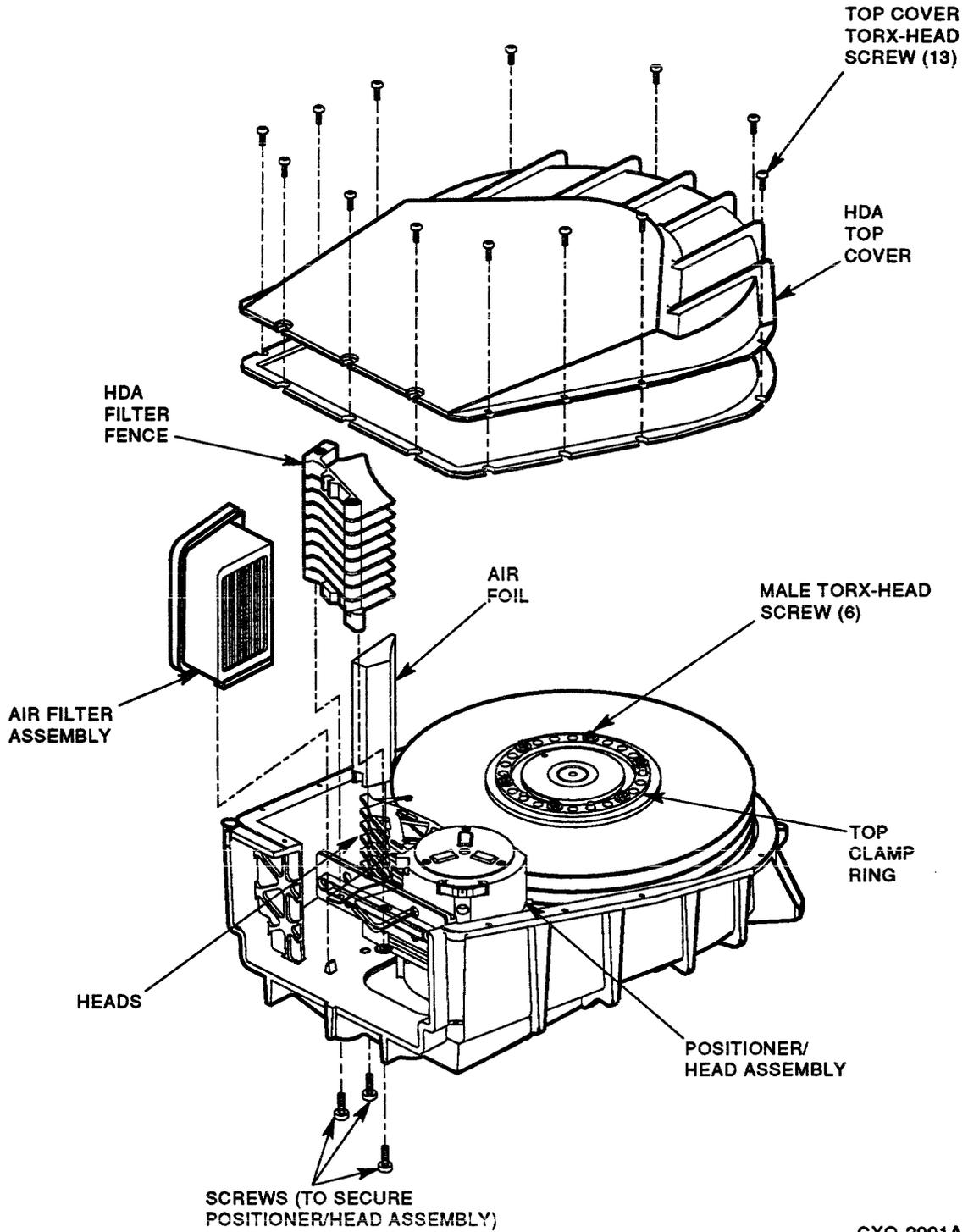


Figure 6-18 HDA Media Removal — Top View

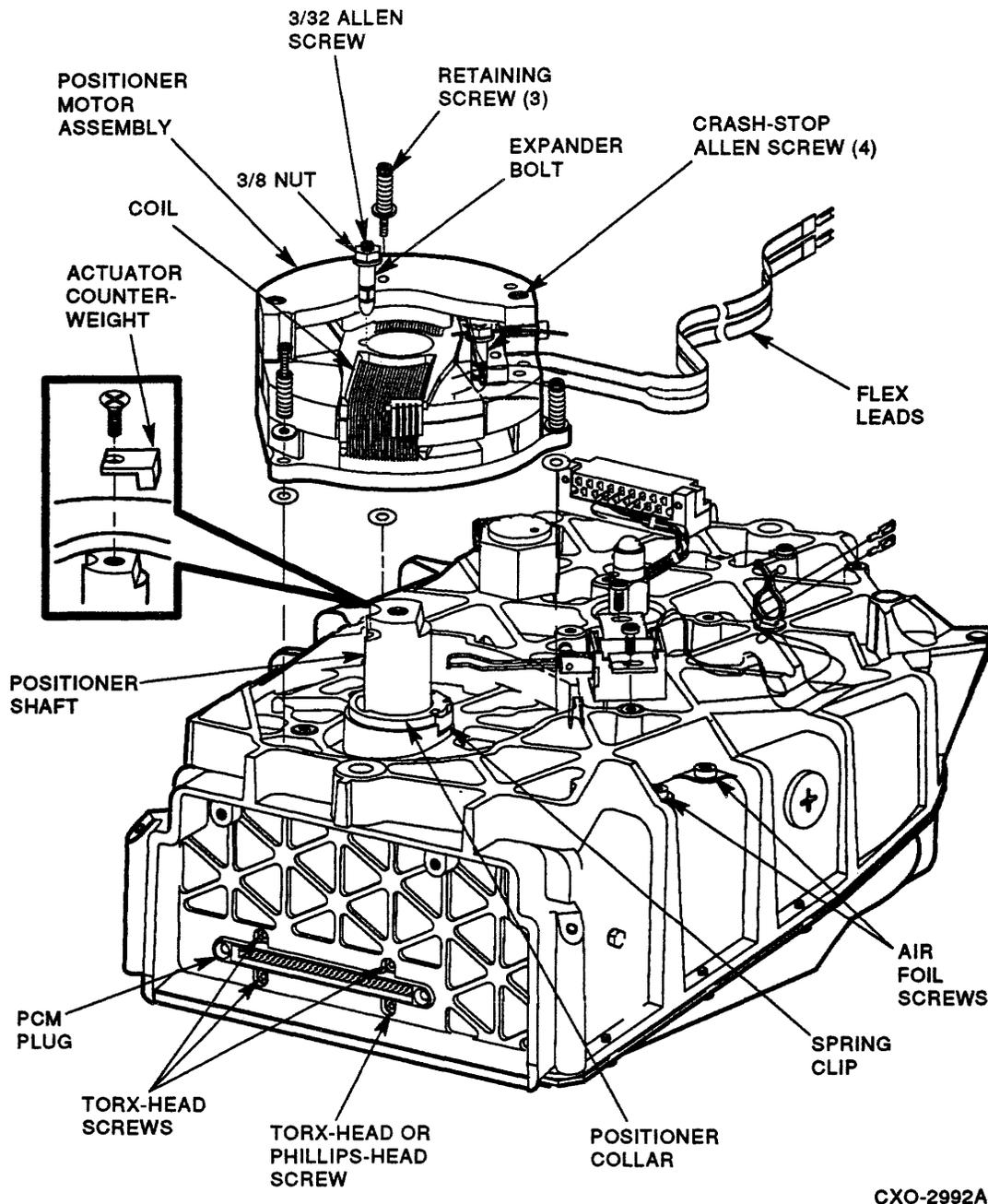


Figure 6-19 HDA Media Removal — Bottom View

10. Use a flat-bladed screwdriver to detach the spring clip that secures the positioner lock pin into the positioner collar.
11. Remove the solenoid armature that connects the lock pin to the solenoid from the lock pin. Using a pair of needle-nose pliers, remove the lock pin from the positioner shaft.
12. Use a Torx T-15 wrench to remove the three screws used to secure the positioner/head assembly to the baseplate.

