MEMOREX TELEX

3890-2
Disk Storage Subsystem
Product Reference Manual

3890-2.01-00

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Preface

The 3890-2 Disk Storage Subsystem is a high performance DASD subsystem that consists of the 3898-2 Cluster Control Unit and one or more 3890 Disk Modules. This subsystem offers the customer increased storage capacity, reduced floor space requirements, and a host of other benefits. To familiarize the customer with the 3890-2 subsystem, Memorex Telex publishes several manuals and brochures that describe various aspects of the product line. Some of this material focuses on the advantages and design of the subsystem; other documents furnish planning information, hardware descriptions, etc. of the *Product Reference Manual*. The purpose of the *Product Reference Manual* is to familiarize the operator and system programmer with the basic subsystem components, the operator control panel, the command range, the track format, and a variety of related subjects. Customers who have already acquired a 3890-2 subsystem will find this manual valuable when developing command sequences, migrating datasets, and training system operators. Customers planning to install a 3890-2 subsystem should also review this manual for a fuller understanding of how the subsystem will adapt to the existing environment. The *3890-2 Product Reference Manual* is structured as follows:

> ***Note:*** *For the purposes of this manual, the term "3898" refers to the 3898-2 Cluster Control Unit and the term "3890" refers to the 3890 Disk Module unless otherwise specified.*

Section 1 — This section introduces the 3890-2 subsystem, briefly describing the cluster control unit and drive modules available at this time. Additionally, Section 1 outlines the system operator's responsibilities in regard to the subsystem as well as the safety precautions that all personnel must observe.

Section 2 — This section provides a detailed discussion of the subsystem operator control panel switches and indicators. As a reference for the operator, Section 2 also summarizes a typical power-up sequence, power-down sequence, and an emergency power shutdown.

Section 3 — This section furnishes a complete description of all channel commands accepted by the 3898-2. When applicable, the write-up includes chaining requirements. Section 3 also defines the unit status area, an integral part of the Channel Status Word.

Section 4 — This section briefly reviews the track and record format used by the 3890 disk drive. Section 4 provides a visual layout of the track format as well as a description of each field.

Section 5 — This section describes the basics of 3898-2 error handling. Items of interest include the retry function and error correction.

Section 6 — This section covers the statistical/error recording function. In a related discussion, Section 6 lists and defines Sense Bytes 0 through 7 as logged under the various formats. Additionally, this section furnishes a table of Sense Byte 7 messages.

Appendix A — This appendix defines the abbreviations used in this manual.

Appendix B — This appendix furnishes data conversion and software planning information along with track storage capacities for given record lengths. Appendix B will be of particular interest to the system programmer.

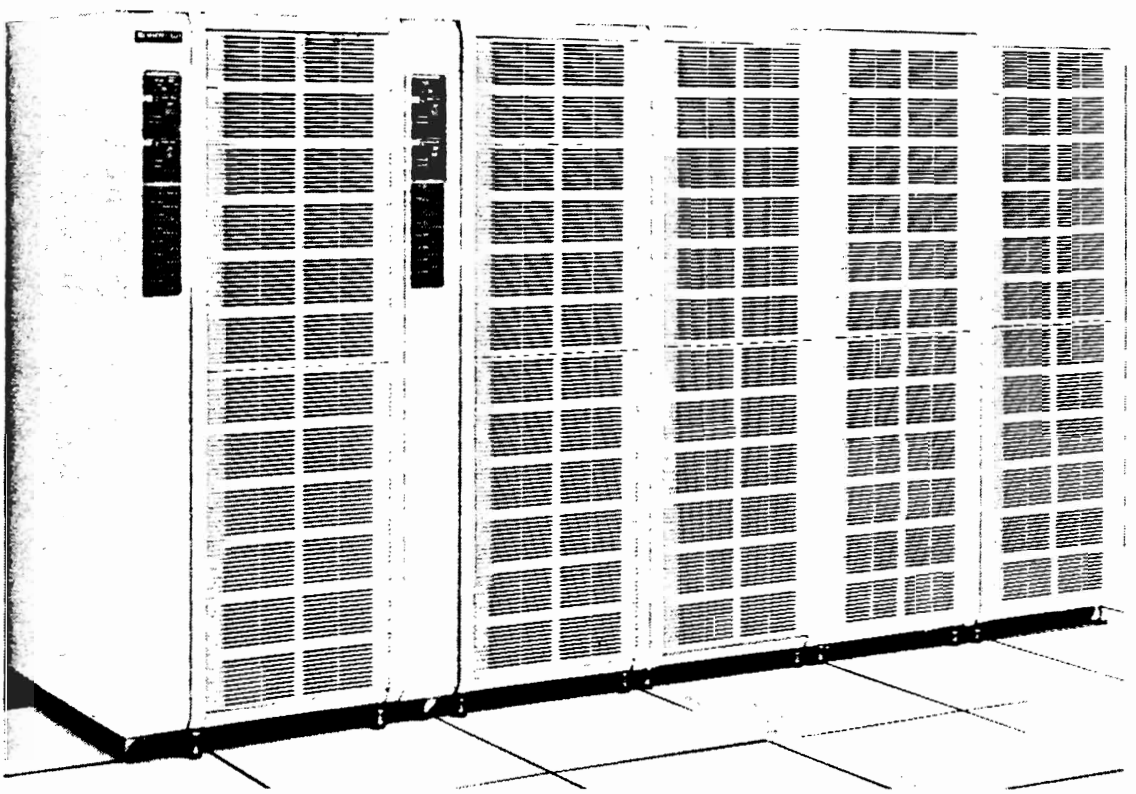
To supplement the Product Reference Manual, Memorex Telex provides a companion manual — the *3890-2 General Information Manual.* Designed for use during the system planning phase, the General Information Manual focuses on issues that prove crucial when developing an overall subsystem configuration scheme. This manual also proves a handy reference for those who wish to familiarize themselves with subsystem performance, features, and hardware. In addition to user documentation, Memorex Telex provides a full range of service documentation for the 3890-2 subsystem. This documentation includes such items as maintenance manuals, functional descriptions, etc., and is listed below.

Document	Publication Number
3890-2 Maintenance Manual	3890-2.20-xx
3890-2 Functional Description	3890-2.21-xx
3890-2 Installation Manual	3890-2.22-xx
3890-2 Illustrated Parts Catalog	3890-2.23-xx
3890-2 Fault Isolation Procedure (FIPs) Manual	3890-2.24-xx
3890-2 Microdiagnostics Reference Manual	3890-2.50-xx

Contents

Figures

Tables



Section 1
Introduction

1.1 General Discussion

The 3890-2 Disk Storage Subsystem is a high-performance, fast-access disk subsystem designed to meet the needs of a sophisticated data processing environment. With computer facility real estate at a premium, the system planner has become increasingly concerned with the amount of space required per megabyte (MB) of storage. In answer to this concern, the 3890-2 subsystem provides larger storage capacities per square foot of floor space than earlier product generations. At the same time, the subsystem features improved reliability and quicker data turnaround. The configuration strategy for the 3890-2 emphasizes the subsystem's flexibility; the 3890-2 can attach to a wide range of mainframes in a variety of different operating environments. The planner will also find the 3890 disk module's intermixed configurations highly adaptable to the specific requirements of the site. The numerous advantages offered by the 3890-2 subsystem make it one of the most cost effective DASD offerings of its kind.

The 3890-2 subsystem is composed of two major elements: the 3898-2 Cluster Control Unit and the 3890 Disk Module. The disk module attaches to the 3898-2 and a maximum configuration may include four modules. The following paragraphs briefly review each of these units, focusing on the distinguishing characteristics of each. For a more detailed discussion of 3890-2 subsystem hardware, configurations, features, and installation planning, the reader may refer to the *3890-2 General Information Manual*; this publication is considered a prerequisite to the Product Reference Manual.

1.1.1 Cluster Control Unit

The 3898-2 Cluster Control Unit provides the basic control logic and power sequencing for the subsystem. From an architectural point of view, the 3898-2 incorporates two storage clusters; each cluster contains two independent storage paths (SPs) that perform the majority of the functional management tasks. The 3898-2 is also equipped with a subsystem control panel, a power subsystem, a cooling system, and an external interface. In a standard channel configuration, each of the four available SPs attach to two IBM (or IBM-compatible) block multiplexer channels. One or more SPs can be attached to the same channel, or the four SPs can be attached to separate channels in the same processor, or to channels in different processors. To increase channel accessibility, the 3898-2 can be equipped with the optional four-channel switch feature which allows access through sixteen channels, four channel attachments per SP. The SPs are capable of transferring data to and from the channels at a rate of 3.0 megabytes/second for disk transactions. Individual SPs can handle up to 60.24 gigabytes (GB) of online storage in an address range that does not exceed 64 volumes, although 3898-2-based subsystems can also be configured with a variety of intermediate storage capacities.

1.1.2 Disk Module

The 3890-2 subsytem supports up to four 3890 Disk Modules. Each disk module provides the following basic components: an SP/device interface, redundant interface power supplies, and a set of either four, eight, twelve, or sixteen drive drawers. The SP/device interface handles a number of conversions and communications tasks for the volumes, and is composed of a number of printed circuit boards (PCBs) housed in a logic gate near the rear of the cabinet. The logic gate is powered by two power supplies; one power supply can act as a backup for the other in an emergency situation. Each drive drawer houses a high-reliability disk drive, a disk drive power supply, and a cooling system. Drive drawers are installed in sets of four and a set is referred to as a storage increment. The 3890 disk module is available in three versions depending on the type of storage increments it contains: the J-type module, the K-type module, or an intermixed module. Table 1-1 summarizes the available configurations of the disk modules to provide an overview of the different storage options the subsystem may contain.

Table 1-1. Configuration Storage Capacities (Gigabytes)

Storage Increments (Drawers)	Disk Modules Required	J Capacity	K Capacity	Intermix Capacity (J + K Volumes*)
1 (4)	One	2.52	3.78	0
2 (8)	One	5.04	7.56	0
3 (12)	One	7.56	11.34	8.92 (8J + 2K)
4 (16)	One	10.08	15.12	12.60 (8J + 4K)
5 (20)	Two	12.60	18.90	13.86 (16J + 2K) 16.38 (8J + 6K)
6 (24)	Two	15.12	22.68	20.16 (8J + 8K) 17.64 (16J + 4K)
7 (28)	Two	17.64	26.46	23.94 (8J + 10K) 21.42 (16J + 6K)
8 (32)	Two	20.16	30.24	27.72 (8J + 12K) 25.20 (16J + 8K)
9 (36)	Three	22.68	34.02	31.50 (8J + 12K + 4J) 28.98 (16J + 10K) 32.76 (16K + 4J)
10 (40)	Three	25.20	37.80	32.76 (8J + 12K + 8J) 32.76 (16J + 12K) 35.28 (16K + 8J)
11 (44)	Three	27.72	41.58	35.28 (8J + 12K + 12J) 36.54 (16J + 14K) 37.80 (16K + 12J)
12 (48)	Three	30.24	45.36	37.80 (8J + 12K + 16J) 40.32 (16J + 16K) 40.32 (16K + 16J)
13 (52)	Four	32.76	49.14	40.32 (8J + 12K + 20J) 44.10 (16J + 18K) 42.84 (16K + 20J)
14 (56)	Four	35.28	52.92	42.84 (8J + 12K + 24J) 47.88 (16J + 20K) 45.36 (16K + 24J)
15 (60)	Four	37.80	56.70	45.36 (8J + 12K + 28J) 51.66 (16J + 22K) 47.88 (16K + 28J)
16 (64)	Four	40.32	60.48	47.88 (8J + 12K + 32J) 55.44 (16J + 24K) 50.40 (16K + 32J)

* Volumes are presented in the order of their addressed priorities.

1.2 Operator Responsibilities

The operator's responsibilities in regard to the 3890-2 are minimal. The following list identifies each of these tasks.

1. The operator must comply with all safety precautions discussed in paragraph 1.3.
2. The operator must be familiar with the subsystem emergency power shutdown procedure.
3. The operator should be familiar with the switches and indicators on the operator control panels.
4. If the subsystem is in local mode (see Section 2), the operator must use the switches on the operator control panels to power the subsystem up and down.
5. If so chartered, the operator must regularly back up the data stored on all 3890 volumes.
6. If the cabinet is smudged, the operator should clean the cover with glass cleaner and a disposable wiper. Do not spray the glass cleaner directly on the equipment.

1.3 Safety Precautions

All personnel working in the computer facility **must** observe the following precautions in regard to the 3890-2 subsystem.

1. Know your fire protection system. If total CO_2 flooding or halon is used, know the warning signal and escape routes.
2. Perform an emergency power shutdown if hazardous conditions occur.
3. Do **not** remove the cabinet covers for any reason.
4. If the covers have been removed by a CE during a service call, do **not** touch the unit. When near the unit, pay special heed to the following warning stickers.

This symbol indicates that the component in question contains uninsulated voltages that can cause electrical shock. **Avoid** any contact with the component; serious personal injury can result.

This symbol indicates that the CE should refer to the installation or maintenance manual before attempting to service the component in question. **Always** observe this restriction and avoid contact with the component.

This symbol indicates that the component in question contains the main grounding point for the subsystem. This grounding point **must** remain attached unless the subsystem has been disconnected from the facility power source for maintenance. The operator should avoid this area.

Heed all warnings, cautions, or danger labels applied to the surface of an exposed component of the equipment.

5. Do not impede cabinet airflow in any way.
6. Do not lean on the cabinets.
7. Do not lean objects against the cabinets.
8. Do not rest anything on the top of the cabinets.
9. Do not eat, drink, or smoke near the equipment. Observe all other site restrictions.
10. Ensure that every visitor to the facility is aware of these safety precautions and complies with them at all times.

Section 2
Control Panel and Power Sequencing

2.1 General Discussion

The 3890-2 subsystem is equipped with a complete set of controls that govern subsystem power and interface activities; these controls are located on two panels mounted in easily accessible areas on the front of the 3898-2 cluster control unit. This section furnishes a complete description of the operator control panels and their use during power sequencing. Among the items discussed are the functional organization of the control panels, the actions initiated by each control panel switch, and the significance of each indicator. Section 2 also presents, for the J-type module and the K-type module, the physical drive layout in relationship to the control panel switches. Additionally, this section guides the system operator through a control panel-initiated power up, power down, and emergency power down. Before reviewing the body of Section 2, the reader should note that the 3890-2 subsystem functions in either local or remote operating mode as described in the following paragraph; the selection of the operating mode affects the use of the control panel.

2.2 Local Mode and Remote Mode

The 3890-2 subsystem provides the customer with a choice of two operating modes: local mode and remote mode. Under local mode, the user manages all subsystem power functions and enables/disables all subsystem interfaces from the 3898-2 operator control panels. In remote mode, the user initiates all power activities from the host system via specific operations; while this mode is activated, many of the operator panel power switches will be overridden by the host and, therefore, rendered inoperative. In choosing which of these modes will govern the subsystem, the customer must carefully consider such issues as general system usage, subsystem accessibility, operator availability, etc. Once the operating mode has been selected, the CE will set the subsystem's internal controls appropriately; these controls are not available for general access. The operator should make a mental note of which mode is active for a given subsystem so that appropriate control procedures can be developed.

Note: *Because remote mode power sequences and commands can vary from CPU to CPU, the remainder of this section will be primarily devoted to local mode functions.*

2.3 Operator Control Panels

The cluster control unit provides two panels of switches and indicators which allow the system operator to manage all of the storage paths and attached disk modules from one convenient location. Each panel provides the controls and indicators for all drives (volumes) in the subsystem and two storage paths. The control panel itself comprises two subpanels — the operator panel and the maintenance panel.

The operator panel provides the customer with four control functions: subsystem management, SP management, channel interface management, and device (or volume) interface management. All operator panel switches and indicators are fully visible to the user; each panel is illustrated in Figure 2-1.

The maintenance panel furnishes a series of control functions activated during subsystem installation and troubleshooting. Because the maintenance panel is intended for CE use only, the panel lies inside the cabinet and cannot be accessed by the operator. The ensuing discussion introduces the switches and indicators available on the operator control panels and defines their use. To help familiarize the reader with the organization of the panels, this presentation has been divided according to the four functional categories mentioned in the preceding paragraph. As an additional reference, the discussion outlines the relationship between the control panel and the disk volumes.

> ***Note:*** *Maintenance panel functions are not utilized by the customer and are, therefore, omitted from this manual. Reference data on the maintenance panel is provided in the 3890-2 Maintenance Manual (3890-2.20-xx).*

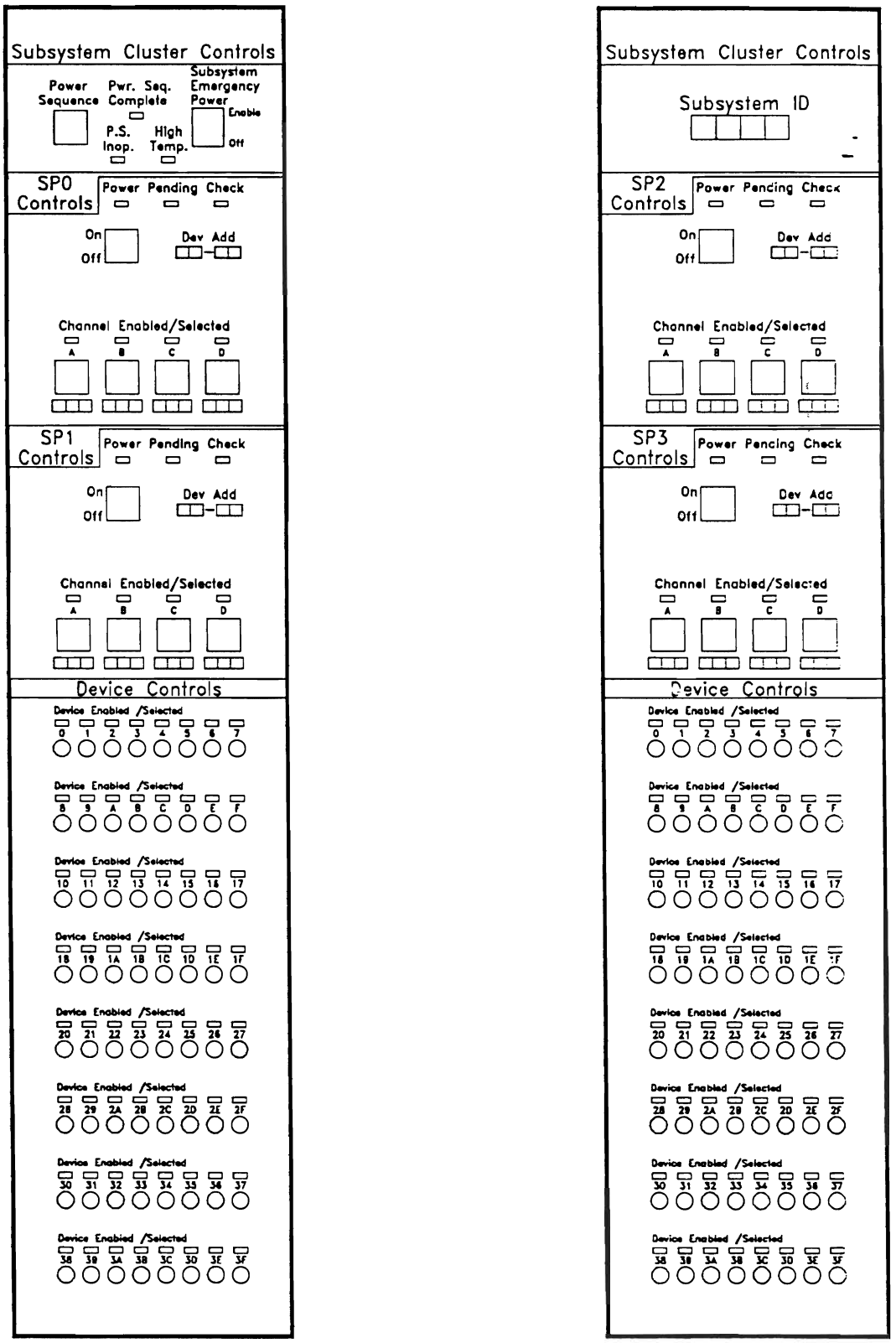


Figure 2-1. Subsystem Operator Control Panels

2.3.1 Subsystem Management Switches and Indicators (Figure 2-2)

Subsystem Emergency Power Switch — This lever switch acts as the emergency power off (EPO) control for the subsystem. In the Enable (up) position, this switch allows power to pass from the wall outlet to the ac input assemblies and, subsequently, to the power sequencing unit (PSU), storage paths (SPs), and drives. When pushed down to the Off position, this switch immediately trips the main ac input assembly circuit breakers, thus halting ac power flow from the ac input assemblies to the subsystem. The operator should note that the subsystem cannot be powered up until the circuit breakers have been reset by a Memorex Telex CE.

> ***Note:*** *The detection of some overtemperature conditions will result in subsystem power shutdown. This type of shutdown is identical to the EPO sequence initiated by the Subsystem Emergency Power switch and requires CE intervention to correct.*

Power Sequence Switch — If operating the subsystem in local mode, this momentary lever switch controls power to the SPs and the drives. When pressed upward, this switch signals the PSU to begin the power-up sequence for the storage paths (providing the SP's power switch is on) and the drives. When pressed downward, this switch inhibits the flow of power to the SPs and the drive string.

If operating the subsystem in remote mode, the Power Sequence switch has no control for powering up but will power down the units.

Power Sequence Complete Indicator — This LED lights when power is applied to all drives; the drives power up at 10-second intervals starting with Drive 0. The power-up sequence may be initiated via the Power Sequence switch (local mode) or from the host system (remote mode).

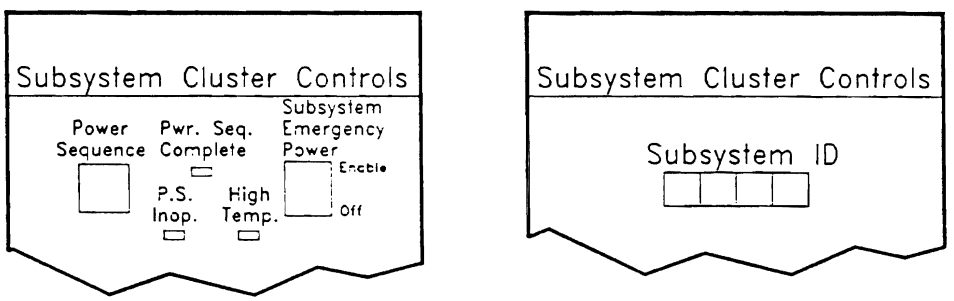


Figure 2-2. Subsystem Management Switches and Indicators

P.S. Inop. Indicator — This LED lights when the PSU microcode detects any error in the power control subsystem or when any of several subsystem power supplies has failed. Since the subsystem is designed to minimize the impact of power faults through the use of backup supplies, the LED does not typically indicate that the subsystem has halted operations. However, the operator should contact the CE immediately. This measure minimizes the risk of downtime in the event that the backup power supply also experiences a problem.

High Temp. Indicator — This LED lights when one or more of the drives or logic gates experiences a high temperature condition. The High Temp. LED also remains on for most overtemperature conditions although, as already noted, some overtemperature conditions will result in a subsystem power shutdown as well. A high temperature condition may be isolated to the failing area via a power system diagnostic function. High temperature conditions are reported as a warning only. However, the operator is encouraged to contact the CE as soon as possible to ensure that the condition is quickly remedied. The operator should note that an overtemperature condition will result in a shutdown of that part of the subsystem. This could be the drive, a storage path, or the whole subsystem.

Subsystem ID — On the right-hand panel, Subsystem ID is an area reserved for the CE to apply an adhesive label which indicates the subsystem identifier.

2.3.2 SP Management Switches and Indicators (Figure 2-3)

SP Power Switches (one per SP) — These lever switches furnish SP power control. Assuming that the Emergency Power switch is enabled and that the unit has been told to power on, the SP Power switch, when set to On, sequences power to the associated SP. If set to Off, the switch inhibits power to the SP.

SP Power Indicators (one per SP) — These LEDs light when the corresponding SP has been powered up via the SP Power switch (local mode) or from the computer system (remote mode). The LED in question lights approximately two seconds after the associated SP Power switch is set or remote power-up occurs. This indicator may turn off during certain maintenance procedures.

SP Pending Indicators (one per SP) — These LEDs light whenever the SP awaits acceptance of status bytes by the channel or response to a retry requested for a drive experiencing certain errors.

SP Check Indicators (one per SP) — These LEDs illuminate when the associated SP experiences a Check-1 error. Additionally, these indicators flash four times when the internal power-up diagnostic series completes successfully. If an SP Check indicator lights and remains lit, the corresponding SP is inoperative.

Device Address — This area of the panel allows the CE to apply an adhesive label to the surface of the panel which defines the device (volume) address range accessible to the storage paths.

2.3.3 Channel Interface Management Switches and Indicators

The locations of these switches and indicators on the operator control panels are shown in Figure 2-3.

Channel Enabled/Selected Indicators (one per channel for each SP) — These dual colored LEDs illuminate in green whenever the associated channel interface is logically enabled. These LEDs light in yellow whenever the channel in question selects the SP.

Channel Enabled/Selected Switches (one per channel for each SP) — These lever switches, in the enabled (up) position, activate the specified channel for the SP in question if that channel is physically installed. When set to the disable (down) position, these switches inhibit communication between the specified channel and the SP.

The area beneath these switches identifies positions reserved for the CE to apply an adhesive label which defines either the logical address or the channel path identifier (CHPID) for each SP.

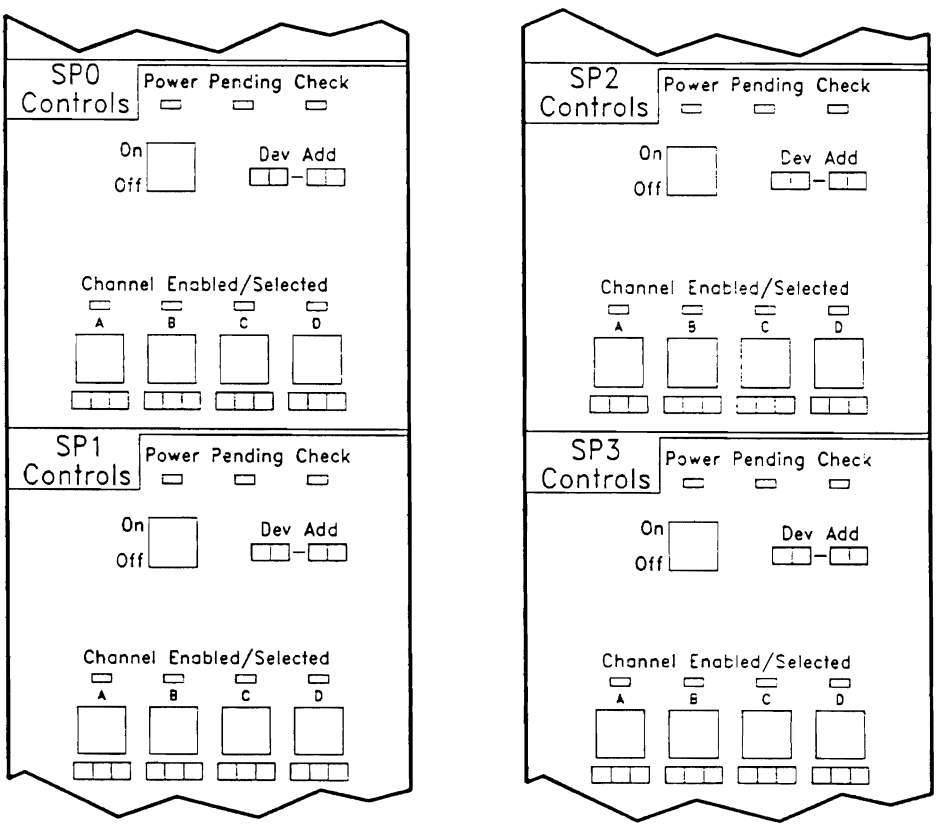


Figure 2-3. SP and Channel Interface Management Switches and Indicators

2.3.4 Device Interface Management Switches and Indicators (Figure 2-4)

Device Enabled/Selected Switches (on each panel, one per volume) — These lever switches are duplicated on each operator control panel as shown in Figure 2-4. For the device interface to be enabled for **all** storage paths, the associated switch on **both** operator control panels must be in the up position; if the associated switch is enabled on only one control panel, only the storage paths controlled by that panel can access the associated volume. Similarly, **either** switch in the down position inhibits communication with the associated volume for the two storage paths managed by that panel. When both switches associated with a volume are down, the device interface is disabled for all storage paths.

Device Enabled/Selected Indicators (on each panel, one per volume) — These dual colored LEDs light in green whenever the associated device interface is logically enabled. These LEDs illuminate in yellow whenever the corresponding volume is selected for command execution.

