IBM

Storage Subsystem Library

GC26-4491-2

IBM 3380 Direct Access Storage Introduction

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Third Edition (September 1990)

This edition replaces and makes obsolete the previous edition, GC26-4491-1. This is the third edition of *Storage Subsystem Library: IBM 3380 Direct Access Storage Introduction*, and applies until otherwise indicated in new editions or technical newsletters. Consult the latest edition of the applicable IBM system bibliography for current information on this product.

The changes for this edition are summarized under "Summary of Changes" following the preface. Specific changes are indicated by a vertical bar to the left of the change. A vertical bar to the left of a figure caption indicates that the figure has changed. Editorial changes that have no technical significance are not noted.

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Preface

This book is part of the Storage Subsystem Library (SSL)—a set of books providing information about the components of IBM disk storage subsystems. The SSL includes direct access storage devices (DASD) and storage control publications. This book is part of the SSL subset that is concerned primarily with 3380 DASD.

About This Book

This book is written for the storage administrator, system programmer, hardware performance specialist, or operator who is involved in acquiring, configuring, installing, managing, or operating direct access storage.

"Chapter 1. Introducing the IBM 3380 Direct Access Storage" on page 13, defines the 3380 model groups, highlights the product capabilities, and provides basic 3380 product description and string composition. In addition, attributes of the various 3380 models and other IBM DASD are compared.

"Chapter 2. Functional Characteristics" on page 25, describes standard functions of the 3380, internal path capabilities of the various models, and other model-specific functions: Device Reserve and Release, Dynamic Path Selection, Device Level Selection and Device Level Selection Enhanced.

"Chapter 3. Support and Attachment" on page 33, defines operating system and processor support for 3380 storage, enumerates features related to attachment of 3380s to 3880 Storage Controls and to 3990 Storage Controls, and describes the various options for configuring 3380 strings attached to 3880s and to 3990s.

"Chapter 4. Planning for Installation and Use" on page 67, describes physical planning considerations such as power, cable, and floor space requirements, and discusses other planning activities and configuring techniques that promote efficient installation for meeting capacity needs without disrupting operations.

"Chapter 5. Operation" on page 73, provides information for using the operator panels on the various A-unit models and for powering DASD strings up and down.

Appendix A, "Device Addressing and Identification" on page 87, describes the conventions and requirements for defining device addresses and identifications.

Appendix B, "Record Format, Track Format, and Space Calculations" on page 97, describes the count-key-data track format and provides formulae and tables for space calculation.

Appendix C, "3380 Support in Transaction Processing Facility" on page 115, summarizes the requirements for using the 3380 in the Transaction Processing Facility (TPF) operating environment.

"Acronyms and Abbreviations" on page 117, lists the acronyms used in the Storage Subsystem Library books.

"Glossary" on page 119, lists terms used in the Storage Subsystem Library books.

"Bibliography" on page 125, lists publications that you can reference for further information on related topics and hardware.

Terminology

A comprehensive glossary is provided at the back of this book. This glossary contains terms used not only in this book but also terms, abbreviations, and acronyms from other DASD and storage control books in the Storage Subsystem Library.

Before reading further, be sure you understand how the following terms are used within this book:

3380 refers to all models of the IBM 3380 Direct Access Storage, unless otherwise indicated.

Controller refers to the part of the 3380 A-unit or C-unit that controls the transfer of data between the devices and the storage control.

Device refers to a uniquely addressable part of the 3380 unit that includes a set of access arms, their associated disks, and the electronic circuitry needed to locate, read, and write data.

Storage Control refers to the hardware that handles interactions between the processor channel and the controller. In the past, this has been called a control unit.

Volume refers to the DASD space accessible by a single actuator.

The Storage Subsystem Library

The Storage Subsystem Library describes characteristics, capabilities, and features of the hardware and provides instructions for installing, using, and maintaining storage subsystem components effectively in the various operating environments. The library is designed to provide both hardware- and software-related information for both DASD and storage controls.

The DASD subset of the Storage Subsystem Library contains the following books:

- *IBM 3380 Direct Access Storage Introduction*, GC26-4491

  Provides a complete description of the various models of the 3380, including characteristics, features, and capabilities. In addition, the configuration and attachment options are described along with other information that helps in designing a storage subsystem to meet your needs. (This book does *not* cover the 3380 Model CJ2.)