13. Use a Torx T-15 wrench to remove the two (in some cases three) screws that secure the internal airfoil. All Torx screws should now be removed from the bottom of the baseplate.
14. Turn the HDA over to access top cover Torx-head screws.
15. Use a Torx T-15 head wrench to remove the 13 top cover Torx-head screws (refer to Figure 6-18).
16. Remove the top cover of the HDA.
17. Remove the internal air filter assembly from the HDA.
18. Remove the HDA filter fence from the HDA assembly. It may be necessary to rotate the positioner/head assembly so the heads are toward the inner guardband area of the media.
19. Push the loose PCM plug out of the chassis and maneuver the PCM plug and its attached cable assembly so the positioner/head assembly can be removed from the chassis.
20. Rotate the positioner out of the way as you manually unload the heads from the media.
21. Lift the entire positioner/head assembly out of the HDA chassis.
22. Use a Torx T-15 internal socket wrench to remove the six (6) male Torx-head screws securing the top clamp ring on the media stack, and lift clamp rings, media, and spacer rings from the spindle hub.
23. Give the media to the customer.
24. Collect all loose pieces of hardware and remove from the site. Return hardware to Customer Services Logistics for proper disposal.

Microcode Update Procedure

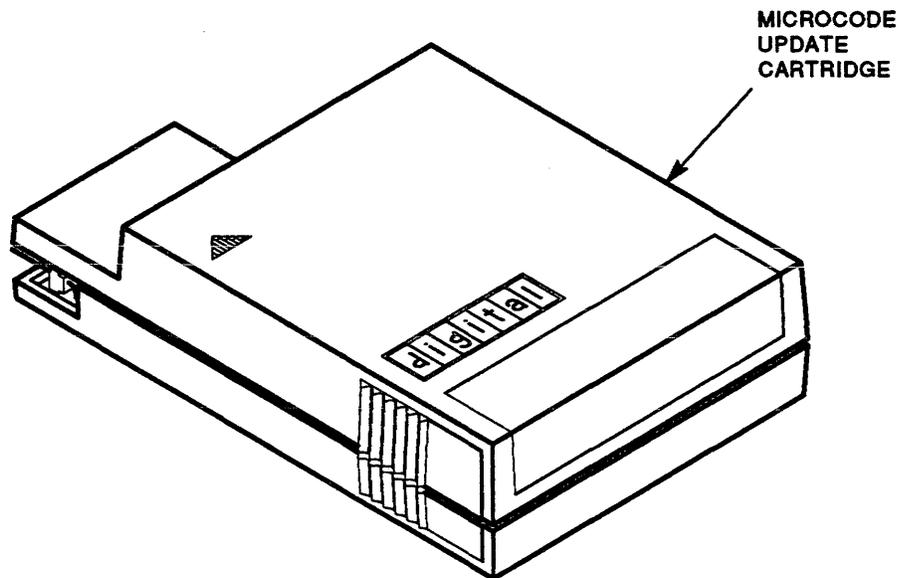
7.1 Introduction

This chapter describes the procedure for updating RA90/RA92 disk drive microcode when a new version of the microcode is released.

7.2 Microcode Update Cartridge Description

The microcode update cartridge is a ROM assembly that contains updated microcode for the RA90/RA92 disk drive microprocessor. Figure 7-1 shows the microcode update cartridge.

To update the RA90/RA92 microcode, insert the cartridge in the microcode update port and run T40.



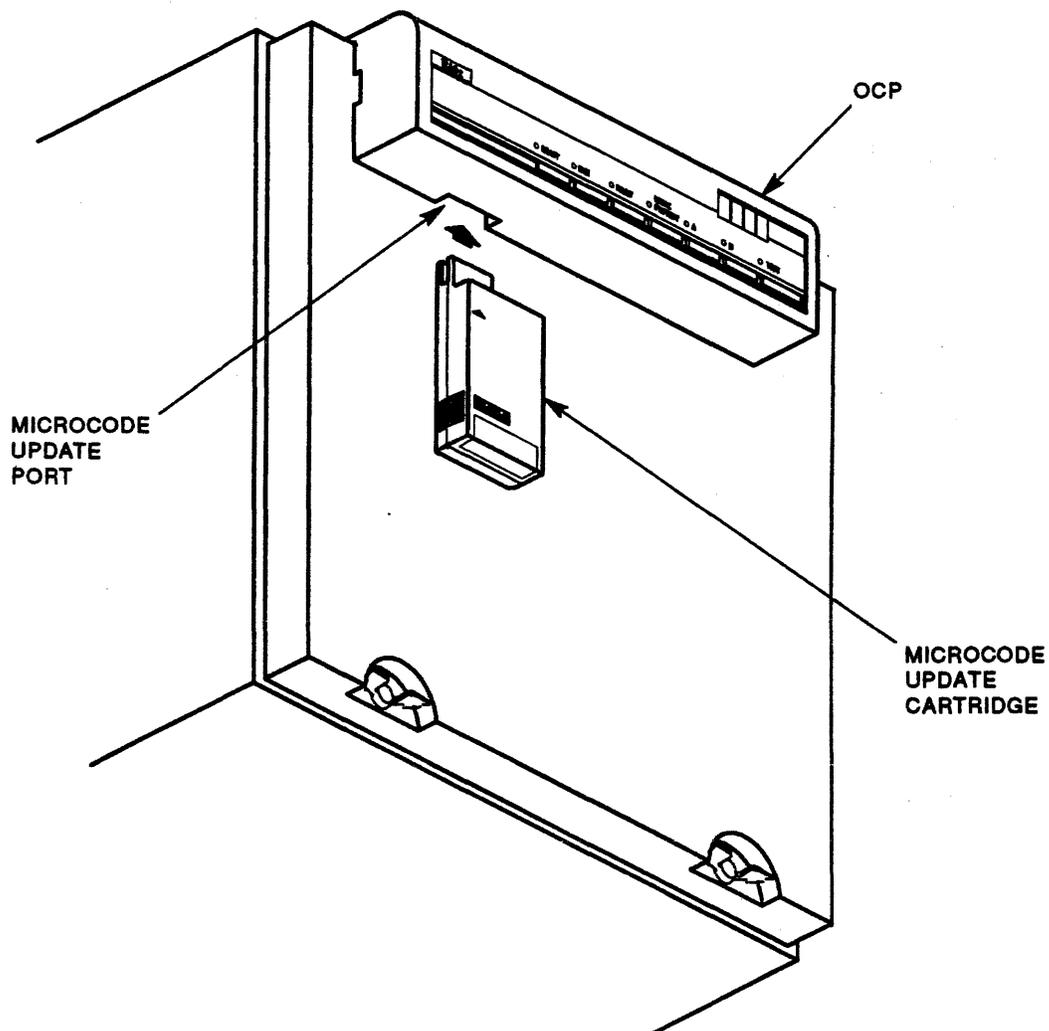
CXO-2164A

Figure 7-1 Microcode Update Cartridge

7.3 Microcode Update Port Description

The microcode update port is a cutout in the operator control panel (OCP). It is located below and to the left of the Run switch. Figure 7-2 shows the location of the RA90/RA92 microcode update port.

To access the microcode update port, it is necessary to remove the cabinet front access panel.



CXO-2165C

Figure 7-2 Microcode Update Port

7.4 Running Test 40 (T40)

T40 is a microcode subroutine used to load the new microcode from the microcode update cartridge into the master processor. The new microcode may be intended as a servo microcode update, a diagnostic update, or a functional microcode update.