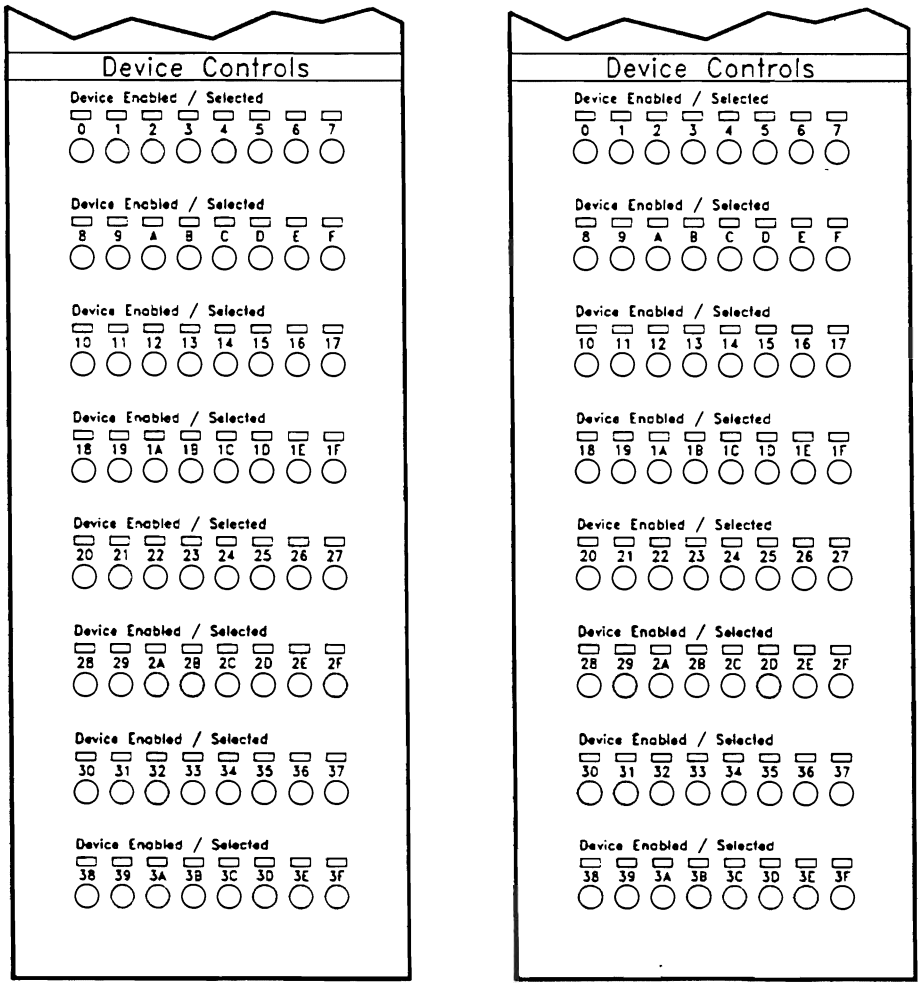
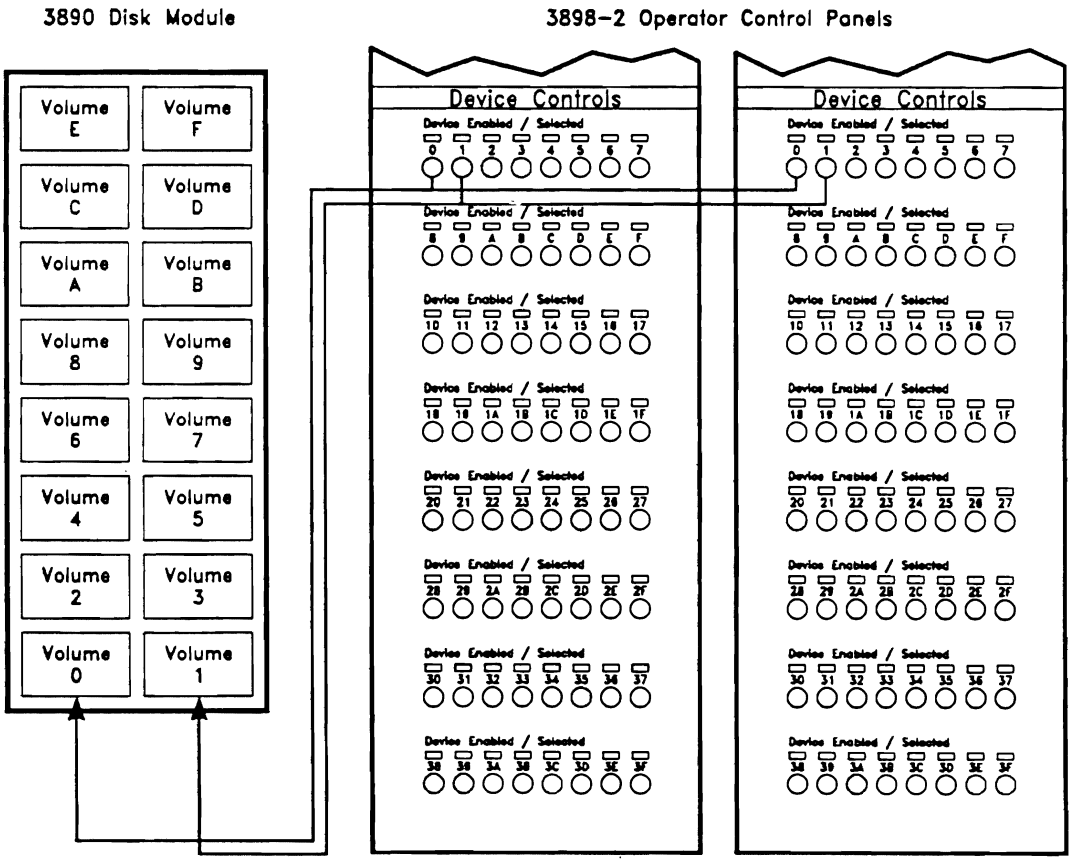


Figure 2-4. Device Interface Management Switches and Indicators

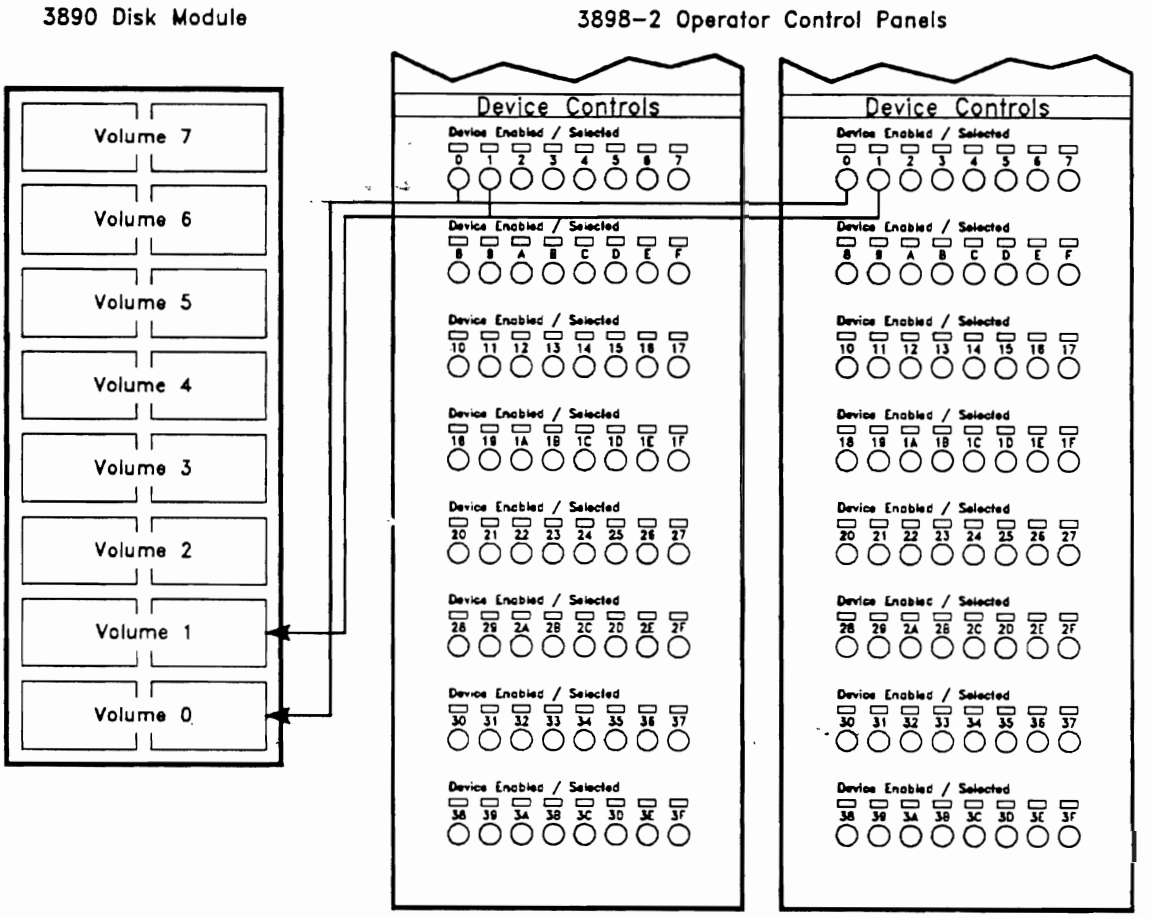
2.3.5 Device Layout

The device interface sections of each control panel provide controls for a maximum configuration of four J-type disk modules (i.e., 64 addressable units). As an aid to the operator, Figures 2-5 and 2-6 illustrate the relationship of the device interface controls with specific drives in the subsystem. Figure 2-5 furnishes the layout for the J-type module and Figure 2-6 covers the K-type module. In the case of a maximum configuration, the 3898-2 provides one Device Enabled/Selected switch per J-type volume and all Device Enabled/Selected switches are assigned. In K-type, intermixed versions, or smaller configurations, fewer volumes are addressable; therefore, a number of the Device Enabled/Selected switches are not connected. When reviewing Figures 2-5 and 2-6, the operator should recall that one volume is equivalent to one disk drive in a J-type configuration. However, for the K-type configuration, one volume is equivalent to two drives. Intermixed versions contain varying storage increments of both types.



Note: All volume/switch connections follow the pattern shown for Drives 0 and 1. These connections have been omitted from the drawing for simplicity.

Figure 2-5. J-Type Disk Module Device Layout



Note: All volume/switch connections follow the pattern shown for Drives 0 and 1. These connections have been omitted from the drawing for simplicity.

Figure 2-6. K-Type Disk Module Device Layout

2.4 Power Sequencing

As mentioned, subsystem power sequencing may be initiated from the operator control panel or the CPU. Since the topic of power sequencing is an important one, the user should acquire a solid background on the subject. In this light, the following paragraphs present an overview of power sequencing for the subsystem. The material summarized in this discussion includes a typical power-up, a typical power-down, and an emergency power-down sequence. Because the remote mode power sequences and commands can differ from CPU to CPU, this discussion covers local mode powering only.

Note: *The following discussion is not intended to provide detailed information on power sequence signal activity or timing.*

2.4.1 Typical Power-up Sequence

The following steps present an overview of the basic power-up sequence as initiated in local mode.

1. At the operator panel, the user sets the Power Sequence switch to the Up position.
2. The PSU powers up Drive 0, the Drive 0 power supply, and the Drive 0 fan.
3. Drive 0 begins disk rotation.
4. At 10-second intervals, each of the remaining drives receives power, sequences up, and begins disk rotation.

Note: *After all of the drives have begun powering up, the Power Sequence Complete LED lights. If desired, the operator may perform the remainder of the power-up sequence before this LED illuminates.*

5. At each of the control panels, the user sets the Power switches to the On positions for each of the storage paths (SP0 and SP1 on the left panel, and SP2 and SP3 on the right panel).
6. The PSU powers up the SP logic gate fans and the SP power supplies.
7. After approximately two seconds, each of the SP Power LEDs light.
8. The subsystem initiates the power-up (hardcore) diagnostic routines.
9. As the diagnostics execute, each of the SP Check LEDs brightly flash four times.
10. After the fourth flash, the user may set the Channel Enabled/Selected and Device Enabled/Selected switches to their enabled (up) positions as appropriate to the channel configuration.

Important

The Device Enabled/Selected switch for the device (volume) must be in its up position on both panels for the device (volume) to be enabled for all storage paths.

2.4.2 Typical Power-down Sequence

The following steps present an overview of the basic power-down sequence as initiated in local mode.

1. At the control panels, the user sets all Device Enabled/Selected and Channel Enabled/Selected switches to the off (down) position.
2. The user sets all SP Power switches to their Off positions.
3. The PSU inhibits power flow to the SP logic gate fans and the SP power supplies.
4. The SP Power LEDs extinguish.
5. The user sets the Power Sequence switch to the Down position.
6. The Power Sequence Complete LED extinguishes.
7. The PSU inhibits power flow to the individual drives, the drive power supplies, and the drive fans.
8. Each disk drive slows and halts disk rotation.

2.4.3 Emergency Power-down Sequence

The emergency power-down sequence is only executed under conditions that pose a hazard to personnel or to the equipment. Because customer data (specifically write data) can be lost as a result of an emergency shutdown, this sequence should be carefully considered before it is initiated. However, once an operator has chosen to perform an emergency shutdown, it should be completed as quickly as possible. Emergency power-downs may be initiated from the operator panel (local mode and remote mode). For any emergency power-down, the customer must schedule a CE service call prior to attempting a subsystem power-up. The following discussion covers the emergency power-down sequence.

1. At the operator panel, the user toggles the Subsystem Emergency Power switch to the Off position.
2. The 3898-2 trips the internal circuit breakers located in the ac input assemblies.
3. The 3898-2 immediately inhibits the flow of ac power past the ac input assemblies (i.e., to both the 3898-2 PSU and any attached 3890 disk modules).
4. The flow of dc power ceases and all operator panel LEDs extinguish.

Section 3
Commands

3.1 Introduction

For the programmer's convenience, this section furnishes reference material on the range of subsystem commands performed during execution of I/O operations. These commands are known as Channel Command Words (CCWs) and are listed in Table 3-1. Table 3-1 is followed by a detailed description of each command, its parameters, and any chaining requirements. The command descriptions include specialized information on device type where applicable. As an additional reference, Table 3-2 defines Bits 32–39 of the Channel Status Word (CSW); this area is known as the Unit Status and can prove useful when interpreting the channel commands.

Table 3-1. Commands

Command Word Grouping	Command Word	I/O Command (Hex) Code	Paragraph Number
Control Commands	Define Extent	63	3.2
	Locate Record	47	3.3
	No-Operation (No-Op)	03	3.4
	Seek	07	3.5
	Seek Cylinder	0B	3.6
	Seek Head	1B	3.7
	Space Count	0F	3.8
	Recalibrate	13	3.9
	Restore	17	3.10
	Set File Mask	1F	3.11
	Set Sector	23	3.12
	Set Path Group ID	AF	3.13
	Suspend Multipath Reconnection	5B	3.14
	Transfer-in-Channel*	x8	3.15

continued

* The x is not significant except in XA mode. Data addresses should not exceed storage capacity.

Table 3-1. Commands (continued)

Command Word Grouping	Command Word	I/O Command (Hex) Code	Paragraph Number
Sense Commands	Sense	04	3.16
	Sense ID	E4	3.17
	Sense Path Group ID	34	3.18
	Sense Subsystem Status	54	3.19
	Device Reserve	B4	3.20
	Device Release	94	3.21
	Unconditional Reserve	14	3.22
	Read Device Characteristics	64	3.23
	Read and Reset Buffered Log	A4	3.24
	Reset Allegiance	44	3.25
Read Commands	Read Data	06	3.26
	Multitrack Read Data	86	3.26
	Read Key and Data	0E	3.27
	Multitrack Read Key and Data	8E	3.27
	Read Count, Key, and Data	1E	3.28
	Multitrack Read Count, Key, and Data	9E	3.28
	Read Multiple Count, Key, and Data	5E	3.29
	Read Record Zero (R0)	16	3.30
	Multitrack Read Record Zero (R0)	96	3.30
	Read Count	12	3.31
	Multitrack Read Count	92	3.31
	Read Home Address	1A	3.32
	Multitrack Read Home Address	9A	3.32
	Read IPL	02	3.33
	Read Sector	22	3.34
	Read Track	DE	3.35
Write Commands	Write Data	05	3.36
	Write Key and Data	0D	3.37
	Write Count, Key, and Data	1D	3.38
	Write Record Zero (R0)	15	3.39
	Write Home Address	19	3.40
	Erase	11	3.41
	Write Count, Key, and Data Next Track	9D	3.42
	Write Update Data	85	3.43
	Write Update Key and Data	8D	3.44

continued

Table 3-1. Commands (continued)

Command Word Grouping	Command Word	I/O Command (Hex) Code	Paragraph Number
Search Commands	Search Home Address Equal	39	3.45
	Multitrack Search Home Address Equal	B9	3.45
	Search ID Equal	31	3.46
	Multitrack Search ID Equal	B1	3.46
	Search ID High	51	3.47
	Multitrack Search ID High	D1	3.47
	Search ID Equal or High	71	3.48
	Multitrack Search ID Equal or High	F1	3.48
	Search Key Equal	29	3.49
	Multitrack Search Key Equal	A9	3.49
	Search Key High	49	3.50
	Multitrack Search Key High	C9	3.50
	Search Key Equal or High	69	3.51
	Multitrack Search Key Equal or High	E9	3.51
Diagnostic Commands	Diagnostic Write Home Address	09	3.52
	Diagnostic Sense/Read	C4	3.53
	Diagnostic Read Home Address	0A	3.54
	Diagnostic Control	F3	3.55
	Diagnostic Write	73	3.56
	Perform Subsystem Function	27	3.57
	Read Configuration Data	FA	3.58
	Read Subsystem Data	3E	3.59
	Test I/O*	00	3.60

* Automatically generated by the channel when it requires status information.

Table 3-2. CSW Unit Status Definitions

Bit in CSW	Bit in Unit Status	Function
32	0	Attention — Indicates a Ready status when set in conjunction with Bits 5 and 7.
33	1	Status Modifier — When set, this bit: (a) Modifies Bit 6 (Unit Check) to indicate than an unusual condition exists and that the last command must be retried. (b) Modifies Bit 3 (Busy) to indicate that the SP is Busy. (c) Modifies Bit 5 (Device End) to indicate that the sequence of commands is modified (the next CCW has been skipped). This condition generally results from successful completion of a Search command.
34	2	Control Unit End — When set, this bit indicates that the SP status changed from Busy to available.
35	3	Busy — When this bit is set and Bit 1 is reset, this bit indicates that the drive or volume is Busy. If Bit 1 is also set, this bit indicates that the SP is Busy.
36	4	Channel End — When set, this bit indicates completion of data or control information transfer to or from the channel.
37	5	Device End — When set, this bit indicates completion of a device operation. If this bit, Bit 0, and Bit 7 are set, the drive or volume is now at a Ready status and can accept communication from the SP.
38	6	Unit Check — When set, this bit indicates that the SP or device has detected a malfunction.
39	7	Unit Exception — When set, this bit indicates the detection of an end of file on the addressed track during either 1) a *Read Record 0*, *Read IPL*, or *Read Count, Key*, and *Data*, or, 2) a *Write Key and Data* or *Write Data*. This bit can indicate a Ready status if Bits 0 and 5 are also set.

3.2 Define Extent

Command Code 63 (hex)

This command transfers 16 bytes of parameters from the channel to the 3898-2. These parameters define limits on operations that follow, and provide a block size value for the channel program. The command resets orientation in the storage path.

Parameters of the *Define Extent* command are listed below. The significance of bit settings within each of the 16 bytes is defined in Table 3-3.

Byte	Parameter
0	Mask byte
1	Global attributes
2–3	Block size in bytes
4–5	Not used
6	Reserved — must be 0
7	Not used
8–11	Beginning of extent address
12–15	End of extent address

The 3898-2 verifies the parameters and reserved fields in sequence from Byte 0 through Byte 15 except that it checks Byte 1, bits 0 and 1 first to determine that the mode is correctly set to indicate Extended Count, Key, and Data (ECKD). If an exception condition is encountered in more than one parameter, only the first exception is reported. If the channel sends fewer than 16 bytes, the command is rejected with Unit Check ending status and subsequent sense data reports Command Reject with Format 0, Message 3 (CCW Count is less than required).

Channel End and Device End are presented after parameters are transferred and checked for validity. If parameters are invalid, Channel End, Device End, and Unit Check are presented.

Data Address — Defines main storage location of first parameter byte.

Flags — Used at the programmer's discretion.

Count — 16

Initial Status — Normally 0.

Chaining Requirements — If *Define Extent* is used in the domain of a *Locate Record* command, it is terminated with Unit Check ending status. Subsequent sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence). In addition, the command is rejected with the same ending status and sense data if preceded in the same CCW by a *Define Extent*, *Space Count*, or *Set File Mask* command.

Table 3-3. Define Extent Parameters

Byte	Significance	Bit	Setting	Significance
0	Mask Byte Function			*Write Control* — Specifies the types of write operations allowed in the CCW.
		0–1	00	*Write Home Address* and *Write Record 0* inhibited. Permits all other Write operations.
			01	All Write commands inhibited.
			10	Only Update Write operations permitted.
			11	All Write operations permitted.
		2		Reserved.
			0	Must be set to 0. If not 0, *Define Extent* is rejected with Unit Check and sense data reporting Command Reject with Format 0, Message 4 (Data Value not as required).
		3–4		*Seek Control* — Specifies which Seek commands and multitrack head switching operations are permitted outside the domain of a *Locate Record* command. These constraints have no effect on CCWs operating within the domain of a *Locate Record* command.
			00	All Seek commands and the *Recalibrate* command permitted.
			01	Only *Seek Cylinder* and *Seek Head* commands permitted.
			10	Only *Seek Head* commands permitted.
			11	All Seek commands and multitrack operations inhibited.
		5–6		*Access Authorization* — Specifies an access authorization for channel program operations.
			00	Normal Authorization. Inhibits access to diagnostic or device support tracks.
			01	Device Support Authorization. Allows access to all tracks in all track groups. Also, these channel programs can perform all Locate Record operations. Certain operations require this access authorization.

continued

Table 3-3. Define Extent Parameters (continued)

Byte	Significance	Bit	Setting	Significance
0	Mask Byte Function		10	Diagnostic Authorization. Allows access to the diagnostic tracks only. This authorization inhibits the retry and correction of Data Checks unless the check occurs in a Home Address field.
			11	Device Support Authorization with Inhibit Data Check Retry and Correction. Except during execution of a *Read Home Address* or *Diagnostic Read Home Address* command, the 3898-2 inhibits retry and correction of any data checks encountered while sending data to the channel by one of the read commands. This authorization does not inhibit retry and correction if reading Home Address or during a search operation.
		7		*PCI (Program-Controlled Interrupt) Fetch Mode* — Specifies whether or not the mode is active.
			0	PCI Fetch Mode inactive
			1	PCI Fetch Mode active. In this mode, the channel program terminates with Unit Check ending status whenever channel command retry recovers from an exception condition for a read command and at least one byte of data has transferred to the channel. *Note: Host programs using PCI Fetch Mode access data being read before ending status is presented for the read command. If the retry results in sending valid data to the channel, the host program still needs to be notified that it may have accessed data that may not have been valid. Therefore, if the PCI Fetch Mode bit in the file mask is set to 1, the read command that was retried is teminated with Unit Check ending status. If retry was unsuccessful, the channel program is terminated with Unit Check status.*

continued

Table 3-3. Define Extent Parameters (continued)

Byte	Significance	Bit	Setting	Significance
1	Global Attributes			*Global Attributes Function* — Defines global attributes of operations in the channel program.
		0-1	11	ECKD Mode. The 3898-2 supports only the ECKD mode of the *Define Extent* command. Any other setting in these bits causes termination and Unit Check ending status. Sense information reports Command Reject with Format 0, Message 4 (Data Value not as required).
		2	0	Count, Key, and Data (CKD) Conversion Mode. Not used in this subsystem and bit 2 must be 0.
		3-5	000	Subsytem Operation Mode. Not used in this subsystem and must be 000 to indicate that the subsystem operates as a normal cache replacement.
		6-7	00	Cache Operations. Not used in this subsytem and must be set to 00.
2–3	Block Size			*Block Size in bytes* — Specifies a value defining the average number of bytes for a single record in the channel program. A zero value is also valid; it is interpreted as specifying the maximum record length that the device supports. Maximum record length is 8 (Count field) plus the value in Bytes 44 and 45 of the *Read Device Characteristics* command (i.e., BB7C). When a subsequent *Locate Record* command contains a update write type of operation without a transfer length factor, the block-size value must be the exact data length (or sum of key and data lengths if the Key field is to be updated) of each record in the *Locate Record* domain (see *Locate Record Operation Codes, Write Data*). The correct block-size value depends on the area of the record that is to be sent. The value must be one of the following: • the data length (DL) • the key and data lengths (KL + DL) • the sum of KL and DL plus 8 (for the Count field). If the block size value exceeds the device's track capacity (maximum Record 0 length), the command is rejected with Unit Check ending status. Sense information reports Command Reject with Format 0, Message 4 (Data Value not as required). The 3898-2 does not check the block-size value except as necessary for update writes.

continued

Table 3-3. Define Extent Parameters (continued)

Byte	Significance	Bit	Setting	Significance
4–5				*Cache Fast Write Identifier* — Not used by this subsystem and must be '00'
6				Reserved. Must contain zeros. If not zeros, the command is rejected with Unit Check ending status. Sense information reports Command Reject with Format 0, Message 4.
7				Not Used. This byte is ignored.
8–11	Beginning Extent Address			*Beginning of Extent Address* — Specifies the address (CCHH format) of the first track in the extent. CCHH must be a valid track address for the device, specifically: • If the mask byte setting is Normal Authorization (bits 5 and 6 are '00'), CCHH must be a primary or an alternate track address. • If the mask byte setting is Diagnostic Authorization (bits 5 and 6 are '10'), CCHH must be a diagnostic track address. • If the mask byte setting is Device Support authorization (bits 5 and 6 are '01' or '11'), CCHH can be any valid track address. If the address is invalid, the Define Extent command is rejected with Unit Check ending status. Sense information reports Command Reject with Format 0, Message 4.
12–15	Ending Extent Address			*End of Extent Address* — Specifies the address (CCHH format) of the last track in the extent. CCHH must be equal to or greater than the value specified for the "beginning extent address" in Bytes 8 through 11. The track address must be valid for the access authorization specified. If CCHH is an invalid track address, the command is rejected with Unit Check ending status. Sense information reports Command Reject with Format 0, Message 4. *Note: With Device Support Authorization, device support tracks and other tracks can be accessed within the same extent. Because write operations are inhibited on such tracks, any access to a device support track in the same chain will be write-inhibited.*

3.3 Locate Record

Command Code 47 (hex)

This command transfers 16 bytes of parameters from main storage to the SP. The *Locate Record* command resets orientation in the SP and establishes the orientation state specified by the Orientation and Operation byte parameter before any data transfers to or from the device. The parameters specify the type of operation, location, and number of records to be processed. The SP verifies the parameters and reserved fields in order from Byte 0 through Byte 15, except that it checks bits 2 through 7 of Byte 0 first. If the SP detects an exception condition in more than one parameter, it reports only the first exception.

The SP presents Channel End status after it validates the parameters. It presents Device End after it completes track and sector positioning of the device.

The *Locate Record* parameters, shown in Figure 3-1, are as follows:

Byte	Name and Significance
0	**Orientation and Operation Byte** — Specifies the orientation to establish when track access is complete. It also specifies the operations to perform in the *Locate Record* domain. (Further details on the specifications for this parameter byte are provided in Table 3-4 and *Section 3.3.2, Locate Record Operation Codes.*)
1	**Auxiliary Byte** — Used for verifying optional fields in the *Locate Record* parameter list. • Bit 0 = 0. Bytes 14 and 15 are not used. • Bit 0 = 1. Bytes 14 and 15 contain the transfer length factor that overrides the block size parameter in the Define Extent command. • Bits 1 - 6. These bits are reserved and must be zeros. • Bit 7 = 0. No *Read Count* as the last CCW in the *Locate Record* domain. • Bit 7 = 1. Specifies that the last data transfer CCW in the *Locate Record* domain is a *Read Count* CCW. The record it processes is included in the count of records to be processed as specified by the count parameter, Byte 3. The *Read Count* CCW suffix is only valid for a *Locate Record* command that specifies *Write Data* (01) or *Read* (16) operations. If this suffix is specified for any other code, the command is rejected with Unit Check ending status. Sense bytes contain Command Reject with Format 0, Message 4 (Data Value not as required).
2	**Reserved.** Must always contain zeros. If not, the command is rejected with Unit Check ending status (sense bytes report Format 0, Message 4).

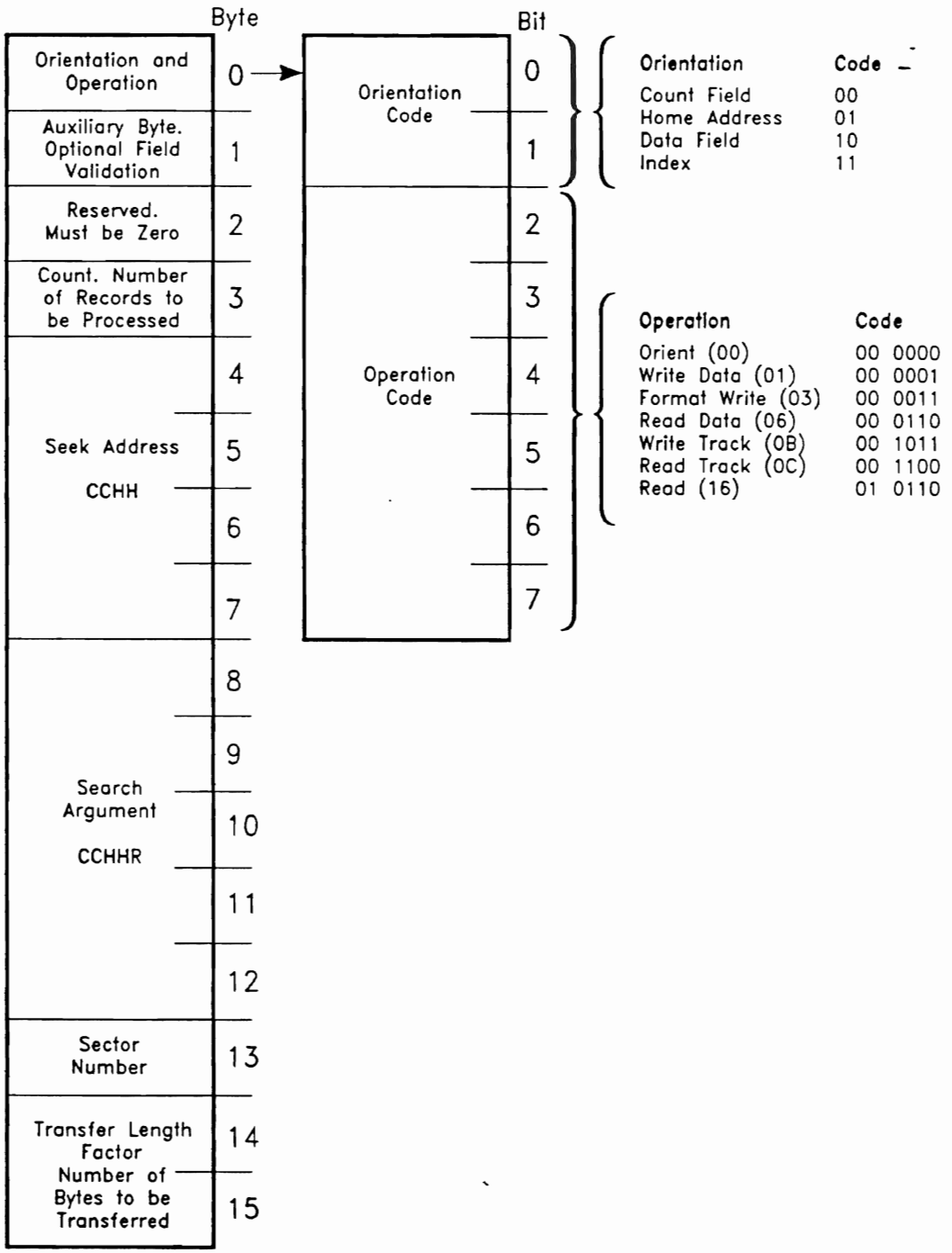


Figure 3-1. Locate Record Command Parameters

Byte	Name and Significance
3	**Count** — Determines the domain of the *Locate Record* command. This parameter specifies the number of records or tracks to be processed by the data transfer command following *Locate Record*. Specific use of this parameter depends on the operation code in Byte 0 (see *3.3.2, Locate Record Operation Codes*). When the operation code is Orient (00), the count must be zero. For any other valid operation code, the count must not be zero. If *Read Count CCW* suffix is set to '1' (Byte 1, bit 7), the count must be greater than 1. If the count parameter is not valid, the command is rejected with Unit Check ending status (sense bytes report Format 0, Message 4). ***Note:*** *The 3898-2 does not present an error if the count parameter is greater than the number of records or tracks transferred before the end of chain in a Locate Record domain. However, the user should ensure that the count parameter is correct to avoid possible Unit Check conditions that an incorrect count might cause in future product.*
4–7	**Seek Address** — Bytes 4 through 7 specify a seek address (CCHH) and must be a valid address for the device. If the seek address is not valid, the command is rejected with Unit Check ending status (sense bytes report Format 0, Message 4). If the seek address is not in the extent defined in the preceding *Define Extent* command, the command is terminated with Unit Check ending status (File Protected in Sense Byte 1).
8–12	**Search Argument** — Bytes 8 through 12 contain the search argument (CCHHR) for the *Locate Record* search operation. When the operation (Byte 0) does not need orientation to a specific record, Bytes 8 through 12 are ignored and no search takes place. When Home Address orientation is specified, Byte 12 (R) is ignored.
13	**Sector Number** — Contains a sector number value. This value represents the actuator's angular position on the track at which the SP should establish orientation. The sector number must be valid for the device. If invalid, the command is rejected with Unit Check ending status (sense information reports Command Reject with Format 0, Message 4. An 'FF' value is valid and specifies that sector positioning is not to be performed before the SP establishes channel connection and device orientation.
14–15	**Transfer Length Factor** — The SP uses the transfer length factor to determine the number of data bytes to request from the channel for each *Write* CCW that follows a *Locate Record* specifying *Write Data* (01). The product of the value in Bytes 14 and 15 and the count parameter determine the total number of bytes to be sent in a *Locate Record* domain specifying *Format Write* (03), *Write Track* (0B), or *Read* (16).