- *IBM 3380 Direct Access Storage Direct Channel Attach Model CJ2 Introduction and Reference*, GC26-4497

  Provides a complete description of the 3380 Direct Channel Attach Model CJ2 characteristics, features, capabilities, and string configuration options.

- *Using the IBM 3380 Direct Access Storage in an MVS Environment*, GC26-4492

  Provides specific guidance for using the 3380 in an MVS operating environment. This book provides detailed instruction for planning the addition of new 3380 devices from a logical and physical point of view, installing devices, moving data to new devices, and performing ongoing activities to maintain a reliable storage subsystem.

- *Using the IBM 3380 Direct Access Storage in a VM Environment*, GC26-4493

  Provides specific guidance for using the 3380 in a VM/SP, VM/SP HPO, or VM/XA* SF operating environment. This book provides detailed instruction for planning the addition of new 3380 devices, installing devices, moving data to new devices, and performing ongoing storage management activities to maintain reliable performance and availability. In addition, storage considerations related to guest systems are addressed.

- *Using the IBM 3380 Direct Access Storage in a VSE Environment*, GC26-4494

  Provides specific guidance for using the 3380 in a VSE* operating environment. This book provides instruction for planning the addition of new 3380 devices, installing devices, moving data to new devices, and performing ongoing storage subsystem management.

- *Maintaining IBM Storage Subsystem Media*, GC26-4495

  Describes how the storage subsystem and the various operating systems handle disk storage errors and provides instruction on using the Environmental Record Editing and Printing (EREP) program and the Device Support Facilities (ICKDSF) program to diagnose and correct disk media errors. Recovery procedures are provided for the various device types. In addition, background material on DASD storage concepts is included.

- *IBM 3380 Direct Access Storage Reference Summary*, GX26-1678

  Provides a summary of 3380 capacity, performance, and operating characteristics.

The Storage Control subset of the Storage Subsystem Library contains the following books:

- *IBM 3990 Storage Control Introduction*, GA32-0098

  Provides a complete description of the various models of the 3990 Storage Control, including its data availability, performance, and reliability improvements over previous storage controls. In addition, this book provides descriptions of the configuration attachment options, optional features, performance characteristics, and software support of the 3990 Storage Control.

- *IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide*, GA32-0100

  Provides a functional description of the 3990 Storage Control. This book describes the planning, program installation, and storage management tasks used in typical environments. Configuration examples as well as sample programs for controlling the various functions of the 3990 Storage Control are provided.

- *IBM 3990 Storage Control Reference*, GA32-0099

  Provides descriptions and reference information for the 3990 Storage Control. This book includes channel commands, error recovery, and sense information.

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* VM/XA and VSE are trademarks of the International Business Machines Corporation.

- *Cache Device Administration*, GC35-0101

  Specifies the access method services tool for administering a cache device under MVS. The book supports storage controls: 3990 Model 3, 3880 Model 23, 3880 Model 21, 3880 Model 13, and 3880 Model 11.

- *IBM 3990 Operations Study Guide*, GA32-0131

  A study guide for operators of 3990 storage subsystems. Provides general information on system control program commands and messages, and guidelines for basic problem determination.

- *IBM 3990 Operations and Recovery Reference*, GA32-0133

  A user's study guide for operators of 3990 storage subsystems. Provides general guidelines for 3990 problem determination and testing of 3990 extended functions. Also provides recommended recovery actions for the 3990.

- *Introduction to Nonsynchronous Direct Access Storage Subsystems*, GC26-4519

  Provides specific information for programmers responsible for writing DASD channel programs that operate in a nonsynchronous environment. This book defines synchronous and nonsynchronous operations, explains ECKD* data transfer commands, and provides examples of using ECKD commands to build nonsynchronous channel programs.

- *IBM 3990 Transaction Processing Facility Support RPQs*, GA32-0134

  Describes 3990 RPQs available for support of the Transaction Processing Facility operating system. Initialization procedures, channel commands, and sense data specific to these RPQs are also provided.

The *Storage Subsystem Library Master Index*, GC26-4496 provides a central source for information related to storage subsystem topics. Books for IBM 3380 Direct Access Storage, 3380 Direct Channel Attach Model CJ2, and 3990 Storage Controls are indexed in this publication. An overview of the material in the Storage Subsystem Library is provided with this index.

Figure 1 on page 7 shows the relationships among the Storage Subsystem Library books in terms of high-level tasks described in each book.

* ECKD is a trademark of the International Business Machines Corporation.