During update, the new microcode is downloaded to its destination EEPROM in three separate passes. Each pass takes approximately 20 seconds. The pass count is displayed in the OCP alphanumeric display during the update procedure.

Pass one reads the cartridge, calculates and verifies the checksum in the cartridge, and verifies the microcode consistency codes. If pass one fails, the update is aborted and an appropriate error code is generated.

Pass two writes the even pages in EEPROM (16 bytes). An even page is defined as BIT04 of the EEPROM address equal to zero.

Pass three writes the odd pages in EEPROM. An odd page is defined as BIT04 of the EEPROM address equal to one.

After the microcode is fully loaded (indicated by [C 40]), the drive performs a reset and goes through its normal power-up sequence of internal diagnostics. The OCP performs a reset, returns the drive to its normal operating state, and displays the unit address.

7.5 Updating the Microcode

Remove the cabinet front access panel before beginning the microcode update procedure. Refer to Section 6.6 for the front access panel removal procedure.

Use the following procedure when updating drive microcode:

1. Load the microcode update cartridge in the microcode update port.
2. Load test T40 (drive must be spun down).
3. Start test T40.

The following occurs in the OCP display (where S = start, P = pass, C = completed):

1. [S 40] (2 seconds).
2. [P 1] (20 seconds) Pass one checks PROM to be loaded.
3. [P 2] (20 seconds) Pass two writes the new code into the even pages in EEPROM.
4. [P 3] (20 seconds) Pass three writes the new code into the odd pages in EEPROM.
5. [C 40] (1 second) Update is complete.
6. [WAIT] (10 seconds) Exits test mode and goes through power-up hardware sequence.
7. [0000] Returns to display the drive unit address.

Remove the microcode update cartridge from the OCP and replace the cabinet front access panel. Select the appropriate port switches to return the drive to the available state.

7.5.1 Error Codes/Common Problems During Microcode Update

The most common problems encountered during a microcode update are as listed by error code in Table 7-1.

Table 7-1 Common Error Codes/Problems During Microcode Update

Error Code	Reason	Solution
BD	The microcode cartridge was not detected.	Reseat the microcode update cartridge.
BC	The cartridge checksum was incorrect.	Reseat the cartridge and retry the update. If it still fails, either replace the OCP or try the cartridge in another drive. Acquire a new microcode cartridge if necessary.
BE	Cartridge and EPROM consistency check failed.	Reseat the cartridge and try again. If the same error occurs, replace the cartridge with one containing compatible code.
FD	An EEPROM checksum error occurred.	Attempt to reload the cartridge code. If the failure occurs again, electronic control module (ECM) replacement may be necessary.

A

Capturing Information for LARS and CHAMPS

This appendix contains sample LARS for installation and general troubleshooting of field replaceable units (FRUs) in the field.

Figure A-1 (Cont.) LARS Example

LINE	ACT	REQ TIME	REQUEST DATE DAY MONTH YEAR	START TIME	START DATE DAY MONTH YEAR	STOP TIME	STOP DATE DAY MONTH YEAR	REPAIR TIME	DEC OPTION	VAR	DEC OPT. S/N	TYP CAL	ACT TAK	FAIL AREA - MODULE - FCO - COMMENTS	AUTHORIZED TESTS
A		1048	04 FEB 88	1111	11 FEB 88	1115	11 FEB 88	10	SA600-HA		CX00045	I	D	DESKIDDED - POSITIONED	Z
B								5	RA90-A		CX00735	I	D	INSTALLED - TEST	Z
C								5	RA90-A		CX00736	I	D	INSTALLED - TEST	Z
D								5	RA90-A		CX00737	I	D	INSTALLED - TEST	Z
E								5	RA90-A		CX00738	I	D	INSTALLED - TEST	Z

SAMPLES OF LINE ITEMS FOR ECM REPLACEMENT:

LINE	ACT	REPAIR TIME	DEC OPTION	VAR	DEC OPT. S/N	TYP CAL	ACT TAK	FAIL AREA - MODULE - FCO - COMMENTS	AUTHORIZED TESTS
A		04	RA90-A		CXA2322	C	C	ECM E28.29 SQ75312345	

ECM WITH VAXimPLUS THEORY CODE:

LINE	ACT	REPAIR TIME	DEC OPTION	VAR	DEC OPT. S/N	TYP CAL	ACT TAK	FAIL AREA - MODULE - FCO - COMMENTS	AUTHORIZED TESTS
A		04	RA90-A		CXA2322	C	C	ECM 1.15.XX.YYSQ75312345	

WHERE XX AND YY ARE VAXimPLUS SUPPLIED NUMBERS

Figure A-1 (Cont.) LARS Example

FOR HDA REPLACEMENT:							ACT TAK	FAIL AREA - MODULE - FCO - COMMENTS	AUTHORIZED TESTS
LINE	ACT	REPAIR TIME	DEC OPTION	VAR	DEC OPT. S/N	TYP CAL			
A		04	RA90	-A	CXA2322			HDAZ ECG HD1 SG75312345	
Z= L AND R FOR LEFT AND RIGHT MOUNTED DR. (FRONT VIEW) HDAZ HEAD ONE ECC ERRORS									
FOR HDA WITH VAXimPLUS THEORY CODE:							ACT TAK	FAIL AREA - MODULE - FCO - COMMENTS	AUTHORIZED TESTS
A		04	RA90	-A	CXA2322			HDAZ1.15.X.Y CX81259478	
WHERE X AND Y ARE VAXimPLUS SUPPLIED NUMBER									
FOR PCM REPLACEMENT:							ACT TAK	FAIL AREA - MODULE - FCO - COMMENTS	AUTHORIZED TESTS
A		04	RA90	-A	KB02322			PCM ERRORS SG75524221	
FOR PCM REPLACEMENT WITH VAXimPLUS THEORY CODE:							ACT TAK	FAIL AREA - MODULE - FCO - COMMENTS	AUTHORIZED TESTS
A		04	RA90	-A	KB02322			PCM 1.15.XX.YY SG75524221	
WHERE XX AND YY ARE VAXimPLUS SUPPLIED NUMBERS									
FOR BLOWER REPLACEMENT:							ACT TAK	FAIL AREA - MODULE - FCO - COMMENTS	AUTHORIZED TESTS
A		04	RA90	-A	CX01210	C	C	BLWR NOISY CX75032100	
OR THE APPARENT CAUSE: FROZEN WON'T TURN									
FOR BLOWER REPLACEMENT WITH VAXimPLUS THEORY CODE:							ACT TAK	FAIL AREA - MODULE - FCO - COMMENTS	AUTHORIZED TESTS
A		04	RA90	-A	CX01210	C	C	BLWR1.15.XX.YY CX75032100	
WHERE XX AND YY ARE VAXimPLUS SUPPLIED NUMBERS									

FOR POWER SUPPLY REPLACEMENT:									
LINE	ACT	REPAIR TIME	DEC OPTION	VAR	DEC OPT. S/N	TYP CAL	ACT TAK	FAIL AREA - MODULE - FCO - COMMENTS	AUTHORIZED TESTS
A		04	RA90	-A	CX26122	C	C	PS CROWBARS CX81122129 NO VOLTAGE; NO POS 24V ERR 22	
FOR POWER SUPPLY WITH VAXimPLUS THEORY CODE:									
LINE	ACT	REPAIR TIME	DEC OPTION	VAR	DEC OPT. S/N	TYP CAL	ACT TAK	FAIL AREA - MODULE - FCO - COMMENTS	AUTHORIZED TESTS
A		04	RA90	-A	CX26122	C	C	PS 1.15.XX.YY CX81122129 WHERE XX AND YY ARE VAXimPLUS SUPPLIED NUMBER	
FOR OCP REPLACEMENT:									
LINE	ACT	REPAIR TIME	DEC OPTION	VAR	DEC OPT. S/N	TYP CAL	ACT TAK	FAIL AREA - MODULE - FCO - COMMENTS	AUTHORIZED TESTS
A		02	RA90	-A	CX26122	C	C	OCP LED OUT CX81122129 SEGMENT OUT OR SWITCH IS BROKEN	
FOR MISCELLANEOUS PARTS:									
LINE	ACT	REPAIR TIME	DEC OPTION	VAR	DEC OPT. S/N	TYP CAL	ACT TAK	FAIL AREA - MODULE - FCO - COMMENTS	AUTHORIZED TESTS
A		19	RA90	-A	CX26122	C	C	SDI CABLE OPEN ITEM REPAIRED	
FOR SA600 REPAIRS:									
LINE	ACT	REPAIR TIME	DEC OPTION	VAR	DEC OPT. S/N	TYP CAL	ACT TAK	FAIL AREA - MODULE - FCO - COMMENTS	AUTHORIZED TESTS
A		22	SA600	-JA	CX00622	C	C	881 RELAY DROPS OUT	

B

RA90/RA92 Error Recovery Levels

RA90 and RA92 disk drives incorporate hardware error recovery as part of the RA90/RA92 circuitry. Read data circuitry is altered any time the controller issues error recovery commands.