The SP does not retain the transfer length factor after the end of the *Locate Record* domain. If a transfer length factor is not specified in the *Locate Record* command, the SP uses the block size parameter value in the *Define Extent* command for the data transfer length.

Unit Check ending status with the sense bytes containing Command Reject with Format 0, Message 4, occurs for the following situations:

- Byte 1, bit 0 = 0 and Bytes 14 and 15 do not contain zeros.
- Byte 1, bit 0 = 1 and Bytes 14 and 15 do not contain a transfer length factor. Bytes 14 and 15 must not be a zero value.
- The transfer length factor is more than the value specified, or implied, in the block size parameter of the Define Extent command.

3.3.1 Locate Record Command Processing

Each operation specifies the number and type of data transfer commands that the *Locate Record* domain expects and allows. If any other command sequence is in the *Locate Record* domain, that command is rejected with Unit Check ending status. Subsequent sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

When operating with the device, the Orientation and Search operations specified in the *Locate Record* parameters are performed during the read, write, or search CCW that follows the *Locate Record* command. Any exception condition that is encountered during these operations is reported in the ending status for that CCW.

Search Operation — Certain operations need orientation to a specific record or record area before data transfer starts. Orientation is performed by a Search operation which occurs as follows, depending on the orientation required:

- When specifying Index orientation, the device positions to Index and no Search operation is performed.
- When specifying Count or Data field orientation (Byte 0, bits 0 and 1 are '00' or '10'), the search argument value (Bytes 8 through 12) is compared with the Count's record ID field in each record, including Record 0, after the device is at the proper sector. When the Search operation starts, it continues until an equal comparison occurs, or until all record IDs on the track have been processed. If no record ID on the track compares equal to the search argument, the command is terminated with Unit Check ending status (No Record Found).
- If the seek address parameter (Bytes 4 through 7) specifies a track that is marked defective (Home Address flag byte, bits 6 and 7 are '10'), the Search operation is performed on the assigned alternate track. If an alternate track is not assigned, or if an invalid alternate track is assigned, the command is rejected with Unit Check status (Improper Alternate Track Pointer).
- When specifying Home Address orientation (Byte 0, bits 0 and 1 are '01'), the search argument value (Bytes 8 through 11 only) is compared with the track address field in the Home Address. If the track does not have a Home Address, the command is terminated with Unit Check ending status. In this case, the sense

information is Data Check for the specific device. If the comparison is unequal, the command is terminated with Unit Check status (No Record Found).

- The Home Address Search operation is performed on the track specified in the seek address parameter, even if that track is marked defective.

3.3.2 Locate Record Operation Codes

Orient (00) — With the Orient code specified, the SP positions the device according to the seek, search, and sector values indicated in Bytes 4 through 13 (see Table 3-4). Bytes 3, 14, and 15 must be set to zero. When the device is at the proper sector, the Search operation occurs as described in *3.3.1, Locate Record Command Processing*.

The *Locate Record* domain ends when the track accessing or Search operation completes. Although the Search operation is performed after the following CCW is received, the following CCW operates outside the domain of the *Locate Record* command.

Write Data (01) — This operation code prepares the SP to updata write to one or more consecutive user data records. The search argument parameter specifies the first record and the count parameter defines the number of records to update. This operation can also update the Key and/or Data fields of Record 0 when the search argument is set equal to the record ID in the Record 0 Count field.

The SP uses the seek address and sector number parameters to start track access. When track access completes, the Search operation specified by the search argument and the orientation modifiers (Byte 0, bits 0 and 1) is performed.

If bit 7 = 0 in the Auxiliary byte parameter (Byte 1), the *Locate Record* command must be followed by the number of *Update Write* commands specified by the count parameter. If bit 7 = 1, the *Locate Record* command must be followed by one fewer number of *Update Write* commands than the value specified in the count parameter. Also, the last *Update Write* command must be followed by a multitrack *Read Count* command.

Table 3-4. Locate Record Command Parameters

Operation Code Bits 2 - 7 Byte 0	Byte 1	Byte 2	Byte 3	Bytes 4–7	Bytes 8–12	Byte 13	Bytes 14–15
00 0000 Orient	Zero	Zero	Zero	Seek address	Search argument	Sector number	Zero
00 0001 Write Data	Bit 0 = 1 Bits 1 - 6 = 0 Bit 7 = 0 Bit 7 = 1	Zero	Count. No. of records to Process Count = 1	Seek address	Search argument	Sector number	Transfer length factor. No. of bytes to transfer
00 0011 Format Write	Zero	Zero	Count. No. of Format cmds. to process	Seek address	Search argument	Sector number	Transfer length factor. No. of bytes to transfer
00 0110 Read Data	Zero	Zero	Count. No. of records to process	Seek address	Search argument	Sector number	Zero
00 1011 Write Track	Bit 0 = 1 Bits 1 - 7 = 0	Zero	Count. No. of records to process	Seek address	Search argument	Sector number (Ignored)	Transfer length factor. No. of bytes to transfer
00 1100 Read Track	Zero	Zero	Count. No. of tracks to process	Seek address	Search argument	Sector number	Zero
01 0110 Read	Bit 0 = 1 Bits 1 - 6 = 0 Bit 7 = 0 Bit 7 = 1	Zero	Count. No. of records to Process Count = 1	Seek address	Search argument	Sector number	Transfer length factor. No. of bytes to transfer

When count orientation is specified and one *Update Write* command is required, the *Locate Record* command must be followed by one of the following commands:

- *Write Data*
- *Write Update Data*
- *Write Key and Data*
- *Write Update Key and Data.*

When more than one *Update Write* command is required, the *Locate Record* command must be followed by either a *Write Update Data* or *Write Update Key and Data* command. These two commands cannot both occur in the same *Locate Record* domain.

Similarly, when data orientation is specified, the *Locate Record* command must be followed by either a *Write Update Data* or *Write Update Key and Data* command and they cannot both occur in the same *Locate Record* domain.

If a multitrack operation continues after the last record on a track, the SP advances to the next track and updates the first user data record on the next track. If the next track does not a contain a user data record, the command is terminated with Unit Check ending status (No Record Found).

The transfer length factor, or the block size parameter value from a *Define Extent* command if the transfer length factor is not specified, must be equal to the actual record length of the records to update. The actual record length is either the data length (DL) or the sum of the key and data lengths (KL + DL), depending on whether the following write commands specify *Write Data* or *Write Key and Data*. If the actual length of any record to update differs from the transfer length factor (or block size) value, the command is terminated with Unit Check ending status (Invalid Track Format) and the record is not updated.

If Bytes 4 through 7 specify a track in the device support address space, the command is rejected with Unit Check status (Command Reject, Format 0, Message 4).

If the file mask inhibits all Write operations (bits 0 and 1 are '01'), the command is rejected with Unit Check ending status (Command Reject, Format 0, Message 2).

In the *Locate Record* command, if *Read Count CCW* suffix (Byte 1, bit 7) is set to '1', the count must be 1. If this condition is not met, the command is rejected with Unit Check status (Command Reject with Format 0, Message 4).

If end of track occurs in a record, the command is terminated with Unit Check status (Invalid Track Format).

Format Write (03) — This operation code prepares the SP to format one or more consecutive user data records. The count parameter defines the number of records to format. This operation can also format Home Address and/or Record 0 when Index or Home Address orientation is specified. After the last record is written on each track, the remaining portion of each track is erased.

The SP uses the seek address and sector number parameters to start track access. If specifying Index or Home Address orientation, a sector value of zero is used for track access — the sector number parameter (Byte 13) is not used. When track access completes, the SP orients the device according to the orientation modifiers (Byte 0, bits 0 and 1).

The *Locate Record* command must be followed by the number of Format Write commands that are specified in the count parameter. Command sequence requirements for these commands are as follows:

- When specifying Index orientation, *Locate Record* can only be followed by a *Diagnostic Write Home Address* command.
- When specifying Home Address orientation, only a *Write Home Address* or *Write Record 0* command can follow *Locate Record*.

- When specifying Count field orientation, only a *Write Count, Key, and Data* command can follow *Locate Record.*
- A *Diagnostic Write Home Address* or *Write Home Address* command can only be followed by a *Write Record 0* command.
- A *Write Record 0* command can only be followed by a *Write Count, Key, and Data* command. If the *Write Record 0* command assigned an alternate track, no Formal Write command can follow.
- A *Write Count, Key, and Data* command can only be followed by another *Write Count, Key, and Data* command or a *Write Count, Key, and Data Next Track* command.
- A *Write Count, Key, and Data Next Track* command can only be followed by a *Write Count, Key, and Data* or a *Write Count, Key, and Data Next Track* command.

If a Format Write command in the domain of a *Locate Record* command does not meet the sequence requirements, the command is rejected with Unit Check ending status (Invalid Sequence).

If Home Address orientation is specified (Byte 0, bits 0 and 1 are '01'), the file mask must permit writing Home Address and Record 0. If Index orientation is specified (Byte 0, bits 0 and 1 are '11'), the file mask must permit writing Home Address and Record 0 and must also specify Device Support Authorization. If the file mask does not permit writing Home Address and Record 0 (bits 0 and 1 are not '11'), the command is rejected with Unit Check status. The sense bytes contain Command Reject with Format 0, Message 4 (Data Value not as required). If the file mask does not specify Device Support Authorization (bits 5 and 6 are not '01' or '11'), the command is rejected with Unit Check status and the sense bytes report the same error information.

If Count field orientation is specified (Byte 0, bits 0 and 1 are '00'), the file mask must allow Format Write operations. If the file mask does not permit Format Write operations (bits 0 and 1 are '01' or '10'), the command is rejected with Unit Check status. The sense data reports Command Reject with Format 0, Message 2 (Invalid Sequence).

If Bytes 4 through 7 (seek address) select a track in the device support address space, the command is rejected with Unit Check status. Sense data contains Command Reject with Format 0, Message 4.

If the SP determines that there is not enough space on the track to write a record, the command is terminated with Unit Check ending status (Invalid Track Format). A partial record may be left on the track. The residual count in the CSW will not necessarily show the amount by which the record length exceeded the available space on the track.

Read Data (06) — With this code specification, the SP sends one or more records (Home Address and Record 0 can be included) to the channel. The count parameter specifies the number of records to read.

The SP uses the seek address and sector number parameters to start track access. When track access completes, the Search operation specified by the search argument and the orientation modifiers (Byte 0, bits 0 and 1) is performed.

The *Locate Record* command must be followed by the number of read CCWs needed to process the number of records specified by the count parameter. The *Read Multiple Count, Key, and Data, Read Track, Diagnostic Read Home Address,* and *Read IPL* commands are not valid in the domain of a *Locate Record* command. Any other sequence of Read commands is valid. If the *Locate Record* domain contains an invalid command sequence, the invalid command is rejected with Unit Check ending status. The sense information contains Command Reject with Format 0, Message 2 (Invalid Sequence).

If the operation continues after the last record on a track has been read, processing continues according to the state of bit 0 (multitrack) in the Read command code. If end of track occurs in a record, the command is terminated with Unit Check ending status (Invalid Track Format).

Write Track (0B) — This operation prepares the SP to Update Write the Record 0 Data field and format the rest of the track. The number of records to format is one less than the value specified in the count parameter. After the last record is written on the track, the remaining portion of the track is erased. If the value in the count parameter is '1', only the Data portion of Record 0 is written and the remaining portion of the track is erased.

The SP uses the seek address parameter and a sector value of zero to start track access; the sector number parameter (Byte 13) is not used. If the seek address parameter (Bytes 4 through 7) specifies a track that is marked defective (Home Address flag byte, bits 6 and 7 are '10'), the operation is performed on the assigned alternate track. If an alternate track is not assigned, or if an invalid alternate track is assigned, the command is rejected with Unit Check status (Improper Alternate Track Pointer).

When track access completes, the SP is oriented to Home Address. It then compares the search argument with the record ID field in the Record 0 Count field. If no Home Address is on the track, the command is terminated with Unit Check ending status. The sense data reports Unit Check for the specific device.

If Bytes 4 through 7 specify a track in the device support address space, the command is rejected with Unit Check status (Command Reject, Format 0, Message 4).

If the file mask inhibits Format Write operations (bits 0 and 1 are '01'or '10'), the command is rejected with Unit Check ending status (Command Reject, Format 0, Message 2).

Unit Check ending status with the sense bytes reporting No Record Found occurs if:

- The track does not contain a Record 0
- The search argument compares unequal to the record ID field in the Record 0 Count field.

The *Locate Record* command must be followed by one *Write Data* and a number of *Write Count, Key, and Data* commands that is one less than the value in the count parameter, with the following exceptions:

- An *Erase* command can be substituted for the last or only *Write Count, Key, and Data* command in the *Locate Record* domain.

- If the count parameter contains a value of 1, no *Erase* or *Write Count, Key, and Data* commands can follow the update data command. In this case, the remaining portion of the track is erased after the Record 0 Data field is updated.

If a command in the Locate Record domain does not meet the sequence requirements, that command is rejected with Unit Check ending status. The sense data contains Command Reject with Format 0, Message 2.

The Record 0 data length must be 8 bytes. If not 8 bytes, the command is terminated with Unit Check ending status (Invalid Track Format).

Unit Check ending status, with sense bytes reporting Invalid Track Format also occurs if the SP determines that there is not enough space on the track to write a record. A partial record may be left on the track.

When Invalid Track Format occurs, the CSW residual count may not show the amount by which the record length exceeded the available space on the track.

Read Track (0C) — With this code specification, the SP sends all records from one or more consecutively addressed tracks to the channel. Data transfer starts with the first record (including Record 0) following orientation specified by the search argument and orientation modifier parameters. The count parameter specifies the number of tracks to use.

The SP uses the seek address and sector number parameters to start track access. When track access completes, the Search operation specified by the search argument and the orientation modifiers (Byte 0, bits 0 and 1) is performed.

The *Locate Record* command must be followed by the number of *Read Track* commands specified by the count parameter. Any other command series in the domain of the *Locate Record* command is invalid and that command is rejected with Unit Check ending status. The sense information contains Command Reject with Format 0, Message 2 (Invalid Sequence).

The first *Read Track* command in the *Locate Record* domain causes the SP to orient to the first Count field (including Record 0) following the orientation that the *Locate Record* command establishes. The SP then sends each Count, Key, and Data field on the track until the end of the track is reached.

The second and subsequent *Read Track* commands cause the SP to:

1. Go to the next track.
2. Orient to Home Address.
3. Send each Count, Key, and Data field (including Record 0) on the track until the end of the track is reached.

After the last record on the track transfers, a pseudo Count field of 8 bytes of 'FF' transfers to the channel. If the track does not have any records to transfer, the *Read Track* command sends only the pseudo Count field.

Note: The pseudo Count field can be used to locate the end of the track image character string in the host system's main storage. The Read Track operation is for dump/restore utility programs to send all records from one or more tracks without first having to determine the number of records on each track and their formats.

The operation can start with a record other than Record 0. Therefore, a Read Track operation that had an exception condition can be restarted at the point of interruption, rather than at the start of the track.

If end of track occurs in a record read by a *Read Track* command that follows the *Locate Record* command, the command is terminated with Unit Check ending status (Invalid Track Format).

Read (16) — This operation code prepares the SP to send one or more consecutive user data records to the channel. The count parameter defines the number of records to read. This operation can also be used to read Home Address and/or Record 0 when Index or Home Address orientation is specified.

The SP uses the seek address and sector number parameters to start track access. If specifying Index or Home Address orientation, a sector value of zero is used for track access — the sector number parameter (Byte 13) is not used. When track access completes, the SP orients the device according to the orientation modifiers (Byte 0, bits 0 and 1). If specifying Home Address orientation and no Home Address is on the track, the command is terminated with Unit Check ending status. The sense data reports Unit Check for the specific device.

If specifying Index or Home Address orientation (Byte 0, bits 0 and 1 are '01' or '11'), a *Read Count* command cannot immediately follow the *Locate Record* domain, or the command is rejected with Unit Check ending status. The sense data reports Command Reject with Format 0, Message 4 (Data Value not as required).

The *Locate Record* command must be followed by a sufficient number of Read commands (other than *Read Track, Read IPL,* or *Read Multiple Count, Key, and Data*) to read the number of records that are specified in the count parameter. If, in the Auxiliary byte parameter (Byte 1), bit 7 is set to '1', the last operation in the *Locate Record* domain must be a multitrack *Read Count* operation. Command sequence requirements for Read commands following a *Locate Record* command are as follows.

- All Read Commands except *Diagnostic Read Home Address, Read Home Address,* and *Read Record 0* must be multitrack commands.
- When specifying Index orientation, *Locate Record* can only be followed by a *Diagnostic Read Home Address* or a *Read Home Address* command.
- When specifying Home Address orientation, only a *Read Record 0* command can follow *Locate Record.*
- When specifying Count field orientation, only a *Read Data* or *Read Key and Data* command can follow *Locate Record.*

- When specifying Data field orientation, only a *Read Count, Read Key and Data, Read Data,* or *Read Count, Key, and Data* command can follow a *Locate Record* command.
- A *Diagnostic Read Home Address* or *Read Home Address* command can only be followed by a *Read Record 0* command.
- A *Read Record 0, Read Count, Read Key and Data, Read Data,* or a *Read Count, Key, and Data* command can only be followed by a *Read Count, Read Key and Data, Read Data,* or *Read Count, Key, and Data* command.

If a command in the domain of a *Locate Record* command does not meet the sequence requirements, the command is rejected with Unit Check ending status (Invalid Sequence).

If the operation continues after reading the last record on a track, the SP advances to the next track and reads the first user data record on the next track. If the next track does not have a user data record, the command is terminated with Unit Check ending status (No Record Found). If end of track occurs in a record, the command is terminated with Unit Check ending status (Invalid Track Format).

Data Address — Defines the main storage location of the first byte of parameters.

Flags — Used at the programmer's discretion.

Count — 16. The SP expects 16 bytes of parameters. If the channel sends fewer than 16 bytes, the command is rejected with Unit Check ending status. The sense data contains Command Reject with Format 0, Message 3 (CCW Count less than required).

Chaining Requirements — The *Locate Record* command is terminated with Unit Check ending status and the sense data reporting Command Reject with Format 0, Message 2 (Invalid Sequence) if it is encountered as follows:

- This *Locate Record* command is in the domain of another *Locate Record* command.
- A *Define Extent* or *Read IPL* command does not precede this command in the same channel program.

3.4 No-Operation (No-Op)

Command Code 03 (hex)

This command is an immediate command resulting in no action at the drive level.

Data Address — Not validated, but should not exceed addressing capacity.

Flags — SLI flag must be set to avoid an incorrect length indication.

Count — Must not be 0. A 0 count sets the Program Check bit (Bit 42) in the CSW.

Initial Status — Channel End and Device End are posted. Because *No-Op* is an immediate command, initial status is treated as ending status.

Special Requirements — This command is not valid within the domain of a Locate Record command. If inadvertently used with *Locate Record*, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

Indiscriminate usage must be avoided because this command resets orientation information. The reset results in a bypass of all or part of the record. For example:

A *No-Op* between *Read Count* and *Read Data* for record n may cause the Data field of record n to be skipped and the Data field of record n+1 to be read.

A *No-Op* between a command that reads the Data field of one record and a command that must process the Count field of the next record (record n) may result in an overshoot of record n. The Count field of record n+1 may then be processed.

3.5 Seek

Command Code 07 (hex) — See paragraph 3.7.

3.6 Seek Cylinder

Command Code 0B (hex) — See paragraph 3.7.

3.7 Seek Head

Command Code 1B (hex)

Any one of the three Seek commands transfers the six-byte seek address to the SP. The *Seek* command and *Seek Cylinder* command are identical. Either command prompts the SP to select the drive and set the cylinder/track seek parameters for the drive. The *Seek Head* command also selects both the drive and the head, but accessing is not performed. These remarks summarize the operational differences and similarities for the three Seek commands. The description which follows applies to any Seek command. Limitations on address byte values for all devices are listed in Table 3-5.

Given that cylinder switching is required, access motion is not initiated until a *Set Sector*, *Read*, *Search*, *Write*, *Diagnostic Read Home Address*, *Diagnostic Write Home Address*, or *Space Count* command is received in the chain or, if the CCW chain ends and the next command is one of the above. In the event that more than one Seek command is received in a CCW chain prior to the start of cylinder switching, only the last Seek command will result in a cylinder switch.

Table 3-5. Address Byte Content and Specifications

Seek Address	J-Type Volume Values	K-Type Volume Values
Bytes 0, 1, and 4	0	0
Bytes 2 and 3 (Cylinder Address)	885	2655
Byte 5 (Head Address) must not exceed	14	14
CE Cylinder	886*	2658*
Surface Analysis Cylinders	–2, –3 (FFFE, FFFD)*	2667–2669*
Alternate Cylinders	885	2655

* CE use only.

For all three Seek commands, Channel End and Device End are presented after the seek address has been transferred. Any Seek command resets track orientation information in the SP.

Data Address — Defines main storage location of the seek address.

Seek Address — Checked for both validity and correct parity by the SP. The format for the seek address is 00CCHH (where CC is a cylinder address and HH is a head address). If an invalid seek address is noted, the command is not executed and the ending status shows Unit Check, Channel End, and Device End. In this case, a Command Reject (Invalid Argument) will be posted for the next *Sense* command.

Flags — Used at the programmer's discretion.

Count — Must be 6. If the count is less than 6, command does not execute and the ending status shows Unit Check, Channel End, and Device End. A Command Reject will be posted for the next *Sense* command. If the count is greater than 6, only the first 6 bytes are transferred.

Initial Status — Normally 0.

Special Requirements — The *Seek* and *Seek Cylinder* commands do not require a preceding CCW. However, the programmer must precede the *Seek Head* command with a command that establishes cylinder orientation. If *Set File Mask* is issued prior to any Seek command, the file mask must be set to allow seeks. If the file mask is not so set, Unit Check is presented in the ending status. For Seek operations against a CE or surface analysis cylinder, the Seek command must be preceded by a Set File Mask command with file mask bits 5 and 6 set as indicated (see Table 3-6).

The Seek commands are not valid within the domain of a *Locate Record* command. If one is inadvertently used with *Locate Record*, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

If the *Seek Cylinder* command was preceded in the channel program by a *Define Extent* command, and the seek address is outside the defined extent, the command is terminated with Unit Check ending status (File Protected).

3.8 Space Count

Command Code 0F (hex)

This command is used to space over an unreadable Count field in order to recover the Key and Data field of the record in question. For the *Space Count* command, three bytes of data are transferred to the SP. They are interpreted as the key length (first byte) and data length (last two bytes) of the record to be recovered. These three bytes of data define the key and data length that could not be read from the Count field. If the number of bytes is less than three, the remaining count is set to 0.

Data Address — Defines main storage location of the key and data lengths of record to be recovered.

Flags — Used at the programmer's discretion.

Count — Must be 3 to transfer the requisite 3 bytes. If the count is less than 3, the specified number of bytes is transferred and the value of the untransferred bytes is assumed to be 0. Should the count exceed 3, only 3 bytes are transferred. Since the channel requires a nonzero value in the CCW count, SLI bit 34 should be set to avoid an incorrect length condition.

In the event that the specified number of bytes to be transferred is less than 3, subsequent *Read Data* and *Read Key* and *Data* commands may result in Unit Exception. A *Read Count*, *Key*, and *Data* command may result in Data Check.

Chaining Requirements — Cannot be chained from a *Format Write* or *Erase* command. Must not be followed by a *Write, Erase*, *Device Release*, *Device Reserve*, *Read IPL*, or *Set File Mask*, in the same chain. Violation of these requirements will cause Channel End, Device End, and Unit Check to be presented to the channel.

If this command is not preceded in the command chain by a *Seek*, *Seek Cylinder*, *Locate Record*, *Read IPL*, or *Recalibrate*, the command is rejected with Unit Check ending status. The sense information contains Command Reject with Format 0, Message 2 (Invalid Sequence).

If the *Space Count* command is chained from a *Space Count*, *Read, Write*, or *Search* command, it points to the start of the next Count field, the Count field is bypassed, key and data length are received from the channel, the End-of-Count field internal orientation indicator is set, and Channel End and Device End are presented to the channel.

If the *Space Count* command is not chained from a *Space Count*, *Read*, *Write*, or *Search* command, it searches for Index, clocks through the Home Address, spaces over the Record 0 Count field, receives the key and data length from the channel, sets the End-of-Count field internal orientation indicator, and presents Channel End and Device End to the channel.

This command is not valid within the domain of a *Locate Record* command. If inadvertently used with Locate Record, the command is rejected with Unit Check ending

status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

A faulty Record 0 Count field will be bypassed by a *Space Count* command followed by a *Read Key and Data* command. Record 1 can be read by *Space Count* followed by a *Read Data* or a *Read Key and Data* command. This function can prove useful when attempting to recover the Record 0 Data field content or the whole of Record 1.

The Key and Data fields of the record ($n \neq 0$) may be recovered by the following: *Set Sector, Search ID (Record n –1), Transfer-in-Channel –8,* Space Count,** Read Key and Data.*

Record n+1 may be recovered by: *Set Sector, Search ID* (Record n –1), *Transfer-in-Channel –8,* Space Count,** Read Count, Key, and Data.*

* Transfers to the address of Transfer-in-Channel less 8.

** Correct key and data lengths must be stated. Unpredictable results, loss of track orientation, or Data Checks may result from requesting an incorrect length.

3.9 Recalibrate

Command Code 13 (hex)

This command returns the track address to cylinder 0, head 0 from any setting. Channel End is presented as the ending status. Device End is presented when the recalibrate has executed.

Data Address — Not checked for validity, but should not exceed addressing capacity.

Flags — SLI flag must be set to avoid an incorrect length indication.

Count — Must not be 0. A 0 count sets the Program Check bit (Bit 42) in the CSW.

Initial Status — Normally 0. Not processed as an immediate command.

Special Requirements — This command must be preceded by a *Set File Mask* command that allows seeks.

If the *Recalibrate* command was preceded in the CCW by a *Define Extent* command, and cylinder 0, head 0 is not in the defined extent, the command is terminated with Unit Check ending status (File Protected).

This command is not valid within the domain of a *Locate Record* command. If inadvertently used with *Locate Record*, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

3.10 Restore

Command Code 17 (hex)

This command is primarily used for compatibility with other direct-access storage devices. It is effectively a *No-Op* command and results in loss of orientation. Channel End and Device End immediately follow initial status.

Data Address — Not checked for validity, but must not exceed addressing capacity.

Flags — SLI flag must be set to avoid an incorrect length indication.

Count — Must not be 0. A 0 count sets the Program Check bit (Bit 42) in the CSW.

Initial Status — Normally 0.

Special Requirements — This command is not valid within the domain of a *Locate Record* command. If inadvertently used with *Locate Record*, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

3.11 Set File Mask

Command Code 1F (hex)

The command provides data protection by inhibiting/permitting execution of a particular Seek and Write command. These functions are accomplished by setting bits of a valid mask byte to predefined values, as indicated in Table 3-6.

Bit 2 of the mask byte must be 0. If bit 2 is not 0, the mask byte is considered to be invalid, a Unit Check condition (CSW bit 38) is generated and Channel End and Device End are presented in the ending status. A subsequent *Sense* command indicates Command Reject.

Commands that violate the file mask are not executed. In these cases, Unit Check is presented in the ending status, and either Command Reject (if a Write command) or File Protected (if a Seek command) is indicated by a subsequent *Sense* command. Multitrack operations that violate the file mask result in Unit Check and File Protected.

The file mask defaults to '00' at the beginning of every CCW chain. A Start I/O instruction issued without a *Set File Mask* command permits Seek and Write commands (except *Write Home Address*, *Diagnostic Write Home Address*, and *Write Record Zero*).

Channel End and Device End are posted after the mask byte is transferred.

Data Address — Defines main storage location of mask byte.

Flags — Used at the programmer's discretion.

Count — 1.

Initial Status — Normally 0.

Special Requirements — Unit Check ending status with sense information reporting Command Reject with Format 0, Message 2 (Invalid Sequence) occurs if the command:

- is in a *Locate Record* domain
- was preceded in the same CCW by a *Define Extent* or another Set File Mask command.

Chaining Requirements — *Device Reserve* or *Device Release* must not follow *Set File Mask*; if these commands appear in the same command chain, they must precede *Set File Mask*. *Space Count* must not precede the *Set File Mask* command.

Table 3-6. File Mask Bit Definitions

Bit	Bit Setting	Definition
0 and 1	00	*Write Home Address* and *Write Record 0* are inhibited.
	01	All Write commands are inhibited.
	10	All Format Write commands are inhibited.
	11	All Write commands are permitted.
2	0	This bit is always set to zero. If this bit is not zero, the device presents a Unit Check in the CSW.
3 and 4	00	All Seek commands are permitted.
	01	*Seek Cylinder* and *Seek Head* are permitted (no full Seek).
	10	*Seek Head* is permitted.
	11	All *Seek* commands and head switches are inhibited.
5 and 6*	00	CE and surface analysis cylinder access is inhibited unless the channel program in question has special authorization.
	01**	CE and surface analysis cylinder access is permitted.
	10	For channel programs with Diagnostic Authorization, access to the CE cylinder is permitted and all other access is inhibited. These restrictions apply regardless of whether the Seek operation precedes or follows the *Set File Mask* command.
	11**	CE and surface analysis cylinder access is permitted. However, retry and ECC correction are only initiated for Read commands (except *Read Home Address* and *Diagnostic Read Home Address*) and Search commands.
7	0	PCI Fetch Mode is inhibited.
	1	PCI Fetch Mode is permitted. If a Data Check occurs and a command retry recovers the data, PCI Fetch Mode presents a Unit Check.

* Use of bits 5 and 6 should be restricted to maintenance sessions. Any other use of these bits may yield unpredictable results.

** This specification is not allowed for a 3890 device.

3.12 Set Sector

Command Code 23 (hex)

This command transfers a sector number (one byte) from main storage to the SP; valid sector numbers are 0–221 and 255. During a *Set Sector*, the drive signals the SP when the requested sector number is nearing the read/write head. The SP then signals the channel to proceed with the operation. If the channel does not respond, the SP waits for the next disk rotation to complete and renotifies the channel. This sequence continues until the channel responds. *Set Sector* is normally used on block multiplexer channels to eliminate the need to maintain channel and SP connection during rotational delays. Execution of *Set Sector* resets orientation information stored in the SP.

The sector number is checked by the SP. One of three conditions may result: valid sector number (0–221), the sector number is greater than 221 and less than 255, or the sector number = 255.

Sector Number between 0 and 221 — The SP presents Channel End. Device End is posted when the adjusted sector number is reached and the channel reconnects to continue the chain. If reconnection fails, the SP attempts reconnection during the next revolution.

Sector Number between 222 and 254 — Channel End, Device End, and Unit Check are presented in the ending status. The next *Sense* command posts a Command Reject.

Sector Number equals 255 — The command is handled as a *No-Op* command. The ending status shows Channel End and Device End. Track orientation is lost.

Data Address — Defines main storage location of desired sector number.

Flags — Used at the programmer's discretion.

Count — 1.

Chaining Requirements — The *Set Sector* command must be preceded in the command chain by a command that specifies, or implies, cylinder and head parameters. If this command is not preceded in the command chain by a *Seek*, *Seek Cylinder*, *Locate Record*, *Read IPL*, or *Recalibrate*, the command is rejected with Unit Check ending status. The sense information contains Command Reject with Format 0, Message 2 (Invalid Sequence).

Set Sector does not ensure positioning. To accurately position the head, the programmer must issue a Search command against the desired records. For multitrack search operations, the most effective sequence is *Set Sector* (0), *Read Home Address*, *Search* (Multitrack).

The *Set Sector* command is not valid within the domain of a *Locate Record* command. If inadvertently used with *Locate Record*, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

3.13 Set Path Group ID

Command Code AF (hex)

This command transfers path group identification information (12 bytes) from main storage to the SP. The path group ID defines the System Control Program (SCP) that manages a channel grouping. Once a path group ID for a device has been established, the device is reserved to those channels having a common ID. Extended Architecture (XA) computer systems provide block reconnections on the first available path which is a member of that established group. System reset will reset the device reservation. When a *Set Path Group ID* command is received by the SP, the ID is checked to see if a path group ID has been set for this channel since the last system reset. If not, the path group ID is accepted. Given that a path group ID has been set, the ID is compared. If the ID is not equal, the command is rejected. Channel End and Device End are presented after the command is executed.

The path group ID format is as follows:

Byte 0 — Function Control Byte

Bit 0=0	Single path mode (370 mode)
1	Multiple path mode (XA mode)
Bits 1–2=00	Establish group: Matching IDs (bytes 1–11) result in the SP forming groups for the addressed device for all channel paths with the same ID.
01	Disband group: A standalone path is established for the addressed device with every channel member of the path group that has the same ID. If a reservation existed for this channel group, it remains with this channel.
10	Resign from group: Issuing channel becomes a standalone channel. If the addressed device was reserved to the group, the reservationcontinues with the remianing members of this group.
11	Invalid
Bits 3–7	Must be zero.

Bytes 1–11 — SCP ID

These bytes identify the system control program (SCP) and must not be all zeros. An all-zero setting results in a Command Reject when the sense information is returned. Under MVS, the SCP consists of bytes 1–6 of the CPU ID (STIDP instruction). These bytes contain the CPU model version, serial number, and model number. Bytes 1–6 of the CPU ID are followed by the first five bytes of the time-of-day clock (STCK instruction) as stored shortly after IPL.

Data Address — Defines main storage location where the first byte of path group ID information is to be stored.

Flags — Used at the programmer's discretion.

Count — 12.

Initial Status — Normally 0.

Chaining Requirement — This command must be the only command in the chain.

Special Requirements — The SCP may not expand or contract a path group while a CCW chain is in progress for the group. Lost interrupts, misdirected interrupts, or other unpredictable consequences will result.

If a path group is expanded, all devices reserved to the original path group are reserved to the expanded group. When a path group with multiple paths is contracted, all devices reserved to the original group are reserved to the contracted group. In the event that a path group is disbanded, all devices reserved to the original group are reserved to the channel that executed the disband function.

When a system reset causes the path group ID for a channel to be reset, reserved devices will be released if the resetting channel is the only member of the group. Multiple channel reserved devices will remain reserved to the channels that did not execute the reset.

3.14 Suspend Multipath Reconnection

Command Code 5B (hex)

This command inhibits channel program execution against a path other than the path on which the command was received. This command is primarily used for fault isolation when operating in a multiple path mode. The use of this command does not affect the existing path groups or the state of device reserves. When the command is executed, the channel program is restricted to a single path until final status for the command chain is presented and accepted by the channel.

Channel End and Device End are presented after the command is executed.

Data Address — Not used.

Flags — Used at the programmer's discretion.

Count — Cannot be 0. A program check will be presented if count is 0.

Initial Status — Normally 0.

Special Requirements — This command is not valid within the domain of a *Locate Record* command. If inadvertently used with *Locate Record*, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

3.15 Transfer-in-Channel (TIC)

Command Code x8 (hex)

This command provides chaining capabilities for noncontiguous CCWs.

Data Address — Defines the main storage location of next CCW to be retrieved. Must not specify another TIC CCW.

Flags — Ignored.

Count — Ignored. (Only CCW that can have a 0 count.)

Chaining Requirement — TIC cannot be the first CCW specified by the channel address word. Command execution does not initiate I/O operations or signal any device. When chaining requirements are violated or an invalid data address (not on a double word boundary) is specified, a Program Check is presented (Bit 42 in the CSW).

3.16 Sense

Command Code 04 (hex)

This command transfers 32 bytes of sense information from the SP to the channel. This information describes Unit Check status, current status of the device that performed the operation, and system error recovery information.

Channel End and Device End are presented after sense bytes are transferred.

Data Address — Defines main storage location where first byte of sense data is to be stored.

Flags — Used at the programmer's discretion.

Count — 32.

Initial Status — 0.

Special Requirements — This command is not valid within the domain of a *Locate Record* command. If inadvertently used with *Locate Record*, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

A *Sense* command Unit Check should always accompany regardless of whether the sense information is used. This command resets track orientation information in the SP.

A standalone *Sense* command, issued during a contingent allegiance, causes the SP to send error data to the channel. The recommended error recovery procedures assume that the *Sense* command is the only command in a chain. If other commands are chained from the *Sense* command, the device may not accept them, which can cause unpredictable results.

Note: This command was formerly *Sense ID*.

3.17 Sense ID

Command Code E4 (hex)

This command transfers 12 bytes of sense information from the SP to the channel. This sense information describes controller and drive type (see chart below). Channel End and Device End are presented after sense bytes are transferred.

Track orientation information is reset after the execution of this command.

If the command is sent to a drive that is not ready, the drive type and model bytes (Bytes 4–6) contain zeros.

Data Address — Defines main storage location where first byte of sense data is to be stored.

Flags — Used at the programmer's discretion.

Count — 12.

Initial Status — Normally 0.

Special Requirement — This command is not valid within the domain of a *Locate Record* command. If inadvertently used with *Locate Record*, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

Drive Type		Controller			Device			Configuration Data				
Byte	0	1	2	3	4	5	6	7	8	9	10	11
J-Type	FF	39	90	C2	33	80	16	00	40	FA	01	00
K-Type	FF	39	90	C2	33	80	1E	00	40	FA	01	00

3.18 Sense Path Group ID

Command Code 34 (hex)

This command transfers path group ID information (12 bytes) from the SP to main storage.

The ID bytes are formatted as follows:

Byte 0 — Path State Byte

Bits 0–1 = 00 The SP has not executed a *Set Path Group ID* command on the channel since the last system reset.

01 Reserved.

10 The channel has a valid ID and the addressed device is not part of a group.

11 The channel has a valid ID for this device and the device is shared by a group.

Bits 2–3 = 00 The selected device is not presently reserved.

01 The selected device is not presently reserved but there is a contingent, or implicit allegiance, to another member of the path group (if one exists).

10 The selected device is reserved for another channel.

11 The selected device is reserved for this channel and for other members of the path group (if they exist).

Bit 4 = 0 Single path mode (370 mode)

1 Multiple path mode (XA mode)

Bits 5–7 Set to 0.

Bytes 1–11 — Path Group ID

These bytes contain the current path group ID associated with the channel path issuing the command. They will contain all zeros if no *Set Path Group ID* command has been issued by this channel since the last system reset. If there is a valid ID for this channel, it will be in this field.

Channel End and Device End are presented after the path group ID information has been transferred.

Data Address — Defines main storage location where the first byte of path group ID information is to be stored.

Flags — Used at the programmer's discretion.

Count — 12.

Initial Status — Normally 0.

Special Requirement — This command must be the only command in the chain.

3.19 Sense Subsystem Status

Command Code 54 (hex)

This command transfers the status of the subsystem (40 bytes) from the storage path to the channel. The transferred information describes the status of the 3890-2 subsystem and the addressed volume. After the transfer is complete, the SP posts Channel End and Device End as the ending status.

This command is accepted even if the device is not ready.

The status bytes and their significance are as follows:

Bytes	Significance
0	Set to zeros.
1	Device Unit Address of the channel program.
2	Reserved — must be set to zeros.
3	Number of Statistics Sets per Device — not used and set to zero.
4	Overall Caching Status — not applicable and set to zero.
5	Overall Nonvolatile Storage Status — not applicable and set to zero.
6–9	Reserved — must be set to zeros.
10–25	Cache Capacity information — not applicable and set to zeros.
26–27	Device Caching Status — not applicable and set to zeros.
28–36	Nonvolatile Storage Capacity and Device Status information — not applicable and set to zeros.
37	Reserved — must be set to zeros.
38–39	Subsystem Identifier (SSID) — Specifies the identifier for this subsystem.

Data Address — Defines the main storage location where the first byte of status is to be transferred.

Flags — Used at the programmer's discretion.

Count — 40. If the CCW count exceeds 40, only 40 bytes are sent. If the CCW count is less than 40, only the specified number of bytes are forwarded.

Initial Status — Normally 0.

Chaining Requirements — This command is not a valid command in the domain of a *Locate Record* command. Also, *Sense Subsystem Status* must be the first command in a chain or be chained directly from a *Read Device Characteristics*, a *Read Configuration Data*, or a *Suspend Multipath Reconnection* command. If chained directly from a *Suspend Multipath Reconnection* command, the *Suspend Multipath Reconnection* command must be the first command in the chain. If these requirements are not met, *Sense Subsystem Status* is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

In addition, if any command is chained from the *Sense Subsystem Status* command, that command is rejected. The Sense Subsystem Status operation is not affected by the rejected command.

3.20 Device Reserve

Command Code B4 (hex)

This command reserves the addressed drive for the path group issuing the command. Reservation is maintained until a *Device Release* for the channel (or any channel in the path group) is successfully executed. A System Reset resets reservation of the device to the resetting channel only. In addition, 32 bytes of sense information are transferred across the channel to main storage. Track orientation is reset after the execution of this command.

Channel End and Device End are presented after the 32 sense bytes are transferred.

Data Address — Defines main storage location where sense bytes are to be transferred.

Flags — Used at the programmer's discretion.

Count — 32.

Initial Status — Normally 0.

Special Requirements — *Device Reserve* must be the first command in the channel program. If preceded by any other command, the *Device Reserve* command is rejected with Unit Check ending status. The sense data reports Command Reject with Format 0, Message 2 (Invalid Sequence).

Device Reserve is an invalid command within the domain of a *Locate Record* command. If inadvertently used with *Locate Record*, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

3.21 Device Release

Command Code 94 (hex)

This command releases the drive address reserved for the path group. In addition, 32 bytes of sense information are transferred across the channel to main storage.

Channel End and Device End are presented after sense byte transfer.

Data Address — Defines main storage location where first byte of sense data is to be stored.

Flags — Used at the programmer's discretion.

Count — 32.

Initial Status — Normally 0.

Special Requirements — *Device Release* is rejected with Unit Check ending status if preceded in a channel program by a *Define Extent*, *Space Count*, or a *Set File Mask* command. Sense data contains Command Reject with Format 0, Message 2 (Invalid Sequence).

This command is not valid within the domain of a *Locate Record* command. If inadvertently used with *Locate Record*, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

3.22 Unconditional Reserve

Command Code 14 (hex)

This command provides all the functions of *Device Reserve* and also reserves the drive for an alternate path even if the drive is reserved or is in use through the original path. This command transfers 32 bytes of sense information to main storage via the channel. Channel End and Device End are presented after the 32 sense bytes are transferred. The *Unconditional Reserve* command resets track orientation in the SP. Command execution is halted if there is no response from the drive or if there is a Preselection Check.

When an *Unconditional Reserve* command is issued to a device not assigned to the channel, the following may occur on the unassigned system.

- If the device was reserved, the reservation is reset and the device becomes reserved to the channel that issued the *Unconditional Reserve* command.
- If the device is disconnected between chained commands, an interrupt will be lost.
- If the device is active when the command is executed, a recoverable Equipment Check will be presented.
- If the device is idle and not reserved, there is no effect.

If the system does not want the device reserved to the issuing path, it must issue a *Device Release* command. The *Device Release* command may be chained to the *Unconditional Reserve* command.

Data Address — Defines main storage location where first byte of sense data is to be stored.

Flags — Used at the programmer's discretion.

Count — 32.

Initial Status — Normally 0.

Special Requirements — The *Unconditional Reserve* command must be the first command in a chain.

This command is not valid within the domain of a *Locate Record* command. If inadvertently used with *Locate Record*, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

Unit Check ending status with the sense data containing Equipment Check with Format 3, Message F (Allegiance Terminated) is sent to the channel when one of the following conditions occurs:

- this command interrupts any I/O chain
- the channel had a reservation for this device without also having an active command chain. The next Start I/O will have Unit Check status pending.
- the channel had a Contingent Allegiance for the device and then sent a Sense command for that device after the *Unconditional Reserve* command was received. *Unconditional Reserve* resets Contingent Allegiance for the affected device for all paths.

3.23 Read Device Characteristics

Command Code 64 (hex)

This command transfers device characteristics information (up to 64 bytes) from the SP to the channel. The information transferred by this command defines the characteristics of the addressed device. Given that the addressed device is neither busy nor in the ready state, *Read Device Characteristics* does not execute and Unit Check is posted in the initial status. When executing normally, the SP posts Channel End and Device End after the data has been transferred.

The 64 bytes of device characteristics are as follows:

		Data In Hex	
Byte	Contents	3890-J-Type	3890-K-Type
00–01	Controller Type	3990	3990
02	Controller Model	C2	C2
03–04	Device Type	3380	3380
05	Device Model	16	1E
06–09	Device and Controller Features	D000 0003	D000 0003
10	Device Class Code	20	20
11	Device Type Code	0E	0E
12–13	Number of Primary Cylinders	0375	0A5F
14–15	Number of Tracks per Cylinder	000F	000F
16	Number of Sectors	DE	DE
17–19	Total Track Length Usable for Data Records	00BB60	00BB60
20–21	Length of Home Address and Record Zero	0440	0440
22	Track Capacity Calculation Formula Code	01	01
23	Track Capacity Calculation Factor	20	20
24–25	Non-Keyed Record Overhead	01EC	01EC
26–27	Keyed Area Overhead	00EC	00EC
28–29	Address of First Alternate Cylinder	0375	0A5F
30–31	Number of Alternate Tracks	000F	000F
32–33	Address of First Diagnostic Cylinder	0376	0A62
34–35	Number of Diagnostic Tracks	000F	000F
36–37	Address of First SA Cylinder	FFFD	0A6B
38–39	Number of SA Tracks	000F	002D
40	MDR Record Identification	21	23
41	OBR Record Identification	21	23
42	Controller Type	06	06
43	Not Used	zeros	zeros
44–45	Length of Record	BB74	BB74
46–63	Not Used	zeros	zeros

Data Address — Defines the main storage location where the first byte of device characteristics information is to be transferred.

Flags — Used at the programmer's discretion.

Count — 64.

Initial Status — Normally 0.

Special Requirement — This command is invalid within the domain of a *Locate Record* command. If inadvertently used with *Locate Record*, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

3.24 Read and Reset Buffered Log

Command Code A4 (hex)

This command transfers 32 bytes of usage and error information from the SP to the channel. This information pertains to the SP addressed by the Start I/O instruction and the device identified in Byte 4. The counters are reset after the data transfer.

The customer should note that the information transferred by this command is identical to the information transferred by a *Sense* command (04) after the usage or error counters overflow.

Track orientation is reset after the execution of this command.

Data Address — Defines main storage location where first byte of error or usage data is to be stored.

Flags — Used at the programmer's discretion.

Count — 32. If the CCW count is greater than 32, only 32 bytes are transferred. If the CCW count is less than 32, the number of bytes specified is transferred. Channel End and Device End are presented after the data transfer.

Initial Status — Normally 0.

Special Requirements — This command is not valid within the domain of a *Locate Record* command. If inadvertently used with *Locate Record*, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

3.25 Reset Allegiance

Command Code 44 (hex)

The *Reset Allegiance* command sends 32 bytes of data to the channel. It is used to terminate a device's allegiance to a channel path or a path group, and operates even if the device is busy or not ready. *Reset Allegiance* does not, however, reset any allegiances if the device is reserved to another channel or path group.

The SP presents Channel End after the data transfer completes and Device End when the operation completes. If the device is awaiting completion of an asynchronous operation, the SP presents Channel End to the *Reset Allegiance* command, disconnects from the channel until the asynchronous operation completes, and then presents Device End.

The significance of bits in Byte 0 are defined below. Bytes 1 through 31 of the data sent to the channel are zeros.

Byte 0

Bits	Significance
0	1 = Device selection successful. When 0 (selection failed) and bits 2 and 3 are not '01', the SP attempted device selection and failed. The failure preventing selection is reported in sense information as Environmental Data Present (Byte 2, bit 3) in the next initial selection to the failing device.
1	Set to zero.
2–3	Reservation Status. 00 = Device is not reserved. 01 = Device is reserved to another channel or path group. 10 = Device is reserved to this channel or path group.
4–5	Allegiance Reset for the Addressed Device. 00 = No Allegiance was reset for the device. 01 = Implicit Allegiance was reset for the device. 10 = Contingent Allegiance was reset for the device..
6	Contingent Allegiance was reset on another device.
7	Implicit Allegiance was reset on another device.

Data Address — Defines main storage location of the first device status byte.

Flags — Used at the programmer's discretion.

Count — 32.

Initial Status — Normally 0.

Chaining Requirements — This command is not a valid command in the domain of a *Locate Record* command. *Reset Allegiance* must be the first command in the channel program. If any command precedes it, *Reset Allegiance* is rejected. If the device is reserved to another channel or path group, the *Reset Allegiance* command only returns the 32 bytes of sense data and any command chained to *Reset Allegiance* is rejected. A command rejection results in Unit Check ending status and the sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

If the device is either not reserved or is reserved to this channel or path group, the following occurs:

- Any CCW chain in progress on this device for this channel or path group is terminated and any status for the CCW chain (including sense data) is reset. Multitagged or untagged status for this device is not reset, however.
- Any chain in progress on this device for a different channel or path group is terminated with Unit Check ending status, and any pending sense data changes. Sense information contains Equipment Check with Format 3, Message F (Allegiance Terminated).
- The device will be selected if possible, using unconditional selection sequences if necessary. If selection is successful, normal chaining requirements apply to any CCW that is chained to this one. If selection is not successful, any CCW that is chained to this one is rejected with Unit Check ending status. Sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

3.26 Read Data

Command Code 06 (hex)

Command Code 86 (hex) multitrack

This command transfers the Data field of a record from the drive to main storage. The data read falls into the following categories:

- Data field of a record read by a *Search ID* or *Search Key* immediately preceding the *Read Data* command.
- Data field of a record read by *Read Count* or *Space Count* immediately preceding the *Read Data* command.
- Data field of the record associated with the next Count field. The exception is Record 0.

ECC bytes following each Data field are used to validate the field. Channel End and Device End are posted when the ECC check for the Data field completes successfully. If an uncorrectable Data Check or Command Overrun condition is detected, Channel End, Device End, and Unit Check are presented to the channel. If the error is correctable, the sense information is set so that error recovery procedures can proceed. Command retry is initiated by the SP for all error conditions considered correctable by retry.

Note: When this command processes a record with a data length of 0 (End of File), a Unit Exception status is set in the CSW (bit 39).

In the domain of a *Locate Record* command, if the end of the track is detected before a Count field, the Read operation continues depending on the state of the multitrack bit (bit 0) in the CSW.

- When the multitrack bit is 0, the SP is oriented to the Count field of the first data record on the same track. The SP sends the Data field of the record to the channel. If the track does not have a data record, the *Read Data* command is terminated with Unit Check ending status and No Record Found in the subsequent sense information.
- When the multitrack bit is 1, the SP advances to the next track and sends the Data field of the first record to the channel (refer to *Locate Record* command). Again, if the track does not have a data record, the *Read Data* command is terminated with Unit Check ending status and No Record Found in the subsequent sense information.

For multitrack read commands that are not in a *Locate Record* domain, the SP selects the next sequential head (on the same cylinder as the currently read track) when Index is detected, indicating the end of that track. Sequential head selection continues until the read command is satisfied or until the End of Cylinder (EOC) is reached. When EOC is detected, Channel End, Device End, and Unit Check are presented to the channel. The next sense information returned will show EOC as set in Sense Byte 1, bit 2. EOC is determined after the last track (14) on a logical cylinder is read. An attempted head switch from Track 14 will generate the EOC indication.

Data Address — Defines main storage location where first Data field byte is to be transferred.

Flags — Used at the programmer's discretion.

Count — Indicates number of bytes to be received.

Initial Status — Normally 0.

Chaining Requirements — A *Seek, Seek Cylinder, Locate Record, Read IPL*, or *Recalibrate* command must precede *Read Data*. A *Read* (code 16) *or Read Data* (code 06) can be the only operation specified in the domain of a *Locate Record* command.

Any other conditions for the *Read Data* command result in Unit Check ending status with sense data containing Command Reject with Format 0, Message 2 (Invalid Sequence).

3.27 Read Key and Data

Command Code 0E (hex)

Command Code 8E (hex) multitrack

This command transfers the Key and Data fields of a record from the drive to main storage. The key and data read falls into the following categories.

- Key and Data fields of a record read by *Search ID* immediately preceding the *Read Key and Data* command.
- Key and Data fields of a record read by *Read Count* or *Space Count* immediately preceding the *Read Key and Data* command.
- Key and Data fields of the record associated with the next Count field. The exception is Record 0. ECC bytes following each Key and Data fields are used to validate the fields. Channel End and Device End are posted when the ECC check for the two fields completes successfully. A Data Check or Command Overrun condition, if detected, initiates an SP recovery attempt by command retry. If command retry is not used or is unsuccessful when a Command Overrun or Data Check condition occurs, Channel End, Device End, and Unit check are posted.

Note: *When this command processes a record with a data length of 0 (End of File), a Unit Exception status is set in the CSW (bit 39). In this case, the data transfer halts once the Key field is processed.*

In the domain of a *Locate Record* command, if the end of the track is detected before a Count field, the Read operation continues depending on the state of the multitrack bit (bit 0) in the CSW.

- When the multitrack bit is 0, the SP is oriented to the Count field of the first data record on the same track. The SP sends the Key and Data fields of the record to the channel. If the track does not have a data record, the *Read Key and Data* command is terminated with Unit Check ending status and No Record Found in the subsequent sense information.
- When the multitrack bit is 1, the SP advances to the next track and sends the Key and Data fields of the first record to the channel (refer to *Locate Record* command). Again, if the track does not have a data record, the *Read Key and Data* command is terminated with Unit Check ending status and No Record Found in the subsequent sense information.

For multitrack read commands that are not in the *Locate Record* domain, the SP selects the next sequential head (on the same cylinder as the current track) when Index is detected, indicating the end of that track. Sequential head selection continues until the read command is satisfied or until End of Cylinder (EOC) is reached. When EOC is detected, Channel End, Device End, and Unit Check are presented to the channel. The next sense information returned will show EOC as set in Sense Byte 1, bit 2. EOC is determined after the last track (14) on a logical cylinder is read. An attempted head switch from Track 14 will generate the EOC indication.

Data Address — Defines main storage location where the first byte of Key field data is to be transferred.

Flags — Used at the programmer's discretion.

Count — Indicates the number of Key and Data field bytes to be received.

Initial Status — Normally 0.

> ***Note:*** *A key length of zero causes the command to operate as a Read Data command.*

Chaining Requirements — A *Seek, Seek Cylinder, Locate Record, Read IPL,* or *Recalibrate* command must precede *Read Data*. A *Read* (code 16) or *Read Data* (code 06) can be the only operation specified in the domain of a *Locate Record* command.

Any other conditions for the *Read Key and Data* command result in Unit Check ending status with sense data containing Command Reject with Format 0, Message 2 (Invalid Sequence).

3.28 Read Count, Key, and Data

Command Code 1E (hex)

Command Code 9E (hex) multitrack

This command transfers the next record encountered on the track (excluding Record Zero) from the drive to main storage.

ECC bytes following each field are used to validate the field. Channel End and Device End are posted when the ECC check for all fields completes successfully. A Data Check or Command Overrun condition, if detected, initiates an SP recovery attempt by command retry. If command retry is not used or is unsuccessful when a Command Overrun or Data Check condition occurs, Channel End, Device End, and Unit Check are posted.

> ***Note:*** *When this command processes a record with a data length of 0 (End of File), a Unit Exception status is set in the CSW (bit 39). In this case, the data transfer halts once the Count field (if key length = 0) or Key field is processed.*

In the domain of a *Locate Record* command, if the end of the track is detected before a Count field, the Read operation continues depending on the state of the multitrack bit (bit 0) in the CSW.

- When the multitrack bit is 0, the SP is oriented to the Count field of the first data record on the same track. The SP sends the Count, Key, and Data fields of the record to the channel. If the track does not have a data record, the *Read Count, Key, and Data* command is terminated with Unit Check ending status and No Record Found in the subsequent sense information.
- When the multitrack bit is 1, the SP advances to the next track and sends the Count, Key, and Data fields of the first record to the channel (refer to *Locate Record* command). If the track does not have a data record, the *Read Count, Key, and Data* command is terminated with Unit Check ending status and No Record Found in the subsequent sense information.

For multitrack commands that are not in the domain of a *Locate Record*, the SP selects the next sequential head (on the same cylinder as the current track) when Index is detected, indicating the end of that track. Sequential head selection continues until the read command is satisfied or until End of Cylinder (EOC) is reached. When EOC is detected, Channel End, Device End, and Unit Check are presented to the channel. The next sense information returned will show EOC as set in Sense Byte 1, bit 2. EOC is determined after the last track (14) on a logical cylinder is read. An attempted head switch from Track 14 will generate the EOC indication.

Data Address — Defines main storage location where first byte of Count data is to be transferred.

Flags — Used at the programmer's discretion.

Count — Indicates the number of Count, Key, and Data field bytes to be received.

Initial Status — Normally 0.

Chaining Requirements — A *Seek, Seek Cylinder, Locate Record, Read IPL,* or *Recalibrate* command must precede *Read Count, Key, and Data.* A *Read* (code 16) or *Read Data* (code 06) can be the only operation specified in the domain of a *Locate Record* command.

Any other conditions for the *Read Count, Key, and Data* command result in Unit Check ending status with sense data containing Command Reject with Format 0, Message 2 (Invalid Sequence).

3.29 Read Multiple Count, Key, and Data

Command Code 5E (hex)

This command is similar to executing *Read Count, Key, and Data* commands over and over until the next Index is detected. In short, the command transfers the next record and all remaining records encountered on the track (excluding Record Zero) from the drive to main storage.

ECC bytes following each field are used to validate the field. Channel End and Device End are posted when the ECC check for the last Data field completes successfully. Unit Exception is not issued for zero-length Data fields.

Data Address — Defines main storage location where the first byte of Count data is to be transferred.

Flags — Used at the programmer's discretion.

Count — In order to read the entire track, the count must exceed 8 (Count field) + 47,476 (maximum Record 1 Key and Data fields).