Generally, error recovery is used to assist the controller during unrecoverable or uncorrectable errors. The intent is to enhance the controller/disk interaction to recover data that might otherwise be lost.

The RA90/RA92 hardware recovery circuitry is divided into six functional areas, as shown in Table B-1.

Table B-1 RA90/RA92 Hardware Error Recovery Circuits

Circuit	Description
READ THRESHOLD GAIN	There are two ways to increase the chances of reading data from a potentially bad spot on a disk: increase read threshold or decrease read threshold. The drive determines whether information coming off the disk is either too weak or too strong and consequently increases or decreases the read circuitry amplitude in an attempt to recover information.
HOLD-OVER ONE-SHOT	VCO control voltage is held stable to prevent large phase errors during a momentary loss of read pulses from the disk.
SKEW READ GATE	A delay of one or two byte times is introduced between the moment the SDI gate array (on the I/O-R/W module) receives the READ GATE signal from the SDI controller and the time the I/O-R/W module acts upon the READ GATE signal. The amount of delay (skew) changes for each revolution of the disk when the index pulse is received. The skew time is one byte time for odd revolutions of the disk and two byte times for even revolutions of the disk.
FAST LOCK DELAY	Fast lock delay is accomplished by the R/W ENDEC chip. The drive software enables fast lock delay through Misc. I/O Port 0 (bit <4>) with a 2.24-microsecond delay in addition to the delayed gate signal.
OFFSET OF HEADS	Positive and negative offsets can be applied to the servo circuitry during attempted reads. Six combinations of offsets are utilized in the RA90. These include plus or minus offsets of 5%, 10%, 12.4%, or 20% of the track width.
WRITE DIAGNOSTICS	Thin-film heads can sometimes take on the characteristics of the magnetic media. The buildup of this magnetic field in the heads interferes with the drive's ability to read the surface of the disk. Running write current through the heads usually breaks up the magnetic alignment of the thin-film heads substrata layers. This level of error recovery writes internal diagnostics within the dedicated inner guardband to eliminate this problem. With normal drive operations, this should rarely be a problem.

B-2 RA90/RA92 Error Recovery Levels

The RA90/RA92 error recovery circuits are activated when the SDI controller issues an SDI ERROR RECOVERY command to the drive. This occurs after the controller has exhausted its read retry count (five for the RA90/RA92). An error recovery level is specified by the controller in the SDI ERROR RECOVERY command. The level number specifies which combination of error recovery circuits the drive is to employ. There is no controller intervention in the actual drive error recovery process.

RA90 and RA92 disk drives employ 14 levels of error recovery, as shown in Table B-2.

Table B-2 RA90/RA92 Error Recovery Levels

Level	Description
14	Offset of heads by dedicated servo to +5% (offset is towards outer guardband).
13	Offset of heads by dedicated servo to -5% (offset is towards inner guardband).
12	Offset of heads by dedicated servo to +10%.
11	Offset of heads by dedicated servo to -10%.
10	Offset of heads by dedicated servo to +12.4%.
9	Offset of heads by dedicated servo to -12.4%.
8	Offset of heads by dedicated servo to +20%.
7	Offset of heads by dedicated servo to -20%.
6	Enable hold-over one shot.
5	Fast lock delay level.
4	Turn on low threshold.
3	Turn on high threshold.
2	Turn on read gate delay.
1	Diagnostic writes (to clear head domain clattering).
0	NOP: This is the normal default state of the drive. No error recovery circuits are activated.

The drive supplies the controller with the number of error recovery levels it has at its command. This is done by the drive in response to a GET COMMON CHARACTERISTICS command from the controller. The actual mechanism is transparent to the user, but works as follows:

During a read data operation, the controller reads a block of data from the disk. If there are no ECC errors, data is passed to the host operating system. However, if the controller detects an ECC error, it compares the number of ECC symbols in error to the drive's ECC error symbol threshold. The RA90/RA92 disk drive has an error symbol threshold of six.

As long as the error symbol threshold has not been reached, the controller can correct the data. If the error symbol threshold is equaled or exceeded, the drive then sends an error to the host error log and sets the BBR (bad block replacement) flag. The BBR process is actually implemented at a later time.

The controller then determines if it can correct the data. If the data is uncorrectable, the controller examines the drive's common characteristics to determine the drive's read retry count parameter. The RA90/RA92 disk drive has a read retry count of five.

If, after exhausting the read retry count on a block of data, the data is still uncorrectable, the controller determines if the drive has error recovery capabilities. The RA90/RA92 disk drive has 14 error recovery levels (see Table B-2). The controller issues an ERROR RECOVERY command to the drive. The drive then initiates the first level of error recovery. In the case of the RA90/RA92, level 14 is used first and the drive decrements down to zero. The RA90/RA92 activates the appropriate hardware circuits corresponding to a level 14 error recovery. The controller repeats the entire read data block process including, if necessary, the read retry process.

If the data has still not been recovered, the controller issues another **ERROR RECOVERY** command, this time specifying level 13. Again, the drive error recovery process starts and continues until the data has been recovered or all the error recovery levels have been tried. If the read retry operation fails and the error recovery levels fail, the controller returns an error to the host and **BBR** is implemented on that block of data.

The error recovery mechanism is not restricted to **ECC** errors encountered during reads. Header-related errors may also cause the hardware error recovery levels to be implemented.

C

Customer Equipment Maintenance

This appendix will assist customers in maintaining their equipment to ensure the highest level of equipment performance and reliability. Specifically, this appendix addresses the maintenance of 60-inch storage array cabinet systems.

C.1 Customer Responsibilities

The customer is directly responsible for:

- Supplying accessories, including storage racks, cabinetry, tables and chairs, as required.
- Making the appropriate documentation available in a location convenient to the system.
- Obtaining cleaning supplies specified in this appendix.
- Performing the specific equipment maintenance described in this appendix.

C.1.1 Cleaning Supplies

To properly maintain the equipment, the customer must acquire the following items and supplies:

- Vacuum cleaner with flexible hose and nonmetallic, soft-bristle brush attachment
- Isopropyl alcohol (at least 91%) (Digital P/N 29-19665)
- Lint-free tissues or cloths
- All-purpose spray cleaner

CAUTION

When using spray cleaner, do not spray cleaner directly into computer equipment. This could adversely affect equipment reliability or damage electrical components.

C.1.2 Ongoing Equipment Care

The following should be performed on an ongoing basis:

- Keep the immediate area in front of the storage array cabinets free of obstructions.
- Keep the exterior of the cabinets and the surrounding area clean. Use a lint-free cloth and isopropyl alcohol to remove sticky residue left on painted surfaces by customer cabinet number labels, and so forth.
- Maintain the site temperature/humidity to comply with Digital's recommended environmental range (reference product-specific documentation). This will ensure the highest product reliability and product life goals are achieved.