Initial Status — Normally 0.

Chaining Requirements — This command must be preceded by a *Seek, Seek Cylinder, Locate Record, Recalibrate,* or *Read IPL* command. Also, the *Read Multiple Count, Key, and Data* command must not be within the domain of a Locate Record command. If these requirements are not met, the command is rejected with Unit Check ending status and the sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

3.30 Read Record Zero (R0)

Command Code 16 (hex)

Command Code 96 (hex) multitrack

This command transfers Count, Key, and Data fields for Record 0 (R0) from the drive to main storage.

ECC bytes following each field are used to validate the field. Channel End and Device End are posted when the ECC check for all fields completes successfully. A Data Check or Command Overrun condition, if detected, initiates an SP recovery attempt by command retry. If command retry is not used or is unsuccessful when a Command Overrun or Data Check condition occurs, Channel End, Device End, and Unit Check are posted.

> ***Note:*** *When this command processes a record with a data length of 0 (End of File), a Unit Exception status is set in the CSW (bit 39). In this case, the data transfer halts once the Count field (if key length = 0) or Key field is processed.*

In the domain of a *Locate Record* command, the SP is oriented to Home Address when it receives this command. Data transfer begins with the following Record 0 Count field. If the SP is not oriented to Home Address when starting a multitrack *Read Record 0*, the command always advances to the next track before sending Record 0.

For multitrack commands that are not in a *Locate Record* domain, the SP selects the next sequential head (on the same cylinder as the current track) when Index is detected, indicating the end of that track. Sequential head selection continues until the read command is satisfied or until End of Cylinder (EOC) is reached. When EOC is detected, Channel End, Device End, and Unit Check are presented to the channel. The next sense information returned will show EOC as set in Sense Byte 1, bit 2. EOC is determined after the last track (14) on a logical cylinder is read. An attempted head switch from Track 14 will generate the EOC indication.

Data Address — Defines main storage location where first byte of R0 Count data is to be transferred.

Flags — Used at the programmer's discretion.

Count — Indicates number of Count, Key, and Data field bytes to be received.

Initial Status — Normally 0.

Chaining Requirements — A *Seek, Seek Cylinder, Locate Record, Read IPL,* or *Recalibrate* command must precede *Read Record 0.* A *Read* (code 16) *or Read Data* (code 06) and Index or Home Address orientation (Byte 0, bits 0 and 1 are "11" or "01") can be the only operation specified in the domain of a *Locate Record* command. Any other conditions for the Read Record 0 command result in Unit Check ending status with sense data containing Command Reject with Format 0, Message 2 (Invalid Sequence).

3.31 Read Count

Command Code 12 (hex)

Command Code 92 (hex) multitrack

This command reads the eight bytes containing cylinder (2 bytes), head (2 bytes), record number (1 byte), key length (1 byte), and data length (2 bytes) (CC, HH, R, KL, DL, DL) from the next Count field encountered on the track (excluding Record 0). The drive transfers this information to main storage.

ECC bytes following each Count field are used to validate the field. Channel End and Device End are posted when the ECC check for the Count field completes successfully. A Data Check or Command Overrun condition, if detected, initiates an SP recovery attempt by command retry. If command retry is not used or is unsuccessful when a Command Overrun or Data Check condition occurs, Channel End, Device End, and Unit Check are posted.

In the domain of a *Locate Record* command, if the end of the track is detected before a Count field, the Read operation continues depending on the state of the multitrack bit (bit 0) in the CSW.

- When the multitrack bit is 0, the SP is oriented to the Count field of the first data record on the same track. The SP sends the Count field of the record to the channel. If the track does not have a data record, the *Read Count* command is terminated with Unit Check ending status and No Record Found in the subsequent sense information.
- When the multitrack bit is 1, the SP advances to the next track and sends the Count field of the first record to the channel (refer to *Locate Record* command). Again, if the track does not have a data record, the *Read Count* command is terminated with Unit Check ending status and No Record Found in the subsequent sense information.

For multitrack commands that are not in a *Locate Record* domain, the SP selects the next sequential head (on the same cylinder as the current track) when Index is detected, indicating the end of that track. Sequential head selection continues until the read command is satisfied or until End of Cylinder (EOC) is reached. When EOC is detected, Channel End, Device End, and Unit Check are presented to the channel. The next sense information returned will show EOC as set in Sense Byte 1, bit 2. EOC is determined after the last track (14) on a logical cylinder is read. An attempted head switch from Track 14 will generate the EOC indication.

Data Address — Defines main storage location where first byte of Count data is to be transferred.

Flags — Used at the programmer's discretion.

Count — 8.

Initial Status — Normally 0.

Chaining Requirements — The *Read Count* command has the following chaining requirements and restrictions.

- A *Seek, Seek Cylinder, Locate Record, Read IPL,* or *Recalibrate* command must precede *Read Count*.
- A *Read* (code 16) or *Read Data* (code 06) can be the only operation specified in the domain of a *Locate Record* command.
- *Read Count* must be suffixed to a *Locate Record* domain that specifies a *Write Data* (code 01) operation and *Read Count CCW* suffix (auxiliary byte, bit 7 is set to 1).

Any other conditions for the *Read Count* command result in Unit Check ending status with sense data containing Command Reject with Format 0, Message 2 (Invalid Sequence).

3.32 Read Home Address

Command Code 1A (hex)

Command Code 9A (hex) multitrack

This command transfers the flag, cylinder (2 bytes), and head (2 bytes) information (FCCHH) in the Home Address field to main storage.

ECC bytes following each Home Address field are used to validate the field. Channel End and Device End are posted when the ECC check for the Home Address field completes successfully. A Data Check or Command Overrun condition, if detected, initiates an SP recovery attempt by command retry. If command retry is not used or is unsuccessful when a Command Overrun or Data Check condition occurs, Channel End, Device End, and Unit Check are posted.

When in the domain of a *Locate Record,* the SP is oriented to Index when the *Read Home Address* command starts. The 5-byte Home Address transfers to the channel.

For multitrack commands that are not in the domain of a *Locate Record*, the SP selects the next sequential head (on the same cylinder as the current track) when Index is detected, indicating the end of that track. Sequential head selection continues until the read command is satisfied or until End of Cylinder (EOC) is reached. When EOC is detected, Channel End, Device End, and Unit Check are presented to the channel. The next sense information returned shows EOC as set in Sense Byte 1, bit 2. EOC is determined after the last track (14) on a logical cylinder is read. An attempted head switch from this Track 14 will generate the EOC indication.

Data Address — Defines main storage location where Home Address is to be stored.

Flags — Used at the programmer's discretion.

Count — 5.

Initial Status — Normally 0.

Chaining Requirements — A *Seek, Seek Cylinder, Locate Record, Read IPL,* or *Recalibrate* command must precede *Read Home Address*. A *Read* (code 16) or *Read Data* (code 06) and Index orientation (Byte 0, bits 0 and 1 are '11') can be the only operation specified in the domain of a *Locate Record* command.

Any other conditions for the *Read Home Address* command result in Unit Check ending status with sense data containing Command Reject with Format 0, Message 2 (Invalid Sequence).

3.33 Read IPL

Command Code 02 (hex)

This command performs an Initial Program Load (IPL) by instructing the SP to return the selected drive to Cylinder 0, Head 0, and search for Index. Upon detecting Index, the Record 1 Data field is transferred. This command is normally initiated by setting the device address in the LOAD ADDRESS switches on the CPU Operator Panel and pressing the IPL (LOAD) button.

> ***Note:*** *When this command processes a record with a data length of 0 (End of File), a Unit Exception status is set in the CSW (bit 39).*

ECC bytes following each Data field are used to validate the field. Channel End and Device End are posted when the ECC check for the Record 1 Data field completes successfully. A Data Check or Command Overrun condition, if detected, initiates an SP recovery attempt by command retry. If command retry is not used or is unsuccessful when a Command Overrun or Data Check condition occurs, Channel End, Device End, and Unit Check are posted.

Data Address — Defines main storage location where first byte of data is to be transferred.

Flags — Used at the programmer's discretion.

Count — Indicates number of bytes to be received.

Initial Status — Normally 0.

Chaining Requirement — The *Read IPL* command is not valid within the domain of a *Locate Record* command. If it is inadvertently used with *Locate Record*, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

If the command was preceded in the same channel program by a *Define Extent* or *Set File Mask* command, the command is terminated with Unit Check ending status. The sense data reports Command Reject with Format 0, Message 2.

3.34 Read Sector

Command Code 22 (hex)

This command transfers one byte of data from the SP to main storage. The byte transferred normally contains the sector number required to access the Count field of the last record processed. Execution of this command resets orientation information in the SP. Channel End and Device End are posted when the sector number transfer is complete.

Data Address — Defines main storage location where the sector number is to be transferred.

Flags — Used at the programmer's discretion.

Count — 1.

Initial Status — Normally 0.

Special Requirement — This command is not valid within the domain of a *Locate Record* command. If it is inadvertently used with *Locate Record*, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

3.35 Read Track

Command Code DE (hex)

The *Read Track* command transfers multiple records from the drive to the channel. Primarily used for dump/restore utility programs, the command sends all records from a device track without first having to determine the number of records on the track and their formats. After reading the last record on the track, a pseudo Count area of 8 bytes with a value of FF transfers to the channel. If channel data transfer truncates because of an exhausted byte count or an exception condition, no pseudo Count transfers to indicate the end of the track in the host processor storage.

The SP presents Channel End and Device End status when data transfer completes. When the command completes, the SP is oriented to the Data area of the last record on the track.

Data Address — Defines the main storage location for the first Count area.

Flags — Used at the programmer's discretion.

Count — Value should be at least as large as that defined for the maximum record size that can be written on the track, plus the length of the Record 0 Count and Data areas, plus 8 bytes for the pseudo Count area.

Initial Status — Normally 0.

Chaining Requirements — Unit Check ending status (sense information reporting Command Reject with Format 0, Message 2) occurs if the *Read Track* command is:

- Not in a *Locate Record* domain that specifies a *Read Track* (code 0C) operation or,
- Not immediately preceded by a *Locate Record* command or another *Read Track* command.

The first *Read Track* command in a *Locate Record* domain is oriented to the first Count area (including Record 0) that follows the orientation established by the *Locate Record* command. The SP sends each Count, Key, and Data area on the track until the end of the track is reached. If the orientation is to Home Address and there is no Record 0, the command is terminated with Unit Check ending status (No Record Found). If end-of-track occurs before a Count area, only a pseudo Count area of 8 bytes of FF transfers and the SP does not report this action as an exception condition.

Within the domain of a *Locate Record* command, the following *Read Track* commands cause the SP to:

1. Advance to the next track
2. Be oriented to Home Address
3. Send each Count, Key, and Data area (Record 0 included) on the track until end of track occurs.

If the next track does not have a Home Address, the command is terminated with Unit Check ending status. The sense information reports a Data Check for the specific device. If there is no Record 0 on the next track, the command is terminated with Unit Check ending status (No Record Found).

If the length of the Data area is zero. the SP does not transfer the Data area and does not report an exception status. The Read operation continues with the next Count area, if any, on the track.

The *Read Track* command will not read a track that is marked defective. If the command accesses a defective track, the data is read from the assigned alternate track. If an alternate track has not been assigned, or an invalid alternate track has been assigned, the command is rejected with Unit Check ending status. The sense data reports Command Reject with Format 0, Message B (Improper Alternate Track Pointer).

If end of track occurs in a record, the command is terminated with Unit Check ending status indicating Invalid Track Format.

3.36 Write Data

Command Code 05 (hex)

This command performs normal record updating on a formatted track. Execution of this command causes specified data in main storage to be written in the Data field of the selected record. The number of bytes transferred is specified in the CCW count. ECC bytes are written at the end of the Data field; Channel End and Device End are posted after the ECC bytes have been written for the Data field.

> ***Note:*** *When this command processes a record with a data length of 0 (End of File), a Unit Exception status is set in the CSW (bit 39).*

Data Address — Defines main storage location of data used to update record.

Flags — Used at the programmer's discretion.

Count — Indicates number of Data field bytes to be transferred. If CCW count is less than the formatted record data length, the SP pads with zeros for the remainder of the Data field. If CCW count is greater than the formatted record data length, the SP writes only the number of bytes indicated in the Count field for the record. If the CCW count does not match the data length, an incorrect length condition will be returned unless Bit 34 is set in the CCW flag.

Initial Status — Normally 0.

Chaining Requirements — *Write Data* is a valid command in the domain of a *Locate Record* that specifies one of the following:

- A Write Track (code 0B) operation
- A Write Data (code 01) operation that requires only one Write operation (either a Count of 1 or, with Read Count CCW suffix, a Count of 2).

If either of these conditions is not met when in the domain of *Locate Record*, the command is rejected with Unit Check ending status. Subsequent sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

When outside the domain of a *Locate Record*, this command must be chained from the *Search ID Equal* or *Search Key Equal* (the Search command must compare equal on all bytes of the searched field). When chaining requirements are not met, Device End, Channel End, and Unit Check are presented in the ending status.

Unit Check ending status (sense information reporting Command Reject with Format 0, Message 2) also occurs if one of the following conditions is encountered:

- The file mask does not permit Update Write operations (bits 0 and 1 are '01')
- The currently accessed track is in the device-support address space and the command is outside the domain of *Locate Record*.

3.37 Write Key and Data

Command Code 0D (hex)

The command performs record updating on a formatted track. Execution of this command causes specified data in main storage to be written in the Key and Data fields of the selected record. The number of bytes transferred is specified in the CCW count. ECC bytes are written at the end of the Key and the Data fields; Channel End and Device End are posted after the ECC bytes have been written for the Data field.

Note: When this command processes a record with a data length of 0 (End of File), a Unit Exception status is set in the CSW (bit 39). In this case, the data transfer halts once the Key field is processed.

Data Address — Defines main storage location of data used to update record.

Flags — Used at the programmer's discretion.

Count — Indicates number of Key and Data field bytes to be transferred. If CCW count is less than the formatted record key length and data length, the SP pads with zeros for the remainder of each field. If CCW count is greater than the formatted record key length and data length, the SP writes only the number of bytes indicated for the two fields in the Count field of the record. If the CCW count does not match the data length, an incorrect length condition will be returned unless Bit 34 is set in the CCW flag.

Initial Status — Normally 0.

Chaining Requirements — *Write Key and Data* is a valid command in the domain of a *Locate Record* that specifies Write Data (code 01) and requires only one Write operation (either a Count of 1 or, with Read Count CCW suffix, a Count of 2). If this condition is not met, the command is rejected with Unit Check ending status. Subsequent sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

When outside the domain of a *Locate Record*, this command must be chained from the *Search ID Equal* (the *Search ID Equal* command must compare equal on all bytes of the searched field). When chaining requirements are not met, Device End, Channel End, and Unit Check are presented in the ending status.

Unit Check ending status (sense information reporting Command Reject with Format 0, Message 2) also occurs if one of the following conditions is encountered:

- The file mask does not permit Update Write operations (bits 0 and 1 are '01')
- The currently accessed track is in the device-support address space and the command is outside the domain of *Locate Record*.

Note: If the key length is zero, this command is, in effect, a Write Data command.

3.38 Write Count, Key, and Data

Command Code 1D (hex)

This command allows the Count, Key, and Data fields of a record in main storage to be written on the specified track of the selected drive. The Count field is made up of the first eight bytes from main storage; record ID (CCHHR: five bytes) + key length (one byte) + data length (two bytes). The flag byte is generated by the SP; the remaining data is written in the Key and Data fields as specified by the key length and data length bytes in the Count field. ECC bytes are written at the end of the Count, Key, and Data fields; Channel End and Device End are posted after the ECC bytes are written for the Data field.

Data Address — Defines main storage location of the Count, Key, and Data field bytes to be transferred.

Flags — Used at the programmer's discretion.

Count — Indicates number of Count, Key, and Data field bytes (8 + KL + DL) to be transferred. If CCW count is less than 8 + KL + DL, the SP writes zeros in the remainder of the record.

Initial Status — Normally 0.

Chaining Requirements — Unit Check ending status (sense information reporting Command Reject with Format 0, Message 2) occurs if one of the following conditions is encountered.

- The *Write Count, Key, and Data* command is not in a *Locate Record* domain and is not preceded by one of the following:
  - A *Search Id Equal* or *Search Key Equal* command that compares equal on all bytes of the ID or Key field (see Note below)
  - A *Write Record 0* command or a *Write Count, Key, and Data* command that is not in the domain of a *Locate Record.*
  - The *Write Count, Key, and Data* command is outside the *Locate Record* domain and the currently accessed track is in the device-support address space.
- The file mask inhibits Format Write operations (bits 0 and 1 are '10').
- This command follows a *Write Record 0* command that assigns an alternate track.
- The *Write Count, Key, and Data* command is in the domain of a Locate Record that does not specify either a Format Write (code 03) or a Write Track (code 0B) operation.

Note: *A Read Data and/or Read Key and Data command may be chained between the Search ID Equal command and the Write Count, Key, and Data commands. A Write Data or a Write Key and Data command may be inserted between Search ID and the Write Count, Key, and Data, or a Write Data command may be inserted between a Search Key and the Write Count, Key, and Data.*

3.39 Write Record Zero (R0)

Command Code 15 (hex)

This command transfers the Count, Key, and Data fields for Record 0 from main storage to the track. The Count field is made up of the first eight bytes from main storage. The flag is generated by the SP; the remaining data is written in the Key and Data fields specified by the key length and data length bytes in the Count field. ECC bytes are written following each field. Channel End and Device End are posted after the ECC bytes are written for the Data field.

IBM-compatible data management systems require a zero key length and an eight-byte Data field in Record 0.

Data Address — Defines main storage location of Record 0 Count, Key, and Data field bytes to be transferred.

Flags — Used at the programmer's discretion.

Count — Indicates number of Count, Key, and Data field bytes (8 + key length + data length) to be transferred. If CCW count is less than 8 + key length + data length, the SP writes zeros in the remainder of the record.

Initial Status — Normally 0.

Chaining Requirements — Unit Check ending status (sense information reporting Command Reject with Format 0, Message 2) occurs if one of the following conditions is encountered.

- The *Write Record 0* command is not in a *Locate Record* domain and is not preceded by one of the following:
  - — A *Search Home Address* command that compares equal on all four Home Address bytes
  - — A *Write Home Address* command that is not in the domain of a *Locate Record.*
  - — The *Write Home Address* command is outside the *Locate Record* domain and the currently accessed track is in the device-support address space.
- The file mask inhibits the Record 0 Write operation (bits 0 and 1 are not '11').
- This command is in the domain of a *Locate Record* that does not specify a Format Write (code 03) operation with Home Address or Index orientation (Byte 0, bits 0 and 1 are '01' or '11').

Note: *Record 0 is normally written on the disk media by the manufacturer. The use of this command should be limited to identifying defective tracks and assigning alternate tracks. Utility programs are available to perform these functions. The R0 CCHH bytes of the alternate track contain the address of the defective track and the R0 CCHH bytes of the defective track contain the address of the alternate track.*

3.40 Write Home Address

Command Code 19 (hex)

This command transfers the Home Address from main storage to the track. The SP orients on Index and writes Gap 1, the Home Address, and ECC bytes. Channel End and Device End are posted after the ECC bytes are written for the Home Address field.

Data Address — Defines main storage location of the Home Address bytes; the format of these bytes is FCCHH (only the last two bits of F, the Home Address flag, are used).

Flags — Used at the programmer's discretion.

Count — Must be 5. If less than 5, Command Reject is presented. If greater than 5, only five bytes are transferred.

Initial Status — Normally 0.

Chaining Requirements — Unit Check ending status (sense information reporting Command Reject with Format 0, Message 2) occurs if one of the following conditions is encountered.

- The *Write Home Address* command is not in a *Locate Record* domain and is not preceded by a *Search Home Address* command that compares equal on all four Home Address bytes of the track address field
- The *Write Home Address* command is outside the *Locate Record* domain and the currently accessed track is in the device-support address space.
- The file mask inhibits the Home Address Write operation (bits 0 and 1 are not '11').
- This command is in the domain of a *Locate Record* that does not specify a Format Write (code 03) operation with Home Address orientation (Byte 0, bits 0 and 1 are '01').

Special Requirements — *Write Home Address* establishes track identity (prerequisite for data operations on the track) and writes zeros on the balance of the track if this is the last command in a CCW chain.

The SP verifies Home Address data from the channel as follows:

- Bits 0 through 5 of the flag byte must be 0.
- Flag byte, bits 6 and 7, must be '01' or '11' if the addressed track is in the alternate track address space. Bits 6 and 7 must be '00' or '10' if the track is not an alternate track.
- The track address must equal the address of the currently accessed track.

3.41 Erase

Command Code 11 (hex)

This command writes zeros on the remainder of the specified track. The erased record and all records that follow on the track are not recoverable. Channel End and Device End are presented after ECC bytes have been read or written at the end of the Data field for the previous record.

Data Address — Defines main storage location of the Count, Key, and Data field bytes.

Flags — Used at the programmer's discretion.

Count — Indicates number of bytes to be transferred for the Count, Key, and Data fields.

> ***Note:*** *Even though the Count, Key, and Data field bytes are transferred to the SP, they are not written on the track.*

Initial Status — Normally 0.

Chaining Requirements — Unit Check ending status (sense information reporting Command Reject with Format 0, Message 2) occurs if one of the following conditions is encountered.

- The *Erase* command is not in a *Locate Record* domain and is not preceded by one of the following:
  - A *Search ID Equal* or *Search Key Equal* command that compares equal on all bytes of the ID or Key field, or
  - A *Write Record 0* or *Write Count, Key, and Data* command that is not in the domain of a *Locate Record.*
- The *Erase* command is outside the *Locate Record* domain and the currently accessed track is in the device-support address space.
- The file mask inhibits Format Write operations (bits 0 and 1 are '01' or '10').
- This command is in the domain of a *Locate Record* that does not specify a Write Track (code 0B) operation.

Read Data and *Read Key and Data* commands may be chained between *Search ID Equal* and *Erase* commands. *Read Data* may be chained between *Search Key Equal* and *Erase*. *Write Data* or *Write Key and Data* may be chained between *Search ID* (Equal, High, or Equal High) and *Erase*. Additionally, *Write Data* may be chained between *Search Key* (Equal, High, or Equal High) and *Erase*.

3.42 Write Count, Key, and Data Next Track

Command Code 9D (hex)

The *Write Count, Key, and Data Next Track* command formats the first user Data record on the next track. The first 8 bytes of the record are the Count area; the remaining bytes are written into the Key and Data areas. If the channel sends less than an 8-byte Count area, the remainder of the Count area is filled with binary zeros. The Write operation continues and zeros are used to fill any fields that are not transferred.

The storage path is oriented to a Data area when this command is started. It then erases the remaining portion of the current track, advances to the next track, and formats a user Data record following Record 0 on the next track.

If there is no Record 0 on the next track, the operation is terminated with Unit Check ending status (No Record Found).

After the Count area transfers, the SP receives the Key and Data areas from the channel. The lengths of these areas are defined in the Count area. If the key length (KL) is zero, the record formats without a Key area. If the data length (DL) is zero, the record formats as an end-of-file record. If the channel provides less bytes than the sum of KL + DL, the SP fills the remaining bytes of the Key and Data areas with binary zeros.

Channel End and Device End status are presented after the device completes the Write operation. When the command completes, the SP is oriented to the Data area of the record that was just written.

Data Address — Defines the main storage location of the Count (8 bytes), Key, and Data bytes.

Flags — Used at the programmer's discretion.

Count — The number of bytes to write.

Chaining Requirements — *Write Count, Key, and Data Next Track* is valid only in the domain of a *Locate Record* command which specifies a Format Write (code 03) operation. If this command is not followed by a *Write Count, Key, and Data* command, the remaining portion of the track is erased. This command can only be chained from a *Write Count, Key, and Data* command or another *Write Count, Key, and Data Next Track* command.

If there is not enough space on the track to write the complete record, the command is terminated with Unit Check status (Invalid Track Format). The track may contain a partial record, and the residual byte count in the CSW may not indicate the amount by which the length of the record exceeded the available space on the track.

3.43 Write Update Data

Command Code 85 (hex)

The *Write Update Data* command updates the Data field of an existing record. The SP writes the existing record with the amount of data specified in the transfer length factor parameter of the *Locate Record* command (or the block size parameter of the *Define Extent* command if the transfer length factor was not specified). If the channel transfers less than the specified number of bytes, the remaining area of the Data field is filled with zeros; if too many bytes are sent, only the specified number of bytes are written in the Data field.

If the SP is oriented to a Count field when the command starts (as a result of the preceding Locate Record command), it writes the following Data field. If the SP is not oriented to a Count field at the start of the command (the preceding command was a *Write Update Data* command), it is oriented to the next Count field. It then writes the first user record on that track (not Record 0).

If end-of-track occurs, and the next track is in the extent defined by the previous *Define Extent* command, the SP advances to the next track.

Channel End and Device End are presented when the device completes the Write operation. When the command completes, the SP is oriented to the Data field of the record just updated.

Data Address — Defines the main storage location of the data.

Flags — Used at the discretion of the programmer.

Count — Indicates the number of Data field bytes to write. If CCW count is less than the record data length, the SP pads with zeros for the remainder of the Data field. If CCW count is greater than the record data length, the SP writes only the number of bytes indicated in the Count field for the record.

Initial Status — Normally 0.

Chaining Requirements — *Write Update Data* is a valid command only in the domain of a *Locate Record* that specifies a Write Data (code 01) operation. If this condition is not met, the command is rejected with Unit Check ending status. Subsequent sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

If the transfer length factor (*Locate Record*) or block size (*Define Extent*) value is not equal to the Count field data length value of the record, the record is not updated. The operation ends with Unit Check status (Invalid Track Format). In addition, if end-of-track occurs in the record, the operation is terminated with Invalid Track Format indicated for the Unit Check ending status.

3.44 Write Update Key and Data

Command Code 8D (hex)

The *Write Update Key and Data* command updates the Key and Data fields of an existing record. If the Key length (KL) is zero, this command operates as a *Write Update Data* command. The SP writes the existing record with the amount of data specified in the transfer length factor parameter of the *Locate Record* command (or the block size parameter of the *Define Extent* command if the transfer length factor was not specified). If the channel transfers less than the specified number of bytes, the remaining areas of the Key and Data fields are filled with zeros; if too many bytes are sent, only the specified number of bytes are written in the Key and Data fields.

If the SP is oriented to a Count field when the command starts (as a result of the preceding *Locate Record* command), processing begins on the following Key and Data fields. If the SP is not oriented to a Count field at the start of the command (the preceding command was another *Write Update Key and Data* command), it is oriented to the next Count field. It then writes the Key and Data fields of that record (not Record 0).

If end-of-track occurs, and the next track is in the extent defined by the previous *Define Extent* command, the SP advances to the next track. Processing begins with the Key and Data fields of the first user record on that track (not Record 0).

Channel End and Device End are presented when the device completes the Write operation. When the command completes, the SP is oriented to the Data field of the record just updated.

Data Address — Defines the main storage location of the data.

Flags — Used at the discretion of the programmer.

Count — Indicates the number of Key and Data field bytes to write. If CCW count is less than the sum of the key length and the data length (KL + DL), the SP pads with zeros for the remainder of the Key and Data fields. If CCW count is greater than that specified, only the indicated number of bytes are written.

Initial Status — Normally 0.

Chaining Requirements — *Write Update Key and Data* is a valid command only in the domain of a *Locate Record* that specifies a Write Data (code 01) operation. If this condition is not met, the command is rejected with Unit Check ending status. Subsequent sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

If the transfer length factor (*Locate Record*) or block size (*Define Extent*) value is not equal to the sum of the key length and data length (KL + DL) values in the Count field of the record, the record is not updated. The operation ends with Unit Check status (Invalid Track Format). In addition, if end-of-track occurs in the record, the operation is terminated with Invalid Track Format indicated for the Unit Check ending status.

3.45 Search Home Address Equal

Command Code 39 (hex)

Command Code B9 (hex) multitrack

This command instructs the SP to compare the Home Address on the designated track with the argument read from main storage. Execution begins with a search for Index. When Index is detected, the cylinder and head number from main storage are compared with those in the track Home Address. The Home Address is validated by the ECC.

Given that the single-track version of the command is used, the search takes place on one track. If the comparison is equal, Channel End, Device End, and Status Modifier are presented to the channel. In the event that the main storage Home Address does not match the track Home Address, only Channel End and Device End are posted.

If a multitrack search is indicated and file mask requirements are met, the search continues from track to track as long as the channel reissues the command. The head number is automatically incremented at Index until the search condition is satisfied or End of Cylinder (EOC) is reached. EOC is determined after the last track (14) on a logical cylinder is searched. An attempted head switch from Track 14 will generate the EOC condition.

If No Record Found (for 39) or End of Cylinder (for B9) has been detected, Channel End, Device End, and Unit Check are presented and the channel program is terminated. The flag byte is not transferred by the channel or compared during command execution.

Data Address — Defines main storage location of a cylinder number and head number.

Flags — Used at the programmer's discretion.

Count — Should be 4. If count is greater than 4 bytes, the search utilizes only the first 4 bytes received by the SP. The command is terminated with Channel End and Device End (and Status Modifier if the comparison was equal.) For a count of less than 4 bytes, a comparison of the storage and track data continues until the CCW count is decremented to zero. Channel End and Device End are presented to the channel when the Home Address and the ECC bytes are read and checked. Status Modifier is presented with Channel End and Device End if the truncated search was satisfied.

Initial Status — Normally 0.

Chaining Requirements — This command must be preceded by a *Seek, Seek Cylinder, Locate Record, Recalibrate,* or *Read IPL* command. Also, the *Search Home Address Equal* command must not be within the domain of a *Locate Record* command. If these requirements are not met, the command is rejected with Unit Check ending status and the sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

3.46 Search ID Equal

Command Code 31 (hex)

Command Code B1 (hex) multitrack

This command compares an argument in main storage with the next Count ID (CCHHR) on the track (including Record 0). If an equal comparison results, Channel End, Device End, and Status Modifier are presented to the channel. In the event that the main storage argument does not match the Count ID, only Channel End and Device End are posted.

If a single-track search is specified, the search is confined to one track. As long as the channel reissues the command, the search is repeated until either the search condition is satisfied or two Index points are detected. Upon detection of the second Index, Channel End, Device End, and Unit Check are presented to the channel. The next sense information returned will show No Record Found as set in Sense Byte 1, bit 4.