C.1.3 Monthly Equipment Maintenance

The following tasks should be performed on a monthly basis, or more often if environment warrants:

CAUTION

Avoid touching the operator control panel switches during cleaning operations. The state of the drives could change and affect the operation of the subsystem.

- Vacuum and/or wipe top of storage array cabinet with a lint-free cloth.
- With a soft-bristle brush attachment, vacuum the air vent grill on the front door of the storage array cabinet. Leave the front door assembly attached to the storage array cabinet while vacuuming.

C.1.4 Maintenance Records

Digital suggests the customer keep an accurate log of all equipment maintenance. A maintenance log form for 60-inch storage array cabinets is included in this appendix for customer use. This form may be reproduced and inserted in the customer's site management guide for record-keeping purposes. Refer to Figure C-1.

D

Customer Services' Preventative Maintenance

The information contained in this appendix will assist Digital Customer Services engineers in performing and planning preventative maintenance (PM) procedures for RA90/RA92 disk drive products.

D.1 PM Checklist for RA90/RA92 Disk Drives

The following preventative maintenance steps should be performed by Digital Customer Services on a scheduled basis at specified intervals. The PM checklist is a *per storage element* checklist.

Due to the frequency of this activity, we suggest that you record this activity on the RA90/RA92 Preventative Maintenance Activity Log provided in this section. This log sheet may be reproduced and inserted in the site management guide, as appropriate.

One-Year Interval

Perform the following PM steps at 1-year intervals:

1. Utilize VAXsimPLUS to obtain the repair history of each disk drive. Examine the drive error profile over various lengths of time to determine whether a proactive repair may be warranted. Examination may include opening up the time window for the last week, last month, and last 3 months. Deeper examination of error logs may be necessary if there are any error rate trends of concern. (Time: 10:00 minutes for basic error analysis with VAXsimPLUS)
2. Remove the drive(s) from service. (Time: 2:00 minutes)
3. Remove the cabinet front access panel or bezel assembly. Remove and clean each cabinet pre-filter or air vent grill as necessary. (Time: 5:00 minutes)
4. Determine the drive microcode revision levels by examining subsystem printouts or running drive test T45. Update microcode to the latest compatible functional revision as necessary. (Time: 3:00 minutes)
5. From the rear of the cabinet at the I/O bulkhead panel, verify the SDI cables are dressed and routed in an orderly fashion to prevent the cables from being tripped over or stepped on.
6. Verify the SDI connectors are securely attached to the I/O bulkhead panel.
7. Return the drive(s) to service.

The yearly PM steps can be accomplished in approximately 20 minutes per drive. Servicing more than one drive at a time will result in reduced time per drive.

Two-Year Interval

Perform the following PM steps at 2-year intervals:

1. Remove the drive(s) from service. (Time: 2:00 minutes)
2. Remove drive power.
3. Remove the OCP and blower bezel assembly. Visually inspect the drive chassis interior for debris. If considerable dirt/lint is present, remove the electronic control module (ECM) assembly and head disk assembly (HDA) then vacuum the chassis. Reassemble the drive. (Time: 10:00 minutes)
4. Power up the drive and determine whether the blower motor quickly attains its speed and the drive becomes ready. (Time: 2:00 minutes)
5. Execute drive internal test T00 for one pass. (Time: 10:00 minutes)
6. Return the drive(s) to service.

The 2-year interval PM steps can be accomplished in approximately 24 minutes per drive. Servicing more than one drive at a time will result in reduced time per drive.

Five-Year Interval (for the HDA)

In addition to the 1- and 2-year interval PM steps previously described, perform the following step at 5-year intervals:

1. Remove and replace the spindle ground brush using procedures contained in this manual.

The 5-year interval PM steps should be accomplished within 40 minutes per drive.

Index

A

- Acceptance testing, 2-13
 - drive spun down, 2-18
 - drive spun up, 2-19
- Add-on installation, 2-22
- Address selection, 2-20

B

- BBR algorithms, 5-48
- BBR packet, 5-48
- Blower/bezel motor assembly removal, 6-7
- Blower motor, dual outlet, 3-12
- Brake assembly removal, 6-17

C

- Cluster installation note, 2-20
- Controller byte, 5-5
- Correctable ECC errors, 5-48
- Cylinder address bytes, 5-6

D

- Data rates, 1-6
- Data storage capacity
 - RA90 disk drive, 1-1
 - RA92 disk drive, 1-1
- Deskidding cabinets, 2-5
- Diagnostics
 - host-level, 5-37
 - HSC-based, 5-37
 - KDM-based, 5-37
 - off-line, 5-37
 - power-up, 2-16
 - standalone, 5-37
 - XDA controller-based, 5-38
- Diagnostics and utilities
 - Average Seek Timing test (T38), 4-14
 - Clear DD Bit utility (T55), 4-21
 - Clear Seeks utility (T53), 4-21
 - Clear Spinups utility (T54), 4-21

Diagnostics and utilities (cont'd.)

- Display Drive Serial Number utility (T47), 4-20
- Display Error Log Errors utility (T41), 4-16
- Display Seeks utility (T43), 4-17
- Display Spinups utility (T44), 4-18
- Display Time utility (T24), 4-17
- Drive Revision Level utility (T45), 4-18
- Drive S/N Bus test (T04), 4-7
- Drive-Sensed Temperature Display utility (T29), 4-12
- Error Log Checkpoint utility (T50), 4-21
- Gray Code (Track Counter) test (T29), 4-12
- Guardband test (T30), 4-12
- Hardcore Sequence Test (T18), 4-11
- HDA Revision utility (T46), 4-20
- Head Select and One Seek test sequence (T24), 4-12
- Head Select test (T06), 4-8
- Head Select utility (T63), 4-22
- Head Switch Timing test (T39), 4-15
- idle loop tests (spun down), 4-2
- idle loop tests (spun up), 4-2
- Incremental Seek test (T31), 4-13
- individual descriptions, 4-5
- Loop-Off utility (T62), 4-22
- Loop-On-Error utility (T61), 4-22
- Loop-On-Test utility (T60), 4-21
- Master CPU test, 4-5
- Master RAM test, 4-5
- Master ROM test (T01), 4-6
- Master Timer test (T02), 4-6
- Minimum Seek Timing test (T36), 4-14
- One Seek utility (T64), 4-23
 - power-up, 4-1
 - problem OCP displays, 4-3
- Random Seek test (T33), 4-13
- Read/Write Force Fault test (T16), 4-11

Diagnostics and utilities (cont'd.)

- Read/Write Sequence test (T19), 4-11
- Read-Only Cylinder Formatter test (T17), 4-11
- Read-Only test (T14), 4-9
- SDI Loopback test (external) (T09), 4-9
- SDI Loopback test (internal) (T08), 4-9
- Sector/Byte Counter test (T07), 4-8
- Seek Parameter Input utility (T65), 4-23
- sequence tests, 4-2
- Serial Communications Interface test, 4-6
- Servo Data Bus Loopback test (T03), 4-6
- Servo RAM test, 4-6
- Servo Spinup Sequence test (T20), 4-11
- Tapered Seek test (T34), 4-13
- Toggle Seek test (T32), 4-13
- Total Drive Sequence test (spinning) (T22), 4-12
- Total Drive Sequence test (spun down) (T23), 4-12
- Total Servo Sequence test (T21), 4-11
- Update Cartridge utility (spun down) (T40), 4-15, 7-3
- Variable Average Seek Timing test (T66), 4-25
- Write/Read test (T15), 4-9
- Documentation
 - related, xiii
 - troubleshooting, 5-1
- Drive unit address
 - alternate display mode, 3-21
 - programming, 3-19

E

ECM

- description, 3-3
- I/O-R/W module, 3-3
- module types, compatibility, 3-3
- removal, 6-10
- servo module, 3-5
- Electrical specifications, 1-7
- Electronic control module
 - See ECM
- Electrostatic protection
 - See ESD protection
- Environmental limits, 1-7
- Error byte, 5-4
- Error code byte, 5-9
- Error codes
 - during acceptance testing, 2-20

Error codes (cont'd.)