If a multitrack search is indicated and file mask requirements are met, the search continues from track to track as long as the channel reissues the command. The head number is automatically incremented at Index until the search condition is satisfied or End of Cylinder (EOC) is reached. EOC is determined after the last track (14) on a logical cylinder is searched. An attempted head switch from Track 14 will generate the EOC condition. Upon detection of EOC, Channel End, Device End, and Unit check are posted. The next sense information returned will show EOC as set in Sense Byte 1, bit 2.

Data Address — Specifies main storage address of the five-byte ID (CCHHR) portion of a Count field.

Flags — Used at the programmer's discretion.

Count — Should be 5. If count is greater than 5, only the first 5 bytes from main storage are compared. Channel End and Device End are presented to terminate the command, and Status Modifier is presented if the comparison is equal. For a count of less than 5, a comparison of main storage and track data continues until the CCW count is 0. Channel End and Device End are presented to the channel when the ID and the ECC bytes are read and checked. Status Modifier is presented if the truncated search is satisfied.

Initial Status — Normally 0.

Chaining Requirements — This command must be preceded by a *Seek, Seek Cylinder, Locate Record, Recalibrate,* or *Read IPL* command. Also, the *Search ID Equal* command must not be within the domain of a *Locate Record* command. If these requirements are not met, the command is rejected with Unit Check ending status and the sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

3.47 Search ID High

Command Code 51 (hex)

Command Code D1 (hex) multitrack

This command is identical to *Search ID Equal* except that a high comparison results if the track ID (CCHHR) is greater than the main storage argument. In this case, Channel End, Device End, and Status Modifier are presented to the channel. When a high comparison does not result, the track ID is not greater than the main storage argument and the CSW posts only Channel End and Device End.

3.48 Search ID Equal or High

Command Code 71 (hex)

Command Code F1 (hex) multitrack

This command is identical to *Search ID Equal* except that an equal or high comparison results if the track ID (CCHHR) is equal to or greater than the main storage argument. In this case, Channel End, Device End, and Status Modifier are presented to the channel. When an equal or high comparison does not result, the track ID is less than the main storage argument and the CSW posts only Channel End and Device End.

3.49 Search Key Equal

Command Code 29 (hex)

Command Code A9 (hex) multitrack

This command compares the argument in main storage with the next Key field on the track (normally excluding Record 0, see special note). If an equal comparison results, Channel End, Device End, and Status Modifier are presented to the channel. In the event that the track contains no Key field or the Key field does not match the argument in main storage, only Channel End and Device End are posted.

If a single-track *Search Key Equal* is indicated, the search is confined to one track. As long as the channel reissues the command, the search is repeated until the search condition is satisfied or two Index points are detected. Upon detection of the second Index, Channel End, Device End, and Unit Check are presented to the channel. The next sense information returned will show No Record Found as set in Sense Byte 1, bit 4.

If a multitrack search is indicated and file mask requirements are met, the search continues from track to track as long as the channel reissues the command. The head number is automatically incremented at Index until the search condition is satisfied or End of Cylinder (EOC) is reached. EOC is determined after the last track (14) on a logical cylinder is searched. An attempted head switch from Track 14 will generate the EOC condition. Upon detection of EOC, Channel End, Device End, and Unit Check are posted. The next sense information returned will show EOC as set in Sense Byte 1, bit 2.

Execution of this command on a record with a key length of zero does not set a Status Modifier. If followed by a chained *Read Data* command, the Data field read is the one in the next record.

Data Address — Defines main storage location of the argument to be compared.

Flags — Used at the programmer's discretion.

Count — Number of bytes in the Key field. If count is greater than the key length, the search operation is completed when the Key field is read. Channel End and Device End are presented to the channel, terminating the command. Status Modifier is presented if the comparison is equal. For a count equal to or less than the key length, the track and main storage comparison continues until the CCW count is zero. Channel End and Device End are presented after the Key field and subsequent ECC bytes are read and checked. Status Modifier is presented if the truncated search is satisfied.

Initial Status — Normally 0.

Chaining Requirements — This command must be preceded by a *Seek, Seek Cylinder, Locate Record, Recalibrate,* or *Read IPL* command. Also, the *Search Key Equal* command must not be within the domain of a *Locate Record* command. If these requirements are not met, the command is rejected with Unit Check ending status and the sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

Special Note: *When this command is chained from Search ID or Read Count, the Key field compared is in the same record as the ID or Count field. Search Key Equal bypasses the Record 0 Key field unless chained from a Search ID command which searched Record 0.*

3.50 Search Key High

Command Code 49 (hex)

Command Code C9 (hex) multitrack

This command is identical to *Search Key Equal* except that a high comparison results if the record Key is greater than the main storage argument. In this case, Channel End, Device End, and Status Modifier are presented to the channel. When the Key is not greater than the main storage argument, only Channel End and Device End are presented to the channel.

3.51 Search Key Equal or High

Command Code 69 (hex)

Command Code E9 (hex) multitrack

This command is identical to *Search Key Equal* except that an equal or high comparison results if the record Key is greater than or equal to the main storage argument. In this case, Channel End, Device End, and Status Modifier are presented to the channel. When the Key is less than the main storage argument, only Channel End and Device End are presented to the channel.

3.52 Diagnostic Write Home Address

Command Code 09 (hex)

This command is used to rewrite the Home Address field and define new defects that may have occurred on a track. Following the Home Address (HA) validity check, the SP orients on Index and writes Gap 1, Home Address, and ECC bytes. Bits 0 through 5 of the Home Address flag byte are set to 0. Channel End and Device End are presented after the Home Address has been written. The format for the transferred information is as follows:

3890 Byte	Definition
10–13	Defect Skip Displacement
14, 15	Cell Number
16–18	Physical Address
19	Home Address Flag
20, 21	Cylinder Address
22, 23	Head Address
24–27	Not Used

Note: This command is also known as Write Special Home Address and is sometimes classified as a Write command.

Data Address — Defines main storage location of Home Address bytes.

Flags — Used at the programmer's discretion.

Count — 28.

Initial Status — Normally 0.

Chaining Requirements — Unit Check ending status (sense information reporting Command Reject with Format 0, Message 2) occurs if one of the following conditions is encountered.

- The *Diagnostic Write Home Address* command is not preceded by a *Seek, Seek Cylinder, Locate Record, Read IPL,* or *Recalibrate* command
- This command is outside the *Locate Record* domain and the currently accessed track is in the device-support address space.
- The *Diagnostic Write Home Address* command is in the domain of a *Locate Record* that does not specify a Format Write (code 03) operation and Index orientation (Byte 0, bits 0 and 1 are '11').

When *Diagnostic Write Home Address* is the last command in a chain, the remainder of the track will be erased. For commands other than *Write Record 0* chained from *Diagnostic Write Home Address,* the command will be executed after the track is erased.

When outside the domain of a *Locate Record* command, this command is valid only if the channel program is operating with Diagnostic Authorization and allows writing Home Address. When the file mask does not specify Diagnostic Authorization (bits 5 and 6 are not '10'), the operation is rejected with Unit Check ending status. Sense data reports Command Reject with Format 0, Message 5 (Diagnostic Command not permitted). If the file mask does not allow all writes (bits 0 and 1 are not '11'), the operation is rejected with Unit Check ending status. Sense information reports Command Reject with Format 0, Message 2.

3.53 Diagnostic Sense/Read

Command Code C4 (hex)

This command transfers bytes of diagnostic information to the channel depending on the subcommand specification indicated in Byte 0 of the preceding *Diagnostic Control* command. The format of the diagnostic data may be any one of the following subcommands in Byte 0 of the *Diagnostic Control* command:

Byte 0	Subcommand of Diagnostic Control Command
01	Locate Data Checks
06	Select Subsystem Data
07	Select Trace
0D	Start Application

If the preceding *Diagnostic Control* command does not indicate one of these subcommands, zeros are returned by the *Diagnostic Sense/Read* command.

> ***Note:*** *This command is intended for maintenance purposes only. Any other use may produce unpredictable results.*

Whenever *Diagnostic Sense/Read* successfully executes, Channel End and Device End are posted following the transfer.

Data Address — Defines main storage location for first byte of diagnostic information.

Flags — Used at the programmer's discretion.

Count — 6656 (maximum)

Initial Status — Normally 0.

Chaining Requirement — *Diagnostic Sense/Read* is not valid in the domain of a *Locate Record* command. If it is in a *Locate Record* domain, it is rejected with Unit Check ending status and subsequent sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

Diagnostic Sense/Read must be preceded by a *Diagnostic Control* command in the same chain and it must be chained directly from the *Diagnostic Control* command except for the following:

- when the *Diagnostic Control* subcommand is '01', the *Diagnostic Sense/Read* command must be chained from a Read command.
- when the *Diagnostic Control* subcommand is '0D', the *Diagnostic Sense/Read* command must be chained from a *Diagnostic Write* command.

If these conditions are not met, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2.

3.54 Diagnostic Read Home Address

Command Code 0A (hex)

This command transfers the defect skip displacement bytes, cell number, physical address byte, flag, identifier (CCHH), and ECC bytes for the Home Address field to main storage. ECC bytes following the Home Address are used to validate the field. Command retry is initiated by the SP if Data Overrun or Data Check error conditions are encountered. Channel End and Device End are presented after reading the Home Address ECC bytes.

> *Note: This command is also known as Read Special Home Address and is sometimes classified as a Read command.*

Data Address — Defines main storage location of the first Home Address byte.

Flags — Used at the programmer's discretion.

Count — 28.

Initial Status — Normally 0.

Chaining Requirement — Unit Check ending status (sense information reporting Command Reject with Format 0, Message 2) occurs if one of the following conditions is encountered.

- The *Diagnostic Read Home Address* command is not preceded in the command chain by a *Seek, Seek Cylinder, Locate Record, Read IPL,* or *Recalibrate* command.
- This command is in the domain of a *Locate Record* that does not specify a Read (code 16) operation and Index orientation (Byte 0, bits 0 and 1 are '11').

When outside the domain of a *Locate Record* command, the *Diagnostic Read Home Address* command is valid only if the channel program is operating with Diagnostic Authorization. When the file mask does not specify Diagnostic Authorization (bits 5 and 6 are not '10'), the operation is rejected with Unit Check ending status. Sense data reports Command Reject with Format 0, Message 5 (Diagnostic Command not permitted).

3.55 Diagnostic Control

Command Code F3 (hex)

This command transfers, from main storage to the SP, four bytes of *Diagnostic Control* parameters that specify a service or information request. Following the transfer, the SP validates the subcommand, its modifiers, and the settings for Bytes 2 and 3 (Bytes 2 and 3 should equal 0). Except when the subcommand is *Set Guaranteed Path*, Channel End is presented after the parameter list is validated. Device End is presented after normal termination. Channel End and Device End can occur together.

The four bytes of *Diagnostic Control Parameters* are formatted as follows:

Byte 0 — Subcommand

Byte 1 — Subcommand Modifier

Bytes 2 and 3 — Must be zeros.

Valid subcommands for this subsystem include the following hexadecimal values specified in Byte 0 of the *Diagnostic Control* command. Any other value results in Unit Check ending status.

Hex Value of Byte 0	Subcommand
01	Locate Data Checks
02	Inhibit Write
04	Set Guaranteed Path
06	Select Subsystem Data
07	Select Trace
08	Enable Write
0C	Unfence
0D	Start Application

These values are the only ones valid for Byte 0. If Byte 0 does not contain a valid value, and Bytes 2 and 3 are not zeros, the command is rejected with Unit Check ending status. The sense data contains Command Reject with Format 0, Message 4 (Data Value not as required).

Subcommand Descriptions

Locate Data Checks (01) — This setting allows the programmer to trace Data Checks. When this subcommand is specified, all Data Checks that occur during execution of a Read command will be processed without raising Unit Check or initiating a command retry sequence. Information about the Data Checks, detected in the first field that yielded a Data Check, will be entered in a table generated by the *Locate Data Checks* subcommand. This table will be transmitted to the host via the *Diagnostic Sense / Read* command.

Unit Check ending status, sense information reporting Command Reject with Format 0, Message 2, results if this *Diagnostic Control* command specifying a *Locate Data Checks* subcommand is not chained to a Read-type command and then followed by a *Diagnostic Sense/Read* command.

Inhibit Write (02) — This setting prevents all subsequent Write operations by the SP on the paths that are specified by subcommand modifiers (Byte 1). After issuing this subcommand for a path, any Write commands and *Locate Record* commands specifying write-type operations which attempt to write on this path are rejected with Channel End, Device End, and Unit Check. Unit Check indicates an Equipment Check (Byte 0, bit 3) and Write Inhibited (Byte 1, bit 6) in the sense bytes.

Byte 1 is the subcommand modifier and specifies the SP that will be governed by the *Inhibit Write* subcommand. The format of Byte 1 is as follows.

Modifier	Effect
80	Inhibits all Write operations to all devices through the selected SP.
40	Inhibits all Write operations to all devices through the selected SP from the selected channel path. On receiving this modifier, the SP first checks to determine whether the Inhibit Write subcommand is active on any other channel path. If Inhibit Write is in effect for another channel path, all Write operations are inhibited for the selected SP.
20	Inhibits all Write operations to all devices through the selected SP.

When Write operations are inhibited on a path, the path remains inhibited until one of the following occurs:

- A *Diagnostic Control* command specifies the *Enable Write* (08) subcommand.
- System reset (resets *Inhibit Write* for the channel path in the receiving SP).
- IML (resets all *Inhibit Write* controls in the SP).
- Reset switch for the SP is activated (resets all *Inhibit Write* controls in the SP).

Bytes 2 and 3 of the *Inhibit Write* subcommand must be zeros. If not zeros, the *Diagnostic Control* command is rejected with Unit Check and sense bytes containing Command Reject with Format 0, Message 4 (Data Value not as required).

Set Guaranteed Path (04) — When the specified SP receives this subcommand in the *Diagnostic Control* command, the command performs the functions of the *Suspend Multipath Reconnection* command (see Section 3.14 for a description of this command). Byte 1, the subcommand modifier for *Set Guaranteed Path*, must be set to zeros. If Byte 1 is not valid, the command is rejected with Unit Check ending status and sense information reporting Command Reject with Format 0, Message 4.

For this subcommand of the *Diagnostic Control* command, the SP presents Channel End and Device End status when it establishes a path.

Select Subsystem Data (06) — This subcommand and its modifier are used to identify the subsystem trace that is to be sent by the immediately following *Diagnostic Read* commands. For the 3890-2 subsystem, Byte 1 (subcommand modifier) set to '01' is the only valid value. This subcommand modifier is defined as "Query Trace" and can be used to provide the IDs of all traces currently stored in the subsystem, along with their lengths and content flags.

Bytes 2 and 3 must be set to zero. If not zero, the command is rejected with Unit Check ending status and sense bytes containing Command Reject with Format 0, Message 4.

Select Trace (07) — This subcommand specifies that the trace, identified by the modifier of the *Select Subsystem Data* subcommand or, alternatively, the only available trace, will be sent to the channel by the immediately following *Diagnostic Sense/Read* command(s). The trace can be up to 24 blocks of 1024 bytes.

If any other command is received before all of the trace data is read, or a *Diagnostic Sense/Read* command is received after all the trace data has been read, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

Enable Write (08) — This setting allows the SP to cancel the effect of any previous *Inhibit Write* subcommands set by this SP, thus enabling it to process all Write commands normally. Parameter Bytes 1 through 3 are not used in this case and must be set to zero. If not zeros, the command is rejected with Unit Check ending status and sense bytes containing Command Reject with Format 0, Message 4.

Unfence (0C) — This subcommand removes fences. The specification in Byte 1 defines what to unfence as indicated below.

Bits	Significance
0–3	Unfences one or more storage paths where each bit corresponds to the respective SP (0, 1, 2, or 3).
4	Unfences a device. The addressed device is unfenced from all SPs in the subsystem. Bits 0 through 3 must be zeros when bit 4 is set to 1.
5–7	Reserved. These bits must be set to zeros.

When this subcommand is used, at least one bit in bits 0 through 4 must be set and bits 5 through 7 must be zeros. If bit 4 is set to 1, bits 0 through 3 must be zeros. When Byte 1 is not valid, the command is rejected with Unit Check status. The sense bytes contain Command Reject with Format 0, Message 4.

If channel operations are queued in the SP that is unfenced, the operations are terminated with status that includes Unit Check. The sense data contains Format 0, Message 9 (Storage Path Restart).

The SP presents Channel End when it receives the parameters. Device End occurs when the unfencing operation is complete although Channel End and Device End can occur together.

Start Application (0D) — This subcommand prepares the subsystem for a *Diagnostic Write* command which has a Support Facility Application identifier, the device type, and parameters for the application. A *Diagnostic Sense/Read* can be chained from the *Diagnostic Write* command when status or data from the application is needed.

Byte 1, the subcommand modifier, determines the number of parameter bytes that the following *Diagnostic Write* command expects to transfer. If Byte 1 is zero, 256 parameter bytes are expected. If Byte 1 is not zero, it contains the number of expected parameter bytes.

Only a *Diagnostic Write* command can be chained from a *Diagnostic Control* command with the *Start Application* subcommand. If any other command is received, the command is terminated with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2.

Data Address — Defines the main storage location of the *Diagnostic Control* parameters.

Flags — Used at the programmer's discretion.

Count — 4. The SP expects four bytes of parameters. If the channel sends less than four bytes, the command is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 3 (CCW Count less than required).

Initial Status — Normally 0.

Chaining Requirements — The *Diagnostic Control* command is not valid in the domain of a *Locate Record* command. If it is received in the *Locate Record* domain, it is rejected with Unit Check ending status. The sense information contains Command Reject with Format 0, Message 2 (Invalid Sequence).

This command cannot be preceded in a chain by a command that specifies or implies cylinder and head selection — *Locate Record, Seek, Seek Cylinder, Seek Head, Read IPL,* or *Recalibrate* command. If *Diagnostic Control* is preceded with one of these commands, the command is rejected with Unit Check ending status (sense information reports Command Reject with Format 0, Message 2).

All subcommands require either Diagnostic or Device Support Authorization, or that the command be the first in a chain. If the subcommand does not have the correct authorization, the command is rejected with Unit Check ending status. The sense information contains Command Reject with Format 0, Message 5 (Diagnostic Command not permitted). The following subcommands are allowed only in a channel program that is operating with Diagnostic Authorization or Device Support Authorization.

- Locate Data Checks
- Inhibit Write
- Set Guaranteed Path
- Enable Write
- Unfence
- Start Application

The *Select Subsystem Data* or *Select Trace* subcommand must be the first command in a chain or be chained directly from a *Suspend Multipath Reconnection* that is the first command in a chain. If not first in a chain, the command is rejected with Unit Check ending status. The sense information contains Command Reject with Format 0, Message 2 (Invalid Sequence).

Any additional chaining requirements that must be observed when using subcommands of the *Diagnostic Control* command are provided in the preceding subcommand descriptions.

3.56 Diagnostic Write

Command Code 73 (hex)

The *Diagnostic Write* command transfers data from the channel to the subsystem. The amount of data and the content of the data that the *Diagnostic Write* command transfers is determined by the *Diagnostic Control* command that must precede it. The format of the data for the command is as follows.

Byte	Content of Data Transferred by Diagnostic Write
0	Application identifier — Not used and must be zero.
1	Device type — Not used and must be zero.
2 - 257	Application data — Provides the data content to be transferred. The number of bytes of this application data is determined by the setting of the parameters in Byte 1 of the preceding *Diagnostic Control* command. If parameter Byte 1 of the *Diagnostic Control* command is 0, 256 bytes of application data are read from the channel. If parameter Byte 1 of the *Diagnostic Control* command is not 0, Byte 1 then contains the number of bytes to be read from the channel. This number can be from 1 through 255 bytes.

The SP presents Channel End when it receives data from the channel. It presents Device End when the operation completes. Channel End and Device End can occur together. If a *Diagnostic Sense/Read* command follows the *Diagnostic Write* command, the resultant data from the application sent to the storage path is transferred to the channel.

Data Address — Defines the main storage location of the data.

Flags — Used at the programmer's discretion.

Count — Up to 258 bytes. If the channel transfers more bytes than expected, only the expected number of bytes are accepted. If too few bytes are transferred, the command is rejected with Unit Check ending status. Sense information reports Command Reject with Format 0, Message 3 (CCW Count less than required).

Initial Status — Normally 0.

Chaining Requirements — The *Diagnostic Write* command must be preceded in the same chain by a *Diagnostic Control* command with the *Start Application* (0D) subcommand. In addition, it must be chained directly from the *Diagnostic Control* command or another *Diagnostic Write* command. If these conditions are not met, the command is rejected with Unit Check ending status. Sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence).

A *Diagnostic Sense/Read* or another *Diagnostic Write* command can be chained from this command. If *Diagnostic Write* commands are chained directly together, each must transfer the same number of bytes specified by the *Diagnostic Control* command. When chained directly together, status and data from all but the last *Diagnostic Write* command are lost.

3.57 Perform Subsystem Function

Command Code 27 (hex)

This command provides one of two functions, depending on the function order specified in Byte 0 (see Function Order Descriptions below). It can be executed on devices with equipment checks or intervention required conditions.

Bytes 0 and 1 are common to the two valid orders of this command where Byte 0 specifies the hex value of the selected order and Byte 1 is a flag byte. Valid values for Byte 0 are as follows:

Hex Value	Byte 0 Order for Perform Subsystem Function Command
00–17	Not valid for this subsystem.
18	Prepare for Read Subsystem Data.
19–1A	Not valid for this subsystem.
1B	Set Special Intercept Condition.
1C–FF	Not valid for this subsystem.

The flag byte, Byte 1, contains information specific to the particular function order selected in Byte 0. For the two valid orders of this command on the 3890-2 subsystem, Byte 1 must be zero. If not zero, the command is rejected with Unit Check ending status and the sense information contains Command Reject with Format 0, Message 4 (Data Value not as required).

Function Order Descriptions

Prepare for Read Subsystem Data (18) — This order stores data in an internal buffer of the SP for subsequent retrieval by a *Read Subsystem Data* command.

The order requires 12 parameter bytes, including Byte 0, which specifies selection of the order (18). The significance of Bytes 1 through 11 is as follows:

Bytes	Significance
1	Flag Byte — Must be zero. Any other value results in rejection.
2–5	Reserved — Must be zeros.
6	Suborder defining the data to place in the buffer. • 00 = The status of the SPs in the subsystem. This is the only valid value for Byte 6. • 01 - FF = Not used and these values are invalid.
7–11	Not used and must be zeros.

The *Perform Subsystem Function* command with this order specified requires 12 parameter bytes (Byte 0 specifies '18,' the function order). If these parameter bytes are specified with invalid values, the command is rejected with Unit Check ending status (sense bytes contain Command Reject with Format 0, Message 4).

The SP presents Channel End after it validates the parameters. Device End occurs when the data is available although, in most cases, Channel End and Device End occur together.

Only a *Read Subsystem Data* command can be chained from the *Perform Subsystem Function* command that specifies this order. If any other command is chained from the command with this order, it is rejected with Unit Check ending status. The sense information reports Command Reject with Format 0, Message 2 (Invalid Sequence) and the contents of the buffer can be lost. The buffer's content can also be lost if the order is not chained but, in this case, the SP does not report the error (see *Section 3.59, Read Subsystem Data*).

Set Special Intercept Condition (1B) — This order sets a condition in the subsystem that causes the 3898-2 to reject specific commands for the addressed device.

The order applies only to those paths with the same path group ID (regardless of the grouping status) for the addressed device that receives the next specific command. Only the next specific command received for this address on a path with the specified path group ID is rejected with Unit Check ending status. The sense data reports Command Reject with Format 0, Message F. The SP presents Channel End and Device End after processing completes.

On this subsystem the following two commands can be intercepted and rejected by specifying this order:

- *Perform Subsystem Function* with function order '1B,' *Set Special Intercept Condition*, and
- *Diagnostic Control* with any option.

This order requires two parameter bytes; a valid order byte (Byte 0 = 1B) and the flag byte. The flag byte is Byte 1 and must be zero. If the flag byte is not zero, the command is rejected with Unit Check ending status. Sense information contains Command Reject with Format 0, Message 4 (Data Value not as required).

If the 3898-2 receives less than two parameter bytes for this command and function order, the command is rejected with Unit Check ending status. Sense bytes contain Command Reject with Format 0, Message 3 (CCW Count less than required).

If a device is operating in this condition for a channel path, and the status includes Attention for this device for this path, the SP adds Unit Check to that status. This added Unit Check status does not reset the device to normal operation.

If this command is directed to a device on an interface for which a path group has not been established, the command is rejected with Unit Check ending status. The sense bytes contain Command Reject and Environmental Data Present with Format 0, Message F.

System resets follow normal path group rules for resetting the device to normal conditions. Processing this command with this function order or processing a *Diagnostic Control* command resets the addressed device to normal conditions. However, processing a Selective Reset, a *Set Path Group ID*, or a *Suspend Multipath Reconnection* command does not reset the addressed device to normal conditions.

This command and function order specification must be the first command in a chain or be immediately preceded by a *Suspend Multipath Reconnection* command that is the first command in a chain. If not, the command is rejected with Unit Check ending status (Invalid Sequence in the sense bytes). Also, if any command is chained from this command, it is rejected with Unit Check ending status.

Data Address — Defines the main storage location of the function order.

Flags — Used at the programmer's discretion.

Count — Variable depending on the number of parameter bytes associated with the specified function order. If the channel sends more bytes than the order requires, the SP accepts only the number of bytes required by the order. If the channel sends too few bytes to satisfy the requirements of the order, the command is rejected with Unit Check ending status (sense bytes indicate CCW Count less than required).

Initial Status — Normally 0.

Chaining Requirements — The *Perform Subsystem Function* command is not valid in the domain of a *Locate Record* command. If it is received in the *Locate Record* domain, it is rejected with Unit Check ending status. The sense information contains Command Reject with Format 0, Message 2 (Invalid Sequence).

All function orders of the command require a cache subsystem except for '18' and '1B'; therefore, the command is rejected with Unit Check ending status if any other order or value is specified. The sense information reports Command Reject with Format 0, Message 4 (Data Value not as required).

3.58 Read Configuration Data

Command Code FA (hex)

A description of this command will be supplied at a later date.

3.59 Read Subsystem Data

Command Code 3E (hex)

The *Read Subsystem Data* command causes the 3898-2 to send the data requested by the *Perform Subsystem Function* command. The format of the data depends on the suborder indicated in Byte 6 of the *Prepare for Read Subsystem Data* order of the *Perform Subsystem Function* command (see *Section 3.57, Perform Subsystem Function*). For the 3890-2 subsystem, the only valid suborder in Byte 6 is '00,' which indicates that the *Read Subsystem Data* command is to send Storage Path Status data.

When the *Perform Subsystem Function* command has the order code *Prepare for Read Subsystem Data* with Byte 6 indicating '00,' a 16-byte record containing 4 bytes of path status for each storage path is read. The contents of this record are shown below; the status of each storage path is indicated in the following 4-byte increments of the 16-byte record.

- Bytes 0 - 3 describe Storage Path 0
- Bytes 4 - 7 describe Storage Path 1
- Bytes 8 - 11 describe Storage Path 2
- Bytes 12 - 15 describe Storage Path 3

Bytes	Bit	Significance
0, 4, 8, or 12	0	Storage Path/Device Status 0 = Storage path is not installed on subsystem. 1 = Bytes 1 through 3 (or 5 - 7, 9 - 11, or 13 - 15) contain valid values.
	1	Device attaches through this storage path.
	2	0 = This storage path is enabled. 1 = The following three bytes are not valid because the storage path is disabled.
	3	Device has permanent or internal fence from this storage path (two-way fences are excluded).
	4	Command received on this path.
	5–7	ID of channel requesting status (0 = Channel A, 1 = Channel B, etc.).
1, 5, 9, or 13		Bit map of channels configured in this storage cluster.
2, 6, 10, or 14		Bit map of Channel Enabled/Selected switches.
3, 7, 11, or 15		Bit map of channels fenced from this storage path.

When data transfer is complete, Channel End and Device End are presented.

Data Address — Defines the main storage location for the data.

Flags — Used at the programmer's discretion.

Count — Specifies the number of bytes that the *Perform Subsystem Function* command requests. If the CCW count is more than the number of bytes specified for the data, only the specified number of data bytes are transferred. If the count is less than the message requested, only the specified number of bytes are transferred.

Initial Status — Normally 0.

Chaining Requirements — The *Read Subsystem Data* command is not valid in the domain of a *Locate Record* command. If it is received in the *Locate Record* domain, it is rejected with Unit Check ending status. The sense information contains Command Reject with Format 0, Message 2 (Invalid Sequence).

This command must be chained from a *Perform Subsystem Function* command which specifies a *Prepare for Read Subsystem Data* order. If not in this chain, the command is rejected with Unit Check ending status (sense information reports Command Reject with Format 0, Message 2). In addition, only a *Perform Subsystem Function* command can be chained from the *Read Subsystem Data* command. Any other command chained from *Read Subsystem Data* is rejected.

3.60 Test I/O

Command Code 00 (hex)

This command transfers one status byte from the SP to the channel. This byte is normally set to 0 except when stacked or pending status is posted in the SP or drive. Test I/O command is a system/channel instruction, not a CCW. The subsystem treats the command as an immediate command.

Data Address — Defines main storage location where status byte is to be transferred.

Flags — Not used.

Count — 1.

Section 4
Track Format

4.1 Introduction

Designed to support the command description, this section of the manual presents the track format for the drives that attach to the 3898-2. The reader will find this information particularly useful in relation to the *Read, Write, Diagnostic Read Home Address,* and *Diagnostic Write Home Address* commands. In addition, Section 4 briefly discusses defect skipping and alternate tracks, two design features that minimize the impact of media flaws.

4.2 Track and Record Format

The track and record format for 3890 devices is illustrated in Figures 4-1. The track starts with a track Index, followed by a Home Address and a series of variable length data records in a count, key, data format. Each of these items is separated from the next by a gap — an area that contains filler patterns and structures used to orient the drive. The various track fields are as follows:

- **Home Address Field.** This area contains information that identifies the track. The Home Address is composed of a skip defect field which contains the absolute displacement of the defect skips permitted for the track, the cell number of the field, the physical address (the cylinder and head address of the track), and a Home Address flag which identifies track status. The Home Address also includes an identifier for the cylinder and head, zero-fills, and a set of twelve ECC bytes which contain an Error Code used to recover data if the field is transmitted in error.

- **Count Field.** This field provides identifying and control information for a record. All Count fields have the same general format as the Home Address field with a record number, a key length, and a data length appended.

- **Key Field.** This field is a variable length area that, if used, furnishes indices for the Data field. The Key field contains twelve ECC bytes in addition to user information. Inclusion of Key fields on a track is optional; the Key field is generally omitted from Record 0.

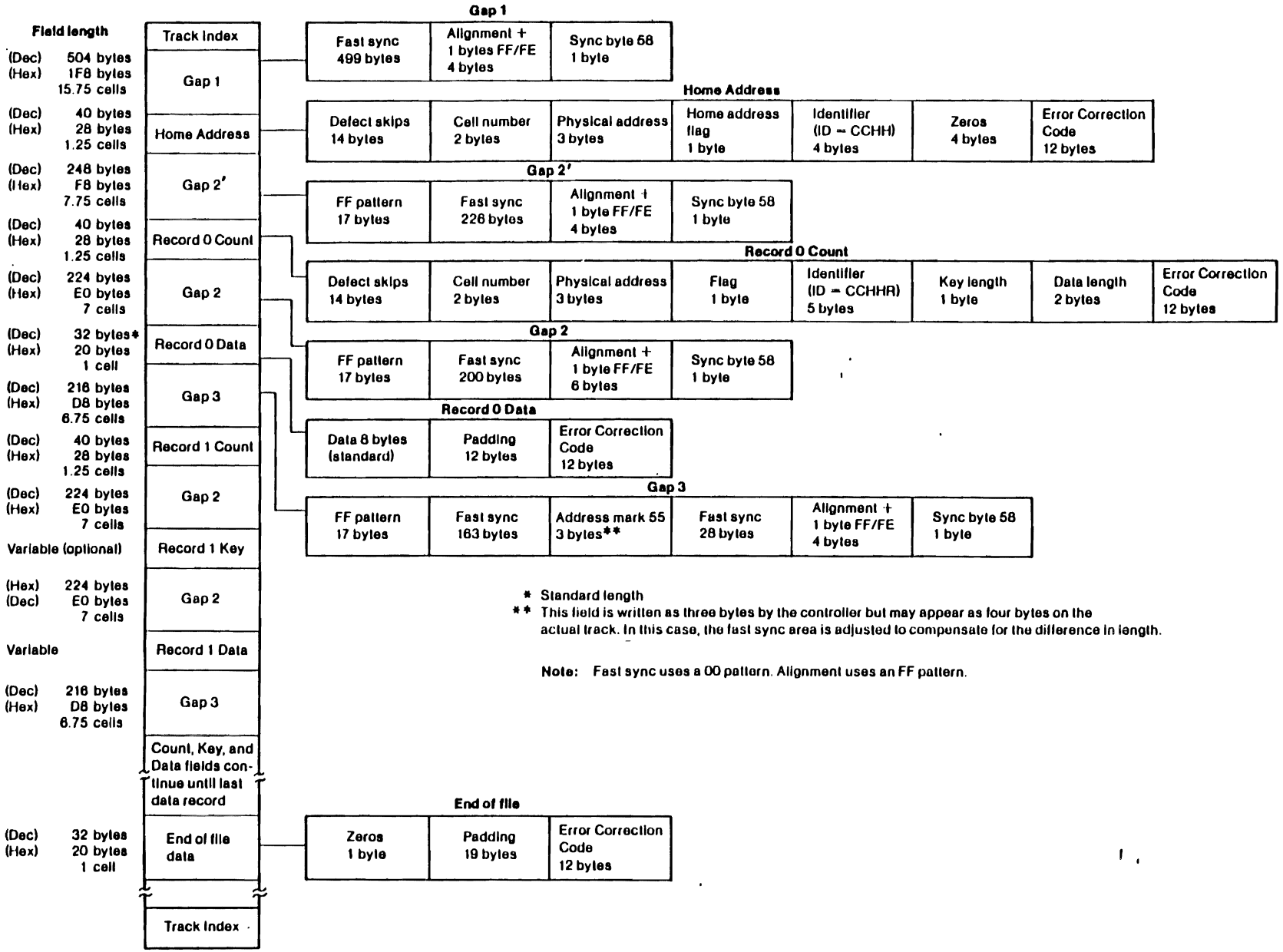
- **Data Field.** The Data field contains user data and is variable in length. Twelve ECC bytes are appended to this field. As an exception to this general format, the Record 0 Data field is usually a fixed length of eight bytes and does not store customer data. Instead, the eight bytes of the Record 0 Data field contain information used by the CPU. Also, if the Data field is part of an End-of-File record (last record on the track), the field is one byte of zero plus ECC. Data length for an End-of-File record is always expressed as zero.

• **Gaps.** The 3890 utilizes three different gap types as record and field separators. The track index is followed by a gap (Gap 1) field that contains 504 bytes and includes fast sync, alignment bytes, and a sync byte. Each record is separated from the next by a Gap 3 field which contains 216 bytes and includes an address mark, fast sync, alignment bytes, and a sync byte. The fields within each record are separated by a Gap 2 field — 224 bytes including fast sync, alignment bytes, and a sync byte. The Gap 2′ field separates Bome Address from the Record 0 Count field. This field contains 248 bytes including fast sync, alignment bytes, and a sync byte.

4.3 Defect Skipping and Alternate Tracks

The subsystem control functions provide defect skipping for each track; this feature allows media faults to be logically avoided during most command operations. A defect skip consists of 96 bytes (3 cells) of zeros and synchronization patterns written over the defective area of the track and referenced in the Home Address and Count Fields. When the microcode reads the Home Address or Count fields, it determines the location of the defect skip and avoids that area. The drive permits seven defect skips per track; tracks containing more that seven defects are considered defective.

In addition to defect skipping, the disk provides 15 alternate tracks (one cylinder). These tracks can be linked to user data tracks in the event that a data track proves defective. Once the data track and the alternate track are linked, all operations normally routed to that track will be routed to the alternate. Thus, data for the original track will be stored on the alternate.



* Standard length

** This field is written as three bytes by the controller but may appear as four bytes on the actual track. In this case, the fast sync area is adjusted to compensate for the difference in length.

Note: Fast sync uses a 00 pattern. Alignment uses an FF pattern.

Figure 4-1. Track Format

Section 5
Error Handling

5.1 General Description

The 3898-2 Cluster Control Unit is equipped with the logic to perform various error handling functions for the subsystem. Error handling functions serve the subsystem by ensuring the integrity of the data passed to the channel, minimizing the number of command rejections, and maintaining records of subsystem usage and error incidences for performance evaluation by the customer and CE. The error handling capabilities of the 3898 include three main functions: the error function, the command retry function, and the statistical/error recording function. The following paragraphs describe the first two of these functions; the statistical/error recording function is covered in Section 6.

5.2 Error Function

The disk drive data error function is inherently linked to the generation of the Error Correction Code (ECC) at the controller level. Each time that the SP receives a write command, it generates a series of bytes (see Figure 4-1) which are appended to the field written on the track. When the field is subsequently read, the 3898 examines it for errors. If an error is detected in the Home Address, Count, Key, or Data fields, the SP handles the error by performing a retry for the command in question. Given a correctable Data Check in one of these fields, the 3898 applies an error algorithm to reconstruct the original data. The corrected data is then transferred to the CPU.

5.3 Command Retry Function

The command retry function can allow several different types of errors. In essence, command retry consists of repeating a command a prescribed number of times or until the operation is successfully completed. During the course of the retry sequence the channel releases the 3898-2. If the command fails throughout the retry sequence, the error is considered unrecoverable and is logged to the system error records. Command retry sequences are executed if a *Read* or *Search* command produces a correctable Data Check, an uncorrectable Data Check is detected, an assigned alternate track is indicated in the Home Address/Record 0 Count field of a defective primary, or a seek error/seek incomplete occurs. The command retry function is also activated when a Command Overrun is present, a Data Overrun occurs, or a track pad operation is in progress for the selected device (in this case a command retry allows the device to be released by the channel).

Section 6
Sense Data

6.1 General Description

Sense data comprises 32 bytes of information that define device or subsystem conditions. This data is gathered from the usage and error counters when one of the counters overflows; the information is then transmitted to the CPU as part of the statistical/error recording function. When the sense bytes are transferred to the CPU, they are stored in the system error and statistical logs (SYS1.LOGREC) and may be retrieved by executing the Environmental Recording, Editing, and Printing (EREP) program.

The EREP program formats the sense data in accordance with the type of information presented in the sense bytes. For instance, certain sense reports are statistical in nature. These reports record the number of accesses, bytes read, etc., for a given device over a period of time. Statistical reports also display the number of Command Overruns and Data Overruns experienced during the time interval. Other types of sense reports are specific in nature, referring to a particular error occurrence and describing the device/subsystem condition at the time of the failure.

The subject of the report presented by EREP is determined by the format sense byte. The format sense byte defines the information stored in the sense byte group as follows; the customer should note that not all subsystems utilize all formats.

Format	Definition
0	Program or system checks
1	Device equipment checks
2	Cluster Control equipment checks
3	Storage Path control checks
4	Data checks
5	Data checks with PCI fetch mode
6	Usage statistics/overrun errors
7	Storage Path check 1 errors
8	Storage Path check 2 errors
9	Device read, write, and seek checks

The 32-byte sense information provides a 24-byte compatibility reporting format to retain compatibility with other disk subsystems that report 24 bytes of sense data. Byte 27 with bit 0 set to 1 indicates that the first 24 bytes of sense data are comparable. Sense information reported as 32 bytes appends 8 additional bytes to the first 24 and these 8 bytes contain the same sense information for all formats (0 through 9).

For the user's reference, the following text presents information on Sense Bytes 0 through 7 as reported by the 3890 subsystem. Sense Bytes 8-31 detail conditions according to one or more of the formats indicated above and have been omitted from this discussion. The description of Sense Bytes 0 through 7 is supported by Tables 6-1 through 6-3.

Table 6-1. Summary of Sense Bytes 0 through 7

Bit	Sense Bytes							
	Byte 0	Byte 1	Byte 2	Byte 3 (Format 1, 2, 6, 7, 8, and 9)*	Byte 4**	Byte 5***	Byte 6****	Byte 7
0	Command Reject	Permanent Error	Request Write Inhibit	Controller ID (Path Identifier)	Path in Use	Low-Order Cylinder Address Cylinder 128	High-Order Cylinder Address 2048	Format Decode (See Table 6-2)
1	Intervention Required	Invalid Track Format	Correctable			Cylinder 64	High-Order Cylinder Address 1024	
2	Channel Bus Out Parity Check	End of Cylinder	First Logged Error		Logical Device Address	Cylinder 32	High-Order Cylinder Address 256	
3	Equipment Check	Message to Operator	Environ-mental Data Present			Cylinder 16	Head Address 128	
4	Data Check	No Record Found	0 (Not Used)			Cylinder 8	Head Address 8	Message Code (See Table 6-3)
5	Overrun	File Protected	Imprecise Ending (Compatiblity Bit)			Cylinder 4	Head Address 4	
6	0 (Not Used)	Write Inhibited	0 (Not Used)			Cylinder 2	Head Address 2	
7		Imprecise Ending				Cylinder 1	Head Address 1	

*For Formats 0 and 3, Byte 3 is set to 00. The Controller ID is in Byte 20 for Format 0. For Formats 4 and 5, the Controller ID is in Byte 14 and Byte 3 is set to 00 except for condition 1 indicated below.

1. If Byte 2, Bit 3 is 1 and Byte 1, Bit 7 is 0, Byte 3 indicates the number of retries attempted by the SP for a record with a temporary data check.
2. If Byte 1, Bit 7 is 0, Byte 3 contains the Controller ID for Formats 1, 2, 6, 7, 8, and 9.
3. If either Byte 1, Bit 7 or Byte 1, Bit 5 is set to 1, Byte 3 indicates the number of records remaining to be processed in the Locate Record domain.

**Set to zero when the SP is not reporting device status.

***If set to 01 for Format 6, byte indicates Command Overrun counter overflow.

****If set to 01 for Format 6, byte indicates Data Overrun counter overflow.

Table 6-2. Sense Byte 7 Format Decode

Format Decode	Type of Format Decode
0	Program or System Checks — This format is generated when Sense Bytes 0-7 describe the error or unusual condition caused by a program or system error.
1	Device Equipment Checks — This format is generated under the following conditions: • Detection of drive, SP/device interface, or SP equipment checks (Sense Byte 0, Bit 3, Equipment Check is also set). • Detection of a device seek check (Sense Byte 0, Bit 3, Equipment Check is also set). • Off-loading of error log information occurred during a successfully retried seek (Byte 2, Bit 3, Environmental Data Present is also set). A seek error was indicated by the message bits in Sense Byte 7. • No online indication in the status (Sense Byte 19, Bit 4, Format 1). Sense Byte 0, Bit 1, Intervention Required is also set.
2	Cluster Control Equipment Checks — This format identifies cluster control failures. The SPs report these types of failures to the system.
3	Storage Path Control Checks — This format is generated to report miscellaneous conditions recorded by the SP in question. These conditions include power-up errors that occur on other SPs, detection of high temperature or power supply failures, and trace table save operations.
4	Data Checks — This format is generated under the following conditions: • Detection of an uncorrectable Home Address, Count, Key, or Data field Data Check after retry failed. • Detection of a Home Address, Count, Key, or Data field Data Check while the subsystem was operating in a diagnostic mode. The Data Check was successfully recovered. • Detection of a Home Address, Count, Key, or Data field Data Check while the subsystem was in logging mode. The Data Check was successfully recovered. • Detection of a Home Address, Count, Key, or Data field Data Check. The error was successfully recovered using head offset during the subsystem retry sequence.

continued

Table 6-2. Sense Byte 7 Format Decode (continued)

Format Decode	Type of Format Decode
5	Data Check with PCI Fetch Mode — This format is generated on detection of a correctable Data Check in the Key or Data field that was successfully recovered via retry with PCI Fetch Mode set in the file mask.
6	Usage/Error Statistics — This format is generated if the usage statistics or overrun errors require off-loading because of a counter-overflow condition or because a Read and Reset Buffered Log command has been issued.
7	Storage Path Check 1 — This format is generated when a Check-1 condition is detected by the SP.
8	Storage Path Check 2 — This format is generated when a Check-2 condition is detected by the SP.
9	Device Read, Write, and Seek Checks — This format is generated under the following conditions: • Detection of a device seek check (Byte 0, Bit 3, Equipment Check and is also set). • Off-loading of error log information occurred during a successfully retried seek (Byte 2, Bit 3, Environmental Data Present is also set).

Table 6-3. Formats and Message Codes in Sense Byte 7

Format (Bits 0-3 Hex)	Message Codes (Bits 4 through 7 Hex) (Byte 1, Bit 3=0)							
	0	1	2	3	4	5	6	7
0 Program or System Checks	No Message	Invalid Command (Device Sense Data Logged Byte 1, Bit 3=1)	Invalid Sequence (Not used Byte 1,Bit 3=1)	CCW Count Less that Required (Device Fenced Byte1,Bit 3=1)	Data Value Not as Required (Not Used Byte 1,Bit 3=1)	Diagnostic Command Not Permitted (Not Used Byte 1,Bit 3=1)	Channel Retry Not Indicated (Not Used Byte 1,Bit 3=1)	Incorrect Retry CCW (Not Used Byte 1,Bit 3=1)
1 Device Equipment Checks	Equipment Check/ Intervention Required	Unexpected Drive Status (Initial Select)	Storage Path Microcode-detected Error	Transmit Tag Error	Sync-out Timing Error	Unexpected Drive Status (Retry/Read IPL)	Transmit Offset Error	Transmit Target Error
2 Cluster Control Equipment Checks	0 (Not Used)							
3 Storage Path Control Checks	0 (Not Used)							
4 Data Checks	Data Check, Home Address Field	Data Check, Count Field	Data Check, Key Field	Data Check, Data Field	Home Address Sync Failure (No Sync Byte)	Count Data Sync Failure (No Sync Byte)	Key Data Sync Failure (No Sync Byte)	Data Sync Failure (No Sync Byte)
5 Data Check with PCI Fetch Mode	0 (Not Used)	0 (Not Used)	Data Check, Key Field (Correctable)	Data Check, Data Field (Correctable)	0 (Not Used)			
6 Usage/Error Statistics	Channel A Overrun Counter	Channel B Overrun Counter	Channel C Overrun Counter	Channel D Overrun Counter	0 (Not Used)			
7 Storage Path Check 1	No Message	Micro-processor Check-1	0 (Not Used)	Channel Interface Check-1	0 (Not Used)	Read/Write Check-1	SPUD Check-1	Firmware-detected Check-1
8 Storage Path Check 2	No Message	Read/Write Check-2	Read/Write Check-2	Read/Write Check-2	Channel Interface Data Transfer Check-2	0 (Not Used)		
9 Device Read, Write, and Seek Check	No Message	0 (Not Used)					Device Check-2	Head Address Miscompare

continued

Table 6-3. Formats and Message Codes in Sense Byte 7 (continued)

Format (Bits 0-3 Hex)	Message Codes (Bits 4 Through 7 Hex) (Byte 1, Bit 3=0)							
	8	9	A	B	C	D	E	F
0 Program or System Checks	Reset Notification (Not Used Byte 1,Bit 3=1)	Storage Path Restart (Not Used Byte 1,Bit 3=1)	0 (Not Used)	Improper Alternate Track Pointer (Not Used Byte 1,Bit 3=1)	0 (Not Used)			Status Not As Required (Reason Code in Byte 8 - see note)
1 Device Equipment Checks	Sector Noncompare Check	Drive Not Ready for Command	Seek Error (Physical Address Miscompare)	Seek Incomplete on Retry	No Interrupt from Drive	0 (Not Used)	Drive Check-2 Condition	0 (Not Used)
2 Cluster Control Equipment Checks	Cluster Control Check-2	0 (Not Used)						Microcode-detected Errors (Reason Code in Byte 8)
3 Storage Path Control Checks	0 (Not Used)		Trace Table Saved	Power-up Error on Another SP	High Temp Fault of Power Supply Failure	0 (Not Used)		Allegiance Terminated
4 Data Checks	0 (Not Used)							
5 Data Check with PCI Fetch Mode	0 (Not Used)							
6 Usage/Error Statistics	Channel A Seeks/Bytes Read Counter	Channel B Seeks/Bytes Read Counter	Channel C Seeks/Bytes Read Counter	Channel D Seeks/Bytes Read Counter	0 (Not Used)			
7 Storage Path Check 1	Small Buffer Check-1	Tall Buffer Check-1	0 (Not Used)					
8 Storage Path Check 2	Channel Interface Microcode-detected Check-2	SP/Device Interface Microcode-detected Check-2	SPUD Interface Microcode-detected Check-2	Read Microcode-detected Check-2	Write Microcode-detected Check-2	0 (Not Used)		
9 Device Read, Write, and Seek Check	0 (Not Used)		Track Physical Address Miscompare While Oriented	0 (Not Used)				

Note: Reason Codes in Byte 8

'29' = Perform Subsystem Function command was not issued with the Set Special Intercept Condition order but no path group has been set.

'35' = Diagnostic Control command with the Set Guaranteed Path subcommand was issued to a fenced path.

'80' = A specific command was issued to an interface that has been disabled for specific commands by a Perform Subsystem Function command with the Set Special Intercept Condition order.

'81' = Attention was presented to an interface that has been disabled for specific commands by a Perform Subsystem Function command with the Set Special Intercept Condition order.

6.2 Sense Byte Definitions

6.2.1 Sense Byte 0

Bit	Definition
Bit 0 Command Reject	1. An invalid command has been issued. 2. An invalid command sequence has been issued. 3. An invalid or incomplete argument has been transferred by a control command. 4. A command in the domain of a *Locate Record* does not conform with the operation parameter or the operation parameter of the *Locate Record* command specifies an operation the file mask inhibits. 5. In the domain of a *Locate Record* command, a multitrack operation attempts to access a track that is outside the primary track group. 6. The write portion of the file mask has been violated. 7. A Format Write command was followed by a *Space Count* command (illegal sequence). Also, a Format Write command other than *Write Home Address*, *Write Special Home Address*, or *Write Record 0* is to a track flagged as defective. 8. A Record 0 Count field for a defective track pointed to itself or an alternate track replacing a defective track pointed to itself. 9. The unit has attempted to write an invalid Home Address. 10. A track has been formatted without a Home Address.
Bit 1 Intervention Required	1. The addressed device was not physically attached to the system or is disabled (the Device Enabled/Selected switch is set to the disabled (down) position). 2. The addressed device was not available for use because the power is off. 3. The addressed device is not ready or is in CE Mode (microcode).
Bit 2 Channel Bus Out Parity	The SP has detected bad parity in data transferred from the channel. A parity error during command transfer does not cause a Command Reject.
Bit 3 Equipment Check	An unusual hardware condition has originated in the channel, SP, or drive. When this condition occurred, the SP instructed the operating system to store the first sense data and retry the failing operation up to nine times. Regardless of whether the retry cycle was successful, the system logged the error, indicating whether the condition was temporary (the retry succeeded) or permanent (the retry failed). Sense Bytes 7 through 23 contain additional information. The reader should note that Bit 3 can be set under any of the following circumstances. 1. An active CCW chain was halted due to a hardware failure. 2. The SP has executed a trace table save operation. In this case, Sense Byte 2, Bit 3 is also set. 3. A *Diagnostic Control* command has inhibited execution of a *Write* command. In this case, Sense Byte 1, Bit 6 is also set.

continued

6.2.1 Sense Byte 0 (Continued)

Bit	Definition
Bit 4 Data Check	1. An uncorrectable Data Check has occurred. 2. A Data Check has occurred but the error correction sequence was inhibited by the file mask setting. 3. A Data Check occurred while PCI Fetch mode was set in the file mask. The error was corrected through a retry sequence and the valid data was forwarded to the channel.
Bit 5 Overrun	The SP did not receive a channel response to a data transfer request or an internal recovery reconnection request within the required time limit. The SP only sets Bit 5 if the retried condition occurs more than ten times in a single command chain or if the operation in question is not one that is normally retried. Command Overrun conditions are also retried by the SP; command overruns, however, do not set this bit. A Data Overrun terminates requests for data from the channel and, if writing a record at the time the overrun occurs, the remainder of the record is padded with zeros. If there is no response to an internal recovery reconnection request, the storage path is released and the overrun is reported to the next selection of the SP/device interface.
Bits 6-7	Not used (set to zero).

6.2.2 Sense Byte 1

Bit	Definition
Bit 0 Permanent Error	This bit is set by the SP error recovery routines under a variety of conditions. The SP sets Bit 0 when a recovery attempt fails, when internal retries are not considered appropriate and the SP provides no other path, or when a retry is not desirable.
Bit 1 Invalid Track Format*	An attempt has been made to write data that exceeds track capacity. This setting also occurs during a read, search, or write operation when Index is detected in the gap following a Count or Key field. Invalid Track Format is posted whenever a write operation has attempted to execute past the end of the track. In this case, part of the record is written into the Index; subsequent read and search commands (except *Search ID*) executed against the partial track will show Bit 1 as set. A *Search ID* command can find this partial record so that it can be erased. The command sequence is *Search ID* followed by *Erase*. Finally, Invalid Track Format is set whenever an Update Write operation is initiated against a field that has a different length (key length, data length) than specified by the record size parameter. *Note: When this bit is set to 1, the residual CSW count in the interrupted CCW chain should not be used to determine track capacity because the residual count may not be accurate.*
Bit 2 End of Cylinder	A multitrack read or search operation outside the domain of a *Locate Record* has attempted to continue beyond the addressable cylinder boundary. Additionally, End-of-Cylinder will be set if the subsystem encounters either a programming error or an expected End-of-Cylinder condition.
Bit 3 Message to Operator	1. When this bit and Byte 0, Bit 3 (Equipment Check) are both set, a trace table has been saved for the SP in question. 2. When this bit and Byte 2, Bit 3 (Environmental Data Present) are both set, the SP has just completed sense data logging (auto-forced logging) for a particular error type. The auto-forced logging mode becomes inactive for the prescribed number of data or seek checks. A Format 0, message 1 is indicated in Byte 7, and a message is sent to the operator console.
Bit 4 No Record Found*	1. Two Indexes have been sensed in the same command chain without an intervening read in the Home Address field or a Data field. 2. Two Indexes have been sensed in the same command chain without an intervening *Write*, *Sense*, or *Control* command. *Note: The 3890 verifies correct actuator positioning before setting this bit.* 3. In the domain of a *Locate Record* command, the search cannot find either Record 0 or a user record after a cylinder or head switch. Imprecise Ending (Byte 1, bit 7) is also set to 1. If the record search occurs after Device End for the *Locate Record* command, the error occurs in the following command.

continued

6.2.2 Sense Byte 1 (continued)

Bit	Definition
Bit 5 File Protected*	1. The specified operation attempts to access a track outside the boundaries established by a *Define Extent* command. 2. The seek controls of the file mask have been violated by a seek operation, a *Recalibrate* command, or a multitrack operation outside the domain of a *Locate Record* command. The *Recalibrate* command may have been received with diagnostic authorization specified. 3. In the domain of a *Locate Record* command, a multitrack operation has attempted to access a track that is outside the primary track group. For this error, Command Reject (Byte 0, bit 0) is also set to 1. 4. A CE cylinder seek has violated the file mask. 5. A diagnostic command has violated the file mask. The correct file mask for diagnostic operations on a CE cylinder is C4; for diagnostic operations on any track, the correct file mask is C6.
Bit 6 Write Inhibited	This setting indicates that a *Write* command has been received on a channel which is governed by a write inhibit generated from a *Diagnostic Control* command. Write operations are inhibited to all devices on this storage path. The write inhibit condition occurs in conjunction with an Equipment Check (Byte 0, bit 3). Bit 6 is set on receipt of a *Write* or *Locate Record* command.
Bit 7 Imprecise Ending	A CCW chain terminated abnormally within the domain of a *Locate Record* command. The resulting status defines a previously executed CCW and indicates that the CCW address actually received does not agree with the CCW address expected by the SP. The condition occurs when an error is detected during the search operation in the *Locate Record* command and the search is not completed until the SP receives the next command.

* Caused by a CCW programming error or detection of an expected programming condition.

6.2.3 Sense Byte 2

Bit	Definition
Bit 0 Request Write Inhibit	The SP has asked the host system to issue a *Diagnostic Control* command specifying the Inhibit Write subcommand (02).
Bit 1 Correctable	The SP encountered a Data Check (Byte 0, bit 4) or Data Overrun (Byte 0, bit 5) while PCI Fetch mode was set in the file mask. In this case, the incorrect data was initially forwarded to the channel. After this transaction, the SP transmitted the corrected data to the channel.
Bit 2 First Logged Error	The error threshold for temporary Data or Seek Checks has been exceeded. The auto-forced logging mode has just started for the device and will remain active for 16 Data or Seek Checks. Byte 2, bit 3 (Environmental Data Present) is also set to 1.
Bit 3 Environmental Data Present	Sense Bytes 8 through 23 have usage counter statistics under Format 6. Usage statistics contain the number of bytes read or searched, the number of overruns by the channel, and the number of *Seek* commands that have been processed by the subsystem. The format for Sense Bytes 8 through 23 is contained in Byte 7. Bit 3 is set with Format 6 to indicate a usage or error counter overflow, or a *Read and Reset Buffered Log* command execution. Bit 3 indicates that the SP is in Logging Mode.
Bit 4	Not used (set to zero).
Bit 5 Imprecise Ending (CompatibilityBit)	This bit duplicates the setting of Byte 1, Bit 7 (Imprecise Ending) and is used for compatibility purposes only.
Bits 6 and 7	Not used (set to zero).

* Caused by a CCW programming error or detection of an expected programming condition.

6.2.4 Sense Byte 3

This byte contains the controller ID (storage path identifier), the residual record count, or the retry count depending on the format indicated in Sense Byte 7.

1. Controller ID — If Imprecise Ending (Byte 1, bit 7) is 0, Formats 1, 2, 6, 7, 8, and 9, indicate the controller ID as shown below.

   Note: The controller ID is in Byte 20 for Format 0 and in Byte 14 for Formats 4 and 5.

2. Residual Record Count — When either Imprecise Ending (Byte 1, bit 7) or File Protected (Byte 1, bit 5) is set to 1, Sense Byte 3 indicates the number of records that remain to be processed within the domain of a Locate Record command.
3. Retry Count — When Imprecise Ending is set to 0 and Environmental Data Present (Byte 2, bit 3) is set to 1, Byte 3 for Formats 4 and 5 reports the number of retries used to recover the error.
4. Sense Byte 3 is set to 00 for Formats 0 and 3, and for Formats 4 and 5 except when condition 3 above is encountered.

Bit	Definition
Bits 0-7 Controller ID	For sense byte Formats 1, 2, 6, 7, 8, and 9, these bits contain the controller ID when Imprecise Ending is set to zero. The CE sets the controller ID during the installation process by executing Routine 48, Controller ID Selection. Controller IDs must be in the range of 02 through FD, and all four storage paths should have the same controller ID.

6.2.5 Sense Byte 4

Bit	Definition
Bits 0, 1 Path In Use	These bits indicate the SP that was in use when the sense data was gathered. The bit setting is as follows: **Bits 0-1** — **Significance** 00 — SP 0 was in use. 01 — SP 1 was in use. 10 — SP 2 was in use. 11 — SP 3 was in use.
Bits 2-7 Logical Device Address	These bits contain the logical device address (00 through 3F).

6.2.6 Sense Byte 5

Bit	Definition
Bits 0-7 Low-Order Cylinder Address	1. This byte contains the low-order cylinder address for all formats except for Formats 3 and 6. Bit 0 = 128 Bit 3 = 16 Bit 6 = 2 Bit 1 = 64 Bit 4 = 8 Bit 7 = 1 Bit 2 = 32 Bit 5 = 4 2. Under Format 6, Byte 5 is set to 01 if the Command Overrun counter has overflowed. 3. If the storage path is not reporting device status, this byte contains zeros.

6.2.7 Sense Byte 6

Bit	Definition
Bits 0-7 High-Order Cylinder and Head Address	1. This byte contains the high-order cylinder and head address of the most recent access position for all formats except for Format 6. **Cylinder Address** / **Head Address** Bit 0 = 2048 / Bit 4 = 8 Bit 1 = 1024 / Bit 5 = 4 Bit 2 = 512 / Bit 6 = 2 Bit 3 = 256 / Bit 7 = 1 2. Under Format 6, this byte is set to 01 if the Sata Overrun counter has overflowed. 3. If the storage path is not reporting device status, this byte contains zeros.