OCP, 2-18

Error descriptions

- A0 Unable to Clear SDI Array Safety Status Register, 5-93
- A1 Unable to Force Encoder Error, 5-93
- A2 Unable to Force Multiple Head Select While Reading, 5-93
- A3 Unable to Force Write Gate and Write Unsafe, 5-94
- A4 Unable to Force Write Current and No Write Gate, 5-94
- A5 Unable to Force Write Gate and No Write Current, 5-94
- A6 Unable to Force Read Gate and Off Track Error, 5-94
- A7 Unable to Force Write Gate and Off Track Error, 5-94
- A8 Unable to Force Read and Write Fault While Writing, 5-95
- A9 Servo Fault/Force Fault Test, 5-95
- AB Forced Read and Write Fault While Reading, 5-95
- 4A Drive Disabled by Controller (DD Bit Set), 5-75
- AD UART Overrun or Framing Error, 5-95
- 5A Embedded Head Gain Calibration, 5-78
- 7A Embedded Offset/Gain Calibration Timeout, 5-84
- AE OCP Data Packet Checksum Error, 5-95
- AF OCP Start Byte is Not a Sync Character, 5-96
- 9A Positioner Corrected Event During Data Transfer, 5-91
- 0A SDI Incorrect Command Opcode Parity Error, 5-56
- 1A SDI Invalid Cylinder Address, 5-63
- 2A SDI Invalid Subunit Specified, 5-68
- 8A Servo Processor Inside of Destination Track During Settle State, 5-88
- 33 Attempt to Write Through Bursts, 5-70
- 6A Unable to Force No-Sync Error, 5-81
- 3A Write Gate and Write-Protected, 5-72
- B0 OCP Invalid Response, 5-96
- B2 OCP Retransmit Failure, 5-96
- B3 OCP Command Unsuccessful, 5-96
- B4 OCP Command Timeout, 5-97

Error descriptions (cont'd.)

- B6 Master Processor UART Loopback Test Failure, 5-97
- B8 Master Processor UART Transmitter/Receiver Error, 5-97
- B9 OCP-to-Master Processor Communications Timeout Failure, 5-97
- BA OCP NMI Timeout Failure, 5-97
- 5B Bias Calibration Error, 5-78
- BB OCP Processor ROM Checksum Failure, 5-98
- BC Cartridge Checksum Failure, 5-98
- BD Microcode Update Cartridge Detection Failure, 5-98
- BE Cartridge/EEPROM/Master Processor Consistency Check, 5-98
- BF Error Log Write Compare Error, 5-99
- 8B Gray Code Error After Settling With Fine Track, 5-88
- 3B Hard INIT Occurred to Drive, 5-72
- 4B Index Error, 5-75
- 1B Inner Guardband Error, 5-64
- 7B Invalid Test While Spindle Running, 5-84
- 6B R/W Write/Read Test Overall Failure (Three or More Bad Heads), 5-81
- 2B SDI Invalid Diagnose Memory Region Location, 5-68
- 0B SDI Invalid Opcode, 5-56
- 9B Write and Positioner Corrected Event, 5-91
- C0 Hardware Revision and Microcode Incompatibility, 5-99
- C1 Outer Guardband Detected After HEAD LOAD Command, 5-100
- C2 Inner Guardband Detected After HEAD LOAD Command, 5-100
- C3 Seek to Outer Guardband Failed, 5-100
- C4 Seek to Outer Guardband Not Detected, 5-101
- C5 HDA and ECM Incompatibility, 5-101
- C6 PLO Failure, 5-101
- C7 Seek to Inner Guardband Failed, 5-101
- C8 Inner Guardband Not Detected After Seek to Inner Guardband, 5-102
- C9 Analog Loop Test Failure, 5-102
- CA Media Not Spinning, 5-102
- 98 Can't Execute Diagnostic/Jumper, 5-91

Error descriptions (cont'd.)

- 64 Cannot Clear IID Error Bits, 5-80
- 67 Cannot Execute Write Test (Read-Only Test Failed or Not Run First), 5-80
- CC Servo Processor Recalibrate Failed, 5-102
- CD Track Counter (Gray Code), 5-103
- CE EEPROM Write Cycle Timeout, 5-103
- CF Invalid Data in EEPROM, 5-103
- 7C Gray Code Match Error After Settling, 5-85
- 5C Incorrect Diagnostic Index or Sector Pulse, 5-78
- 1C Outer Guardband Error, 5-64
- 6C R/W Write/Read Test Partial Failure (One or Two Bad Heads), 5-81
- 9C Read Gate and Positioner Corrected Event, 5-92
- 0C SDI Command Length Error (LVL2), 5-57
- 4C SDI Invalid Write Memory Region Error, 5-75
- 2C SDI Spindle Not Ready with Seek/Recalibration Command, 5-68
- 8C Uncalibrated and PLO Error, 5-88
- 58 Dedicated Head Gain Calibration Error, 5-77
- 79 Dedicated Servo Calibration Timeout Error, 5-84
- 7D Embedded Interrupt Timeout, 5-85
- 9D Error Log Header Corrupted, 5-92
- 3D HDA Read/Write Interlock Broken, 5-72
- 65 Diagnostic Index or Sector Not Detected, 5-80
- 61 Diagnostic Index Sync Timeout Error, 5-79
- 1D Illegal Servo Fault, 5-64
- 8D Polarity Error on Velocity Command During a Multi-Track Seek, 5-88
- 2D Power Supply Over-Temperature, 5-69
- 42 Drive Not On Line/SEEK Command Issued, 5-73
- 0D SDI Invalid Command with Drive Error, 5-57
- 55 DSP Sanity Timeout After Load, 5-77
- 6D Unable to Force Read Gate and Write Gate Together, 5-82
- 4D Write Gate and Bad Embedded Servo Information, 5-76
- E0 Spindle Rotation Not Detected, 5-103

Error descriptions (cont'd.)

- E1 Spindle Speed Out Of Range, 5-104
- E2 A/D or D/A Converter Insane, 5-104
- E3 Excessive Positioner Current During Test, 5-104
- E4 Open Circuit Detected During Power Amp Toggle Test, 5-104
- E5 Overcurrent Detected During Actuator Test, 5-105
- E6 Track Counter Clear Failure, 5-105
- E7 Illegal Zone Detected, 5-105
- E8 Outer Guardband Timeout, 5-106
- E9 Gray Code Timeout During the Turnaround State, 5-106
- EA Gray Code Timeout During Outer Guardband State, 5-107
- EB Sector Pulse Timeout During Sync-Up State, 5-107
- EC Servo Fault and PLO Fault Bit Set in GASP, 5-107
- 9E Drive Faulted, Test Cannot Run, 5-93
- ED Servo Watchdog Timeout, 5-107
- EE Servo Digital Signal Processor Reset, 5-107
- EF Head Unload Failed, 5-108
- 7E Fine Track Lost After Settling, 5-85
- 22 Electronic Control Module Over-Temperature Error, 5-66
- 8E Master Processor ROM/EEPROM Consistency Code Mismatch, 5-89
- 59 Embedded Servo Offset Calibration Error, 5-78
- 34 ENDEC Encoder Error, 5-70
- 3E OCP Interlock Broken, 5-73
- 1E Power-Up After AC Power Loss, 5-64
- 0E SDI Lvl 1 Invalid Select Group Number, 5-57
- 2E SDI Spinup Inhibited by Controller Flags, 5-69
- 6E Unable to Force Write Gate and Write Protect Error, 5-82
- F0 Servo Microcode Update Failed, 5-108
- F1 Command to Servo Processor Timed Out, 5-108
- F3 Servo Spinup Failed, 5-108
- F4 Servo Spindown Failed, 5-109
- F5 Seek Failed, 5-109
- F6 Head Switch Failed, 5-109
- F7 RTZ Failed, 5-109
- F8 Head Load Failed, 5-109

Error descriptions (cont'd.)