6.2.8 Sense Byte 7

Bit	Definition
Bits 0-3 Format	These bits indicate the format of Sense Bytes 8 - 23 (Table 6-2). 0000 = Format 0 — Program or System Checks 0001 = Format 1 — Device Equipment Checks 0010 = Format 2 — Cluster Control Equipment Checks 0011 = Format 3 — Storage Path Control Checks 0100 = Format 4 — Data Checks 0101 = Format 5 — Data Checks with PCI Fetch Mode 0110 = Format 6 — Usage/Error Statistics 0111 = Format 7 — Storage Path Check-1 Errors 1000 = Format 8 — Storage Path Check-2 Errors 1001 = Format 9 — Device Read, Write, or Seek Checks
Bits 4-7 Message Codes	These bits describe the error conditions for the above formats. Messages for Formats 0-9 are defined in Table 6-3.

Appendix A
List of Abbreviations

AF	—	Advanced Function
BDAM	—	Basic Direct Access Method
BISAM	—	Basic Indexed Sequential Access Method
BPAM	—	Basic Partitioned Access Method
BSAM	—	Basic Sequential Access Method
C	—	Cylinder
CCU	—	Cluster Control Unit
CCW	—	Channel Command Word
CE	—	Customer Engineer
CMS	—	Conversational Monitor System
CPU	—	Central Processing Unit
CSW	—	Channel Status Word
CTL	—	Control
DASD	—	Direct Access Storage Device
DDR	—	Dynamic Device Reconnect
dec	—	Decimal
DSF	—	Device Support Facilities
ECC	—	Error Correction Code
EOC	—	End of Cylinder
EPO	—	Emergency Power Off
EREP	—	Environmental, Recording, Editing and Printing Program
ESA	—	Enhanced System Architecture
F	—	Flag
H	—	Head
HA	—	Home Address
HAR	—	Head Address Register
hex	—	Hexadecimal
HPO	—	High Performance Option
IML	—	Initial Microprogram Load
I/O	—	Input/Output
ICKDSF	—	Device Support Facilities
ISAM	—	Indexed Sequential Access Method
JCL	—	Job Control Language
MVS	—	Multiple Virtual Storage
OS	—	Operating System
PCB	—	Printed Circuit Board
PSU	—	Power Sequencing Unit
QISAM	—	Queued Indexed Sequential Access Method
QSAM	—	Queued Sequential Access Method
R	—	Record
SA	—	Standalone
SAM	—	Sequential Access Method
SIO	—	Start I/O
SP	—	Storage Path
TIC	—	Transfer In Channel
UCW	—	Unit Control Word
VLSE	—	Volume Level Selection Enhanced
VM	—	Virtual Machine
VSAM	—	Virtual Storage Access Method
VTOC	—	Volume Table of Contents
XA	—	Extended Architecture

Appendix B
Data Conversion and Media Considerations

B.1 Introduction

This section discusses some of the issues that the customer should consider when migrating data sets from previous drive generations (3650, etc.) to the 3890. Among the subjects that will be covered are data management philosophy, volume initialization, blocking, space calculation, and data set conversion. This section assumes a basic knowledge of access methods and the operating systems compatible with the 3890. As a point of reference, some of the terms used in the course of this discussion are defined as follows.

- **Physical Record** — A physical record is the increment used to organize data on a track. Minimally, a physical record is composed of a Count field and Data field. The Count field contains the location of the record and a description of its attributes. The Data field stores data; the length of the Data field is determined by the Count field and is controllable by the customer. Accounting for track overhead (i.e., Home Address, etc.), the Data field may not exceed the usable area of one track. A physical record may also include a Key field which provides indexing information for the Data field. Physical records contain one or more logical records.

- **Logical Record** — A logical record is the increment that the CPU uses when processing data; the value of this increment is customer-assigned. The length of a logical record does not necessarily correspond to the length of the physical record in which it is located. For instance, to meet the line length requirements for a particular terminal, the customer may assign a logical record length of 80 bytes to a set of data. At the same time, the customer may assign a length of 3200 bytes to the Data field that contains the logical record group. Thus, the physical record would include 40 logical records.

- **Block** — A block is the increment of data transmitted to the system. The size of a given block is in a one-to-one ratio with the Data field length. In other words, if a physical record has a data length of 3200 bytes, the block size is also 3200 bytes. When determining block size, the length of the Key field, when present, must be considered. Block size is always a multiple of logical record length. Block size and logical record length are assigned via Job Control Language (JCL) statements or macros in any operating system environment.

B.2 Data Management Philosophy

Before planning the specifics of data migration and layout, the customer should determine which of the drive performance criteria is central to the installation and application. For instance, customers wishing to reap the benefits of the drive's comparative processing speed should structure data set layout for fast access and turnaround.

Customers who wish to utilize the increased storage capacity of the unit may plan data blocking so that a high percentage of track space will be devoted to data storage. The customer may find it necessary to make certain performance compensations. As an example, the use of full track blocks maximizes the amount of space dedicated to data storage.

However, the length of time required to perform a data transfer for a block this size may result in a channel bottleneck. Thus, the customer should decide which of these two factors is crucial to the application and should find an appropriate balance. As a rule, the customer should consider the priorities of the installation, the expected traffic, and the types of data to be stored when planning the conversion and layout. The following paragraphs furnish some pointers on how to ensure that the various performance characteristics are taken into account.

To minimize CPU interference on I/O accesses, the customer may use three techniques. First, the customer should optimize the number of accesses for a given level of system activity. To accomplish access reduction, the customer may use larger block sizes to ensure the maximum data transfer per access, may place frequently accessed information in main storage at the start of a job or at system initialization, and may employ chained scheduling to access multiple blocks of sequential data. Chained scheduling allocates a group of chained buffers for a rapid series of read or write operations and ensures that the read or write operations are synchronized with buffer allocations. Second, the customer should employ large block sizes to ensure against an increase in Start I/O (SIO) operations. Third, the customer should take care in specifying the space allocation. For example, if a data set is large enough to merit a cylinder allocation instead of a track allocation, the space should be assigned in cylinder units instead of track units. This approach eliminates the time required for the control program to review the record extent each time it finishes a track.

> ***Note:*** *If chained scheduling is active, the customer should verify that main storage has enough space to accept the data blocks.*

To minimize the time that a channel is busy, the customer may employ four techniques. First, the customer should reduce block size on direct access data sets. Second, if the customer stores a high number of data sets, an indexed VTOC will minimize search time. Third, the customer may reduce search time by creating small directories for partitioned data sets. Fourth, the customer may utilize either a fixed record length with standard record format or the search direct option when handling sequential data sets.

> ***Note:*** *If search direct is specified in conjunction with chained scheduling, chained scheduling will supersede the search direct option.*

To reduce the amount of arm movement entailed in accessing data, the customer may utilize seven techniques. First, arm motion will be minimized if the customer groups small, frequently used data sets on one cylinder instead of on separate cylinders. Second, the customer should ensure that frequently accessed sections of partitioned data sets are located near the data set directory. Third, the customer should make sure that all defect skips are assigned prior to linking an alternate track (see Section 4). This measure reduces the number of alternate track accesses performed; the customer may also consider placing rarely used data sets on tracks that have assigned alternates. Fourth, if the customer is storing relatively small data sets that are frequently accessed, these data sets should be grouped near the center of the cylinder range. Fifth, the customer should make sure that data sets receive an accurate space allocation to avoid large groups of unused cylinders. Sixth, the customer should generally locate the most frequently accessed permanent data sets at the center of the cylinder range. Seventh, if concurrently active data sets use the same actuator, these data sets should be clustered over adjacent cylinder groups.

To increase the data transfer speed and decrease the time necessary for an access operation, the customer may employ seven techniques. First, the customer may use a fixed record length with standard record format or the direct search option. Second, the customer should ensure that data sets are arranged so that the data sets that are highly active are evenly mixed with less active data sets. Third, the customer should take advantage of any high-speed channel features whenever possible. Fourth, the customer should minimize the number of data sets that are concurrently active on the same actuator. Such data sets should be distributed over several different actuators. Fifth, the customer should ensure reduced arm motion as described in the previous paragraph. Sixth, taking advantage of the four clustered storage paths, the customer should use different paths to access simultaneously active data sets. Seventh, for direct access data sets, the customer should block data in smaller segments.

B.3 Volume Initialization and VTOC

One of the tasks that must be performed before storing data in the drive is volume initialization. A portion of volume initialization is completed prior to drive shipment; this portion consists of writing a Home Address, standard Record 0, and any necessary defect skips on each track. After installation, volume initialization must be completed to prepare the drive for use by the operating system. The customer generally executes the IBM Device Support Facilities (DSF) program to accomplish this task. Using the DSF INIT command, any of three initialization levels may be achieved.

The first of these performs two tasks. Level 1 initialization writes Initial Program Load (IPL) bootstrap records and a volume label. The bootstrap records are defined on cylinder 0, head 0 — records 1 and 2; the volume label is located on cylinder 0, head 0 as record 3. Level 1 initialization also defines the size and starting point of the Volume Table of Contents (VTOC). If the customer is executing under an OS/VS system, the VTOC location default of cylinder 0, head 1 and the VTOC size default of one track will be employed unless otherwise specified. The second volume initialization level includes three tasks — the two tasks performed at Level 1 and an additional track reformat function that guarantees correct addressing. The track reformat function consists of a Home Address/Record 0 write for all tracks and thus erases any previous track contents. Level 2 volume initialization is required for all replacement drives. The third volume

initialization level executes the three tasks performed at Level 2 as well as a surface analysis which ensures the assignment of all necessary defect skips. Surface analysis consists of extensive track testing using worst case data patterns; the purpose of the test is to find data check errors and assign defect skips or alternate tracks as appropriate. Surface analysis does not eliminate defect skips written prior to shipment. If a defective track proves usable during testing, surface analysis will reclaim that track for normal operating functions.

Among the items crucial to drive performance is the VTOC. The VTOC is a sequential data set required for each cylinder group or volume. If the customer is operating the 3890 in an OS/VS environment, a VTOC index option is available. The VTOC index can minimize the search time required for VTOC review by providing the data set name and its VTOC location; the VTOC may then be accessed directly rather than in a sequential read. Customers who store large numbers of data sets per volume may find an indexed VTOC helpful. The VTOC index is created during volume initialization via the DSF INIT command or at a later time via the BUILDIX command. The customer should consider locating the VTOC index near the VTOC to minimize arm motion.

B.4 Blocking

One of the areas that the customer must examine is blocking. As previously mentioned, a block is the increment used to transmit data; block size corresponds to the data length of a physical record and must be a multiple of the fixed-length logical record size. Choosing the most effective block size for a given application depends on several factors. For instance, if the customer has an application that requires data set transfers between different drive types on a regular basis, a block size close to 6,233 bytes provides 90% space utilization for the 367x, 365x, 368x, and 3890 drive classifications. Thus, transferability with high space utilization is achieved. On the other hand, if the customer is working with system data sets which require larger blocks for peak performance, a block size of 15,476 will maximize space utilization for the track and transmit the system data in appropriately large units. As a general guideline, the customer should be aware of the following blocking characteristics.

- Very large block sizes (i.e., full track length) achieve high space utilization, but may monopolize a channel during data transfer and impact real time users.
- The smaller the block size, the greater the percentage of track overhead and the smaller the percentage of track used for data storage.
- Block sizes in the range of 3,000 to 8,000 bytes provide a better space utilization/performance balance than block sizes at either the upper or lower extreme.
- Block sizes must be adjusted for the amount of main storage devoted to I/O buffers.
- Large block sizes are appropriate for sequential physical records as long as they do not adversely affect response turnaround for real time users.
- Large block sizes can result in data transfer delays for random data set processing by key.
- Virtual Storage Access Method (VSAM) data sets use a control interval as the unit of data. Control interval block sizes are multiples of 512 bytes up to 8 kilobytes

and are then increased by increments of 2 kilobytes. For VSAM, 85% space utilization may be achieved on the 3890 by a block size of 4,096 bytes.

B.5 Space Calculation

To ensure correct data layout, the customer must accurately calculate the number of records that will fit on a track. The customer may use one of two algorithms to perform this calculation. The first of these algorithms applies in situations where all records on the track are assigned the same length. The second algorithm is appropriate when dealing with unequal record lengths on the same track. The following text presents both algorithms. Additionally, Tables B-1 through B-3 calculate the allowable number of records for given record lengths.

Note: All 3890 data is organized in 32-byte increments. Because this approach affects portions of the calculation, areas where the 32-byte increment must be observed are so noted.

Algorithm 1 — Physical Records of Equal Length

For equal length records with a standard Record 0, the customer should calculate as follows:

$$\frac{1499}{C+K+D} = \text{Number of records per track}$$

where 1499 = The number of 32-byte increments available for customer data.

C = The number of 32-byte increments used by the Count field and all record gaps.

K = Key length to the nearest 32-byte increment, rounded upward.

D = Data length to the nearest 32-byte increment, rounded upward.

Key length and data length are further calculated as follows:

$$K = \frac{\text{Length of the Key Field + 12 bytes error correction}}{32}$$

$$D = \frac{\text{Length of the Key Field + 12 bytes error correction}}{32}$$

Note: The value of C is 15 if no Key field is present or 22 if a Key field is used. If records are not keyed, K is 0.

Example:

Key length = 12 Data length = 370

thus:

$C = 22$ because the Key field is present

$$K = \frac{12 + 12}{32} \text{ or } \frac{24}{32} \text{ or 1, rounded upward}$$

$$D = \frac{370 + 12}{32} \text{ or } \frac{382}{32} \text{ or 12, rounded upward}$$

$$\text{Records per track} = \frac{1499}{22 + 1 + 12} \text{ or } \frac{1499}{35} \text{ or 32 records}$$

Algorithm 2 — Physical Records of Unequal Length

For unequal length records with a standard Record 0, the customer should calculate as follows:

$$\left\{ \sum_{x=1}^{n} (C_x + K_x + D_x) \leq 1499 \right\} = \text{number of records per track}$$

For equal length records with a nonstandard Record 0, the customer should calculate as follows:

$$\left\{ \sum_{x=0}^{n} (C_x + K_x + D_x) \leq 1515 \right\} = \text{number of records per track}$$

Note: See Algorithm 1 for definitions of C, K, and D. The customer may find the MVS TRKCALC macro useful in performing these calculations.

B.6 Data Conversion

The method by which data is converted from an older device to the 3890 depends on the operating system, the drive, and the access method used to perform the I/O operations. For MVS environments, the most convenient approach to data conversion is to use an IBM utility program. The IBM utilities provide copy operations, and in some cases, move operations. The choice of a particular utility program or command is an outcome of the access method employed. Utility choices are as follows: differences in conversion results are noted.

Access Method/Data Set Type:	Utility:
SAM,BSAM,QSAM	IEGENER
	IEHMOVE
VSAM	Access Methods Services
	REPRO Command
BDAM	IEHMOVE*
BPAM	IEBCOPY (does not rearrange members)
	IEHMOVE (rearranges members alphabetically)
ISAM,BISAM,QISAM	IEBISAM**

* Normal reorganization programs will aid data transfer in cases where the number of records per track for the 3890 is greater than the number of records per track for the older device.

** The customer should alter load programs to reflect 3890 device characteristics, as appropriate.

Note: If converting cataloged data sets, the catalog must be revised.

For VM environments, the customer may issue CMS commands to migrate data to the 3890. Commands that may prove useful are COPYFILE, MOVEFILE, TAPE, and TAPPDS. If the customer converts system data sets on CP-OWNED cylinders, those data sets require reconstruction.

B.7 Compatible Operating Environments

The 3890-2 subsystem is designed to function in a number of operating environments. Among these environments are MVS/370, MVS/XA, MVS/ESA, VM/SP, VM/SP HPO, VM/XA, and VSE/SP. Over time, these control programs have undergone various revisions — some minor and some more dramatic. This subsystem is compatible with the control program revisions that support IBM 3380 J-type and K-type devices; all minimum control program revision levels required by these IBM devices are also required by the 3890-2 subsystem. Thus, the system programmer must determine whether the control program release and version currently installed at the site are compatible with the 3890 subsystem. This task should be completed during the installation planning phase. For the programmer's convenience, Table B-4 provides the minimum required release or version number for the listed operating environments. Additionally, this table furnishes information on the minimum release/version of the EREP and ICKDSF support programs required by the 3890. If, on reviewing this table, the programmer finds that a control or support program is not compatible with the 3890, appropriate action should be scheduled prior to subsystem installation.

Table B-1. Equal Length Physical Records With Keys

Key Length + Data Length Bytes (maximum)	Track Capacity		Cylinder Capacity	
	Records	Bytes	Records	Bytes
47,240	1	47,240	15	708,600
23,240	2	46,480	30	697,200
15,240	3	45,720	45	685,800
11,240	4	44,960	60	674,400
8,840	5	44,200	75	663,000
7,240	6	43,440	90	651,600
6,120	7	42,840	105	642,600
5,256	8	42,048	120	630,720
4,584	9	41,256	135	618,840
4,040	10	40,400	150	606,000
3,624	11	39,864	165	597,960
3,240	12	38,880	180	583,200
2,952	13	38,376	195	575,640
2,696	14	37,744	210	566,160
2,440	15	36,600	225	549,000
2,248	16	35,968	240	539,520
2,088	17	35,496	255	532,440
1,928	18	34,704	270	520,560
1,768	19	33,592	285	503,880
1,640	20	32,800	300	492,000
1,544	21	32,424	315	486,360
1,448	22	31,856	330	477,840
1,352	23	31,096	345	466,440
1,256	24	30,144	360	452,160
1,160	25	29,000	375	435,000
1,096	26	28,496	390	427,440
1,032	27	27,864	405	417,960

continued

Table B-1. Equal Length Physical Records With Keys (continued)

Key Length + Data Length Bytes (maximum)	Track Capacity		Cylinder Capacity	
	Records	Bytes	Records	Bytes
968	28	27,104	420	406,560
904	29	26,216	435	393,240
840	30	25,200	450	378,000
808	31	25,048	465	375,720
744	32	23,808	480	357,120
712	33	23,496	495	352,440
680	34	23,120	510	346,800
616	35	21,560	525	323,400
584	36	21,024	540	315,360
552	37	20,424	555	306,360
520	38	19,760	570	296,400
488	39	19,032	585	285,480
456	40	18,240	600	273,600
424	41	17,384	615	260,760
392	42	16,464	630	246,960
360	44	15,840	660	237,600
328	45	14,760	675	221,400
296	46	13,616	690	204,240
264	48	12,672	720	190,080
232	49	11,368	735	170,520
200	51	10,200	765	153,000
168	53	8,904	795	133,560
136	55	7,480	825	112,200
104	57	5,928	855	88,920
72	59	4,248	885	63,720
40	62	2,480	930	37,200

Note: *Key length and Data length are rounded to multiples of 32, minus 12.*

Table B-2. Equal Length Physical Records Without Keys

Key Length + Data Length Bytes (maximum)	Track Capacity		Cylinder Capacity	
	Records	Bytes	Records	Bytes
47,476	1	47,476	15	712,140
23,476	2	46,952	30	704,280
15,476	3	46,428	45	696,420
11,476	4	45,904	60	688,560
9,076	5	45,380	75	680,700
7,476	6	44,856	90	672,840
6,356	7	44,492	105	667,380
5,492	8	43,936	120	659,040
4,820	9	43,380	135	650,700
4,276	10	42,760	150	641,400
3,860	11	42,460	165	636,900
3,476	12	41,712	180	625,680
3,188	13	41,444	195	621,660
2,932	14	41,048	210	615,720
2,676	15	40,140	225	602,100
2,484	16	39,744	240	596,160
2,324	17	39,508	255	592,620
2,164	18	38,952	270	584,280
2,004	19	38,076	285	571,140
1,876	20	37,520	300	562,800
1,780	21	37,380	315	560,700
1,684	22	37,048	330	555,720
1,588	23	36,524	345	547,860
1,492	24	35,808	360	537,120
1,396	25	34,900	375	523,500
1,332	26	34,632	390	519,480
1,268	27	34,236	405	513,540
1,204	28	33,712	420	505,680
1,140	29	33,060	435	495,900
1,076	30	32,280	450	484,200
1,044	31	32,364	465	485,460
980	32	31,360	480	470,400
948	33	31,284	495	469,260
916	34	31,144	510	467,160
852	35	29,820	525	447,300
820	36	29,520	540	442,800

continued

Table B-2. Equal Length Physical Records Without Keys (continued)

Key Length + Data Length Bytes (maximum)	Track Capacity		Cylinder Capacity	
	Records	Bytes	Records	Bytes
788	37	29,156	555	437,340
756	38	28,728	570	430,920
724	39	28,236	585	423,540
692	40	27,680	600	415,200
660	41	27,060	615	405,900
628	42	26,376	630	395,640
596	44	26,224	660	393,360
564	45	25,380	675	380,700
532	46	24,472	690	367,080
500	48	24,000	720	360,000
468	49	22,932	735	343,980
436	51	22,236	765	333,540
404	53	21,412	795	321,180
372	55	20,460	825	306,900
340	57	19,380	855	290,700
308	59	18,172	885	272,580
276	62	17,112	930	256,680
244	65	15,860	975	237,900
212	68	14,416	1,020	216,240
180	71	12,780	1,065	191,700
148	74	10,952	1,110	164,280
116	78	9,048	1,170	135,720
84	83	6,972	1,245	104,580
52	88	4,576	1,320	68,640
20	93	1,860	1,395	27,900

Table B-3. Ranges of Key Lengths

Key Length = 1 to 20 Data Length Bytes Maximum	Records Per Track
47,220	1
23,220	2
15,220	3
11,220	4
8,820	5
7,220	6
6,100	7
5,236	8
4,564	9
4,020	10
3,604	11
3,220	12
2,932	13
2,676	14
2,420	15
2,228	16
2,068	17
1,908	18
1,748	19
1,620	20
1,524	21
1,428	22
1,332	23
1,236	24
1,140	25
1,076	26
1,012	27
948	28
884	29
820	30
788	31
724	32
692	33
660	34
596	35

continued

Table B-3. Ranges of Key Lengths (continued)

Key Length = 1 to 20 Data Length Bytes Maximum	Records Per Track
564	36
532	37
500	38
468	39
436	40
404	41
372	42
340	44
308	45
276	46
244	48
212	49
180	51
148	53
116	55
84	57
52	59
20	62

Key Length = 21 to 52 Data Length Bytes Maximum	Records Per Track
47,188	1
23,188	2
15,188	3
11,188	4
8,788	5
7,188	6
6,068	7
5,204	8
4,532	9
3,988	10
3,572	11
3,188	12
2,900	13
2,644	14
2,388	15
2,196	16
2,036	17
1,876	18

continued

Table B-3. Ranges of Key Lengths (continued)

Key Length = 21 to 52 Data Length Bytes Maximum	Records Per Track
1,716	19
1,588	20
1,492	21
1,396	22
1,300	23
1,204	24
1,108	25
1,044	26
980	27
916	28
852	29
788	30
756	31
692	32
660	33
628	34
564	35
532	36
500	37
468	38
436	39
404	40
372	41
340	42
308	44
276	45
244	46
212	48
180	49
148	51
116	53
84	55
52	57
20	59

continued

Table B-3. Ranges of Key Lengths (continued)

Key Length = 53 to 84 Data Length Bytes Maximum	Records Per Track
47,156	1
23,156	2
15,156	3
11,156	4
8,756	5
7,156	6
6,036	7
5,172	8
4,500	9
3,956	10
3,540	11
3,156	12
2,868	13
2,612	14
2,356	15
2,164	16
2,004	17
1,844	18
1,684	19
1,556	20
1,460	21
1,364	22
1,268	23
1,172	24
1,076	25
1,012	26
948	27
884	28
820	29

continued

Table B-3. Ranges of Key Lengths (continued)

Key Length = 53 to 84 Data Length Bytes Maximum	Records Per Track
756	30
724	31
660	32
628	33
596	34
532	35
500	36
468	37
436	38
404	39
372	40
340	41
308	42
276	44
244	45
212	46
180	48
148	49
116	51
84	53
52	55
20	57

continued

Table B-3. Ranges of Key Lengths (continued)

Key Length = 85 to 116 Data Length Bytes Maximum	Records Per Track
47,124	1
23,124	2
15,124	3
11,124	4
8,724	5
7,124	6
6,004	7
5,140	8
4,468	9
3,924	10
3,508	11
3,124	12
2,836	13
2,580	14
2,324	15

continued

Table B-3. Ranges of Key Lengths (continued)

Key Length = 85 to 116 Data Length Bytes Maximum	Records Per Track
2,132	16
1,972	17
1,812	18
1,652	19
1,524	20
1,428	21
1,332	22
1,236	23
1,140	24
1,044	25
980	26
916	27
852	28
788	29
724	30
692	31
628	32
596	33
564	34
500	35
468	36
436	37
404	38
372	39
340	40
308	41
276	42
244	44
212	45
180	46
148	48
116	49
84	51
52	53
20	55

continued

Table B-3. Ranges of Key Lengths (continued)

Key Length = 117 to 148 Data Length Bytes Maximum	Records Per Track
47,092	1
23,092	2
15,092	3
11,092	4
8,692	5
7,092	6
5,972	7
5,108	8
4,436	9
3,892	10
3,476	11
3,092	12
2,804	13
2,548	14
2,292	15
2,100	16
1,940	17
1,780	18
1,620	19
1,492	20
1,396	21
1,300	22
1,204	23
1,108	24
1,012	25
948	26
884	27
820	28
756	29
692	30

continued

Table B-3. Ranges of Key Lengths (continued)

Key Length = 117 to 148 Data Length Bytes Maximum	Records Per Track
660	31
596	32
564	33
532	34
468	35
436	36
404	37
372	38
340	39
308	40
276	41
244	42
212	44
180	45
148	46
116	48
84	49
52	51
20	52

Key Length = 149 to 180 Data Length Bytes Maximum	Records Per Track
47,060	1
23,060	2
15,060	3
11,060	4
8,660	5
7,060	6
5,940	7
5,076	8
4,404	9
3,860	10
3,444	11
3,060	12
2,772	13
2,516	14
2,260	15
2,068	16
1,908	17

continued

Table B-3. Ranges of Key Lengths (continued)

Key Length = 149 to 180 Data Length Bytes Maximum	Records Per Track
1,748	18
1,588	19
1,460	20
1,364	21
1,268	22
1,172	23
1,076	24
980	25
916	26
852	27
788	28
724	29
660	30
628	31
564	32
532	33
500	34
436	35
404	36
372	37
340	38
308	39
276	40
244	41
212	42
180	44
148	45
116	46
84	48
52	49
20	51

continued

Table B-3. Ranges of Key Lengths (continued)

Key Length = 181 to 212 Data Length Bytes Maximum	Records Per Track
47,028	1
23,028	2
15,028	3
11,028	4
8,628	5
7,028	6
5,908	7
5,044	8
4,372	9
3,828	10
3,412	11
3,028	12
2,740	13
2,484	14
2,228	15
2,036	16
1,876	17
1,716	18
1,556	19
1,428	20
1,332	21
1,236	22
1,140	23
1,044	24
948	25
884	26

continued

Table B-3. Ranges of Key Lengths (continued)

Key Length = 181 to 212 Data Length Bytes Maximum	Records Per Track
820	27
756	28
692	29
628	30
596	31
532	32
500	33
468	34
404	35
372	36
340	37
308	38
276	39
244	40
212	41
180	42
148	44
116	45
84	46
52	48
20	49

Table B-3. Ranges of Key Lengths (continued)

Key Length = 213 to 244 Data Length Bytes Maximum	Records Per Track
46,996	1
22,996	2
14,996	3
10,996	4
8,596	5
6,996	6
5,876	7
5,012	8
4,340	9
3,796	10
3,380	11
2,996	12
2,708	13
2,452	14
2,196	15
2,004	16
1,844	17

continued

Table B-3. Ranges of Key Lengths (continued)

Key Length = 213 to 244 Data Length Bytes Maximum	Records Per Track
1,684	18
1,524	19
1,396	20
1,300	21
1,204	22
1,108	23
1,012	24
916	25
852	26
788	27
724	28
660	29
596	30
564	31
500	32
468	33
436	34
372	35
340	36
308	37
276	38
244	39
212	40
180	41
148	42
116	44
84	45
52	46
20	48

continued

Table B-3. Ranges of Key Lengths (continued)

Key Length = 245 to 255 Data Length Bytes Maximum	Records Per Track
46,964	1
22,964	2
14,964	3
10,964	4
8,564	5
6,964	6
5,844	7
4,980	8
4,308	9
3,764	10
3,348	11
2,964	12
2,676	13
2,420	14
2,164	15
1,972	16
1,812	17
1,652	18
1,492	19
1,364	20
1,268	21
1,172	22
1,076	23
980	24
884	25
820	26

continued

Table B-3. Ranges of Key Lengths (continued)

Key Length = 245 to 255 Data Length Bytes Maximum	Records Per Track
756	27
692	28
628	29
564	30
532	31
468	32
436	33
404	34
340	35
308	36
276	37
244	38
212	39
180	40
148	41
116	42
84	44
52	45
20	46

Table B-4. Control and Support Program Requirements

Program Release/ Version	Operating System										
	MVS/370		MVS/XA		MVS/ESA		VM/SP	VM/SP HPO	VM/XA		VSE/SP and AF
	MVS/SP	MVS/370 DFP	MVS/SP	MVS/XA DFP	MVS/SP	MVS/DFP			VM/XA SF	VM/XA SP	
Control Program	Version 1.3.5	Version 1.1.2	Version 2.1.2	Version 1.1.3 or 2.2.3	Version 3.1	Version 3.1	Version 4 or 5 with PTFs included	Version 4.2 with PTFs included	Release 2 with PTFs included	Release 1 with PTFs Release 2.0 with PTFs Release 2.1	3890-00J4/02J4 Version 2.1.7 or 3.1.2 3890-00K4/02K Version 3.2.0*
ICKDSF	Version 9.0		Version 9.0		Version 9.0		Version 9.0	Version 9.0	Version 9.0		Version 9.0
EREP	Version 3.3.2		Version 3.3.2		Version 3.3.2		Version 3.3.2	Version 3.3.2	Version 3.3.2		Version 3.3.2

* Version 3.1.2 also supports 3890-00K4/02K4 via SPE.

Index

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

X

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