- F9 Diagnostic Command Failed, 5-110
- FA Servo Processor Failed Seek to DGN Write Cylinder, 5-110
- FB Servo Processor Failed Seek to DGN Read Cylinder, 5-110
- FD EEPROM Checksum Error, 5-111
- 6F Diagnostic Write Attempted While Write-Protected, 5-82
- 8F EEPROM Checksum Failure, 5-89
- 9F Error Log Check Point Code, 5-93
- 4F Invalid Select Group (Level 1 Command) - Not Read/Write Ready, 5-76
- 44 Format Command and Format Not Enabled, 5-74
- 2F SDI RUN Command with Run Switch in Stop Position, 5-69
- 0F SDI Write Enable on a Write-Protected Drive, 5-57
- 1F Sector Overrun Error, 5-65
- 7F Servo Settling Timer Expired, 5-85
- 77 Head Load Timeout Error, 5-84
- 14 Head Offset Margin Event, 5-62
- 15 Head Offset Out-of-Band Error, 5-62
- 54 Head Select Register Loopback Error, 5-77
- 93 Inner Guardband/Servo Fault: No Interrupt Detected, 5-89
- 92 Inner Guardband Without a Servo Fault Set, 5-89
- 49 Invalid Command During TOPOLOGY Command, 5-75
- 47 Invalid Disconnect Command/TT Bit Error, 5-74
- 05 Invalid Drive Serial Number Code, 5-55
- 46 Invalid Hardware Fault, 5-74
- 48 Invalid Write Memory Byte Counter/Offset Error, 5-75
- 24 Loss of Fine Track During Data Transfer, 5-66
- 88 Master Processor EEPROM Write Violation Error, 5-87
- 85 Master Processor RAM Test Failure, 5-87
- 87 Master Processor ROM Checksum Failure, 5-87
- 80 Master Processor ROM Consistency Code Mismatch, 5-86
- 57 Master Processor Timer Failure, 5-77
- 11 Microcode Cartridge Load Occurred, 5-58
- 06 Microcode Fault, 5-55

Error descriptions (cont'd.)

- 91 No Interrupt Detected During R/W Force Fault, 5-89
- 74 Offset Timeout Error, 5-83
- 60 Read/Write Head Select Failure, 5-79
- 38 Read Gate and Multiple Head Chips Selected, 5-71
- 45 Read Gate and Off Track Both Asserted, 5-74
- 31 Read Gate and Write Gate Both Asserted, 5-70
- 32 Read or Write While Faulted, 5-70
- 62 Read Test Overall Read Failure (Three or More Bad Heads), 5-79
- 63 Read Test Partial Failure (One or Two Bad Heads), 5-79
- 66 Read Test Servo Failure, 5-80
- 71 Recalibrate Timeout Error, 5-82
- 10 SDI Command Length Error (LVL2), 5-58
- 96 SDI Failure: Port B, 5-90
- 07 SDI Frame Sequence Error, 5-55
- 29 SDI Invalid Error Recovery Level Specified, 5-68
- 19 SDI Invalid Format Request, 5-63
- 16 SDI Invalid Group Select LVL2, 5-62
- 40 SDI Invalid Read Memory Region Error, 5-73
- 94 SDI Loopback Test Failure on Both Ports, 5-90
- 09 SDI Lvl 1 Framing Error, 5-56
- 08 SDI Lvl 2 Checksum Error, 5-56
- 17 SDI Port A Command/Response Timeout, 5-63
- 18 SDI Port B Command/Response Timeout, 5-63
- 20 SDI RTCS Parity Error, 5-65
- 95 SDI Test Failure: Port A, 5-90
- 21 SDI Transfer (Pulse) Error, 5-65
- 51 Sector/Byte Counter Error, 5-76
- 89 Seek Speed Out of Range, 5-87
- 50 Servo Data Bus Failure, 5-76
- 25 Servo Fault Error, 5-66
- 27 Servo Over-Temperature Error at S1, 5-67
- 28 Servo Over-Temperature Error at S2, 5-67
- 78 Servo Processor Bias Force Calibration Timeout, 5-84
- 82 Servo Processor Coarse Velocity State Timeout, 5-86
- 83 Servo Processor Fine Velocity State Timeout, 5-86
- 73 Servo Processor Head Switch Timeout, 5-83

Error descriptions (cont'd.)

- 53 Servo Processor Offset Error, 5-77
- 76 Servo Processor Sanity Timeout, 5-83
- 84 Servo Processor Seek Direction Error, 5-87
- 72 Servo Processor Seek Timeout, 5-83
- 81 Servo Processor Settle State Timeout, 5-86
- 70 Servo Processor Spinup Timeout, 5-82
- 75 Servo Processor Unload Timeout, 5-83
- 56 Servo RAM Test Failure (High Byte of Address), 5-77
- 52 Servo RAM Test Failure (Low Byte of Address), 5-76
- 13 Spindle Motor Control Fault, 5-59
- 01 Spindle Motor Transducer Timeout, 5-54
- 01  Spindle Motor Transducer Timeout , 5-53
- 03 Spindle Not Accelerating During Spinup, 5-54
- 26 Spindle Speed Error (Servo Processor), 5-67
- 12 Spindle Speed Unsafe Error, 5-58
- 04 Spinup Too Long to Lock on Speed, 5-54
- 02 Spinup Too Slow, 5-54
- 86 Static RAM Failure, 5-87
- 43 TCR and Not Read/Write Ready Fault, 5-74
- 68 This Diagnostic Cannot Execute Without Software Jumper, 5-81
- 69 Unable to Force Compare Error, 5-81
- 90 Unable to Force Index Error, 5-89
- 36 Write and Servo Uncalibrated, 5-71
- 35 Write and Write Unsafe, 5-71
- 30 Write Current and No Write Gate, 5-69
- 37 Write Gate and No Write Current, 5-71
- 39 Write Gate and Off Track, 5-72
- Error logs, 1-4
- Error recovery level byte, 5-9
- Error recovery levels, B-1
- Error recovery Levels
NOP: no operation., B-2
- Errors related to media
See media errors
- ESD protection, 1-8
- wrist strap use, 1-8

F

Fault display mode setup, 3-16
 Floor loading, 2-3
 Front access panel, removal, 2-7

H**HDA**

brake assembly removal, 6-17
 carrier separation, 6-14
 description, 3-10
 hardware compatibility, 3-12
 installation, 6-14
 removal, 6-12
 spindle ground brush removal, 6-16
 HDA preventative maintenance, D-2
 HDA revision bits byte, 5-6
 Host error logs, 5-2

I**I/O-R/W module**

description, 3-3
 hardware revision matrix, 3-5
 Idle loop testing, 2-16
 Input current (amps), 1-7
 Inrush current, 1-6
 Installation note, cluster, 2-20

L

Labeling, OCP, 2-13
 Lamp test, OCP, 2-16
 LARS examples, A-1
 Latency, 1-6
 Level A Retry, 5-49
 Level B Retry, 5-49
 Leveling cabinets, 2-6
 Logical media layout, 1-3

M

Maintenance activity log, C-3, D-2
 Maintenance strategy, 1-3, 1-4
 Manufacturing fault code, 5-9
 Media errors, 5-32
 drive or controller port not defined
 (random R/W errors), 5-35
 excessive number of blocks replaced
 because of R/W path problems,
 5-33
 isolating random R/W transfer errors,
 5-35
 LBN correlated to a physical cylinder,
 5-34
 LBN correlation to a single group
 (head), 5-33

Media errors (cont'd.)

LBN correlation to multiple groups
 (heads), 5-34
 LBNs correlated to zone write
 boundaries, 5-34
 multiple controllers report same errors,
 5-35
 repeating LBNs/RBNs, 5-33
 single controller port affected, 5-35
 Media removal service, 6-25
 Microcode
 compatibility with drive FRUs, 3-13
 Microcode update procedure, 7-3
 microcode update cartridge description,
 7-1
 running T40, 7-3
 update port description, 7-2
 Mode byte, 5-4
 MSCP status/event
 6B, 5-49
 MSLG\$_LEVEL, 5-46
 MSLG\$_RETRY, 5-46

N

Normal mode setup, 3-15

O**OCP**

functions, 3-14
 removal, 6-6
 OCP error codes, 2-18
 OCP labeling, international, 2-13
 OCP lamp test, 2-16
 On line
 placing drive on line, 2-20
 Operating temperature and humidity,
 2-3
 Operator Control Panel
 See OCP

P

Part numbers, ECM components, 3-3
 Parts removal sequence, 6-3
 PCM
 description, 3-7
 removal, 6-11
 switch pack settings, 3-9
 Phase requirements, 2-1
 Physical characteristics, 1-6
 Physical media layout, 1-3
 Positioner errors, 5-49
 Power, applying to drive, 2-14
 Power and safety precautions, 2-1
 Power cord connections, 2-11

Power dissipation, 1-7
 Power supply
 available voltages, 3-12
 removal, 6-22
 Power supply location, drive, 2-12
 Power-up
 resident diagnostics, 2-16
 Preamp control module
 See PCM
 Preventative maintenance
 customer responsibilities, C-1
 Customer Services' responsibilities,
 D-1
 maintenance activity log, D-2
 Previous command opcode byte, 5-6
 Programming the unit address, 2-20

R

Rear access panel, removal, 2-9
 Rear flex cable removal, 6-23
 Removal/replacement procedures
 bezel and blower motor assembly
 separation, 6-9
 blower/bezel motor assembly removal,
 6-7
 brake assembly removal, 6-17
 contact extraction tool, 6-20
 ECM removal, 6-10
 front access panel removal, 6-4
 FRUs, sequence for removal, 6-3
 HDA and carrier separation, 6-14
 HDA installation, 6-14
 HDA removal, 6-12
 media removal service, 6-25
 OCP removal, 6-6
 PCM removal, 6-11
 power supply removal, 6-22
 rear access panel removal, 6-4
 rear flex cable removal, 6-23
 solenoid removal, 6-22
 spindle ground brush removal, 6-16
 spindle lock solenoid failure, 6-20
 tools checklist, 6-3
 Request byte, 5-3
 Response opcode byte, 5-3
 Retry count byte, 5-5

S

SDI cable connections, 2-10
 Sector format, 1-1
 Seek times, 1-5, 4-5
 Sequence diagnostics, 4-2
 Service delivery strategy, 1-4
 Servo module
 description, 3-5

Servo module (cont'd.)

 hardware revision matrix, 3-7
 Site preparation and planning, 2-1
 Software jumper, 4-4
 Specifications, RA90/RA92, 1-5
 Spindle ground brush removal, 6-16
 Spindle lock solenoid failure, 6-20
 Start/stop time, 1-6

Status/event codes

 14, 5-48
 34, 5-46, 5-48, 5-49
 54, 5-48
 74, 5-48
 94, 5-48
 2A, 5-32
 1A8, 5-48
 1AB, 5-31
 AB, 5-31
 14B, 5-29
 4B, 5-29
 10B, 5-29
 8B, 5-30
 16B, 5-31
 18B, 5-31
 2B, 5-32
 6B, 5-49
 B4, 5-48
 1C8, 5-48
 CB, 5-30
 D4, 5-48
 E8, 5-44, 5-49
 1E8, 5-48

Status bytes

 extended, 5-2
 generic, 5-4

Subunit mask byte, 5-3

T

Temperature, affect on drive performance,
 4-5
 Test selection from OCP, 2-16
 Theory
 drive operations and theory, 3-1
 Thermal stabilization, 2-3
 Tools checklist, 6-3
 Training, 5-1
 Troubleshooting
 bad block replacement (BBR), 5-24
 controller byte, 5-5
 controller-detected communication
 events and faults, 5-30
 controller-detected drive clock dropout,
 5-31
 controller-detected drive failed
 initialization, 5-31

Troubleshooting (cont'd.)

- controller-detected drive ignored
 - initialization, 5-31
- controller-detected EDC errors, 5-28
- controller-detected loss of read/write ready, 5-30
- controller-detected lost receiver ready, 5-30
- controller-detected protocol and transmission errors without communications errors, 5-29
- controller-detected pulse or state parity errors, 5-29
- controller-detected receiver ready collision, 5-31
- controller-detected SERDES error, 5-32
- correctable ECC errors, 5-48
- cylinder address bytes, 5-6
- data collection steps, 5-26
- DBN conversion, RA90, 5-6
- DBN conversion, RA92, 5-8
- drive-detected drive errors and diagnostic faults (DDDE), 5-27
- drive-detected protocol errors without communication errors (DDPE), 5-27
- drive-detected pulse or state parity errors, 5-27
- drive internal error log, 5-9, 5-27
- drive-resident utility dump (T41), 5-14
- error byte, 5-4
- error code byte, 5-9
- error recovery level byte, 5-9
- error reporting mechanisms, 5-1, 5-15
- exiting data collection/action list process, 5-39
- extended status bytes, 5-2
- FRU replacement stage, 5-40
- general information, 5-16
- HDA revision bits byte, 5-6
- host console/user terminal trails, 5-24
- host error log, 5-25
- host error logs, 5-2, 5-23
- host-level diagnostics, 5-37
- host-level diagnostics and utilities, 5-16
- HSC-based diagnostics, 5-37
- HSC console log, 5-24, 5-26
- HSC console utility: DKUTIL, 5-12
- identifying the problem drive, 5-23
- identifying the problem FRU, 5-24
- KDM-based diagnostics, 5-37
- LBN conversion, RA90, 5-6
- LBN conversion, RA92, 5-8
- manufacturing fault code, 5-9

Troubleshooting (cont'd.)

- miscellaneous checks, 5-36
- mode byte, 5-4
- OCP fault indicator/error codes, 5-14, 5-25
- off-line diagnostics, 5-37
- other means (to identify problem drive), 5-24
- performance issues when no errors are being logged, 5-41
- post-verification testing, 5-40
- Power OK indicator, 5-14
- pre-verifying drive symptoms, 5-25
- previous command opcode byte, 5-6
- priority order of DSA errors, 5-27
- RBN conversion, RA90, 5-6
- RBN conversion, RA92, 5-8
- receiver ready collisions: acceptable rates, 5-31
- receiver ready collisions: unacceptable rates, 5-31
- recommended training, 5-1
- reference material, 5-1
- request byte, 5-3
- resident diagnostics limitations, 5-16
- response opcode byte, 5-3
- retry count byte, 5-5
- returning disk to customer, 5-41
- SDI drive command timeout, 5-32
- standalone diagnostics, 5-37
- status/event 6B, 5-52
- step-by-step procedure, 5-16
- subunit mask byte, 5-3
- uncorrectable ECC errors, 5-44
- unit number low byte, 5-3
- unusual problems, 5-36
- VAXsimPLUS, 5-2, 5-23, 5-25
- VMS mount verification, 5-42
- worksheet, 5-23
- XBN conversion, RA90, 5-6
- XBN conversion, RA92, 5-8
- XDA controller-based diagnostics, 5-38

U

- Uncorrectable ECC errors, 5-44
 - hard, 5-44
 - soft, 5-46
- Unit address
 - see drive unit address
- Unit number low byte, 5-3
- Unpacking, 60-inch cabinets, 2-3
- Updating microcode
 - See microcode update procedure

V

VAXsimPLUS, 5-2

**Voltage (frequency) selection
power supply, 2-13**