Storage Subsystem Library

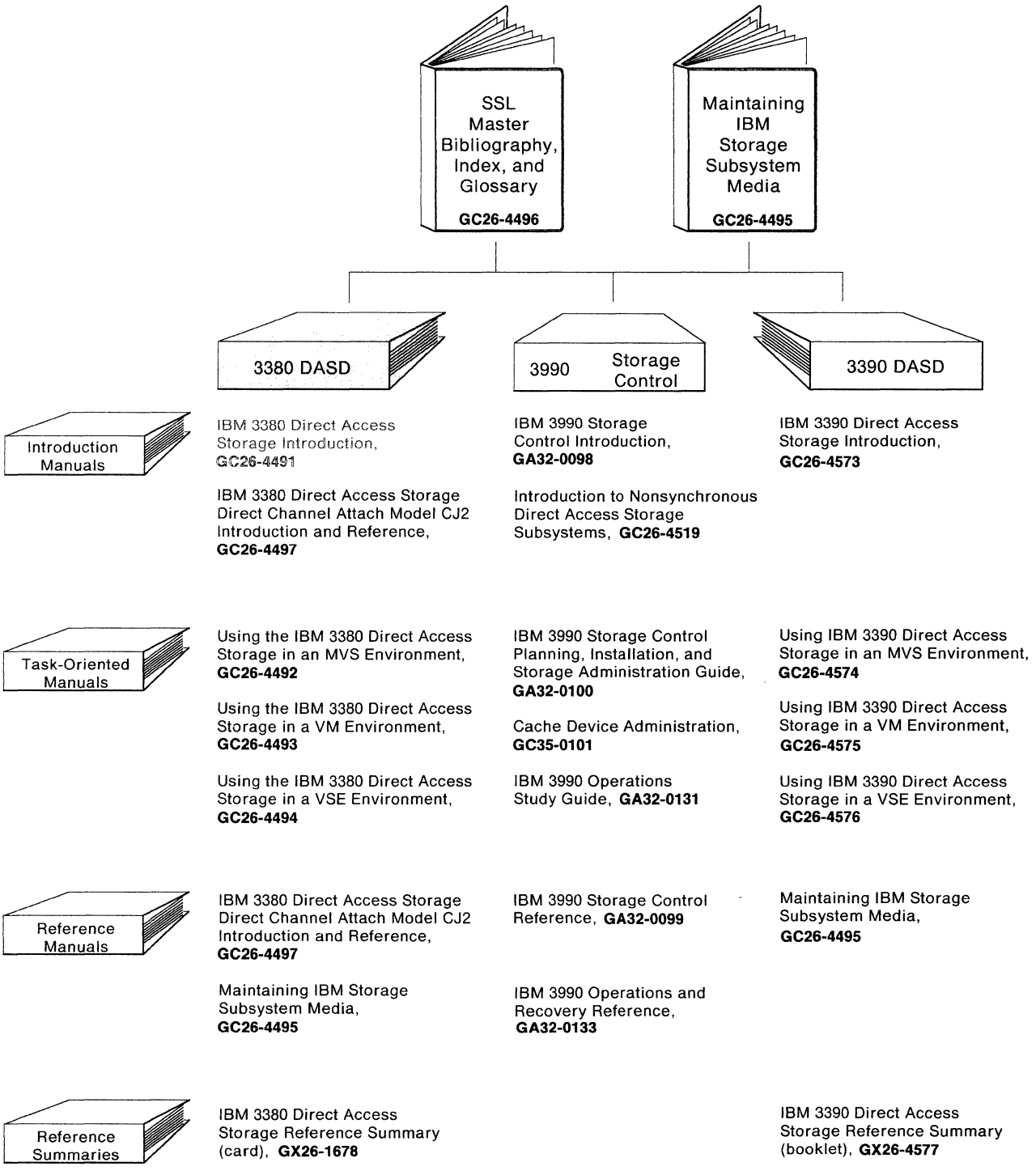

Figure 1. The Storage Subsystem Library

Storage Subsystem Library Ordering Information

You can obtain a copy of **every book** in the SSL using one General Bill of Forms (GBOF) number, **GBOF-1762**. Select one of the following GBOF numbers to obtain subsets of the SSL that provide information for specific environments and equipment. The columns shown in color in the table below describe the contents of the GBOFs that are intended for use with *IBM 3380 Direct Access Storage Introduction*, depending on your operating environment. To obtain an individual book, use its order number.

Title	GBOF-1756	GBOF-1757	GBOF-1758	GBOF-1759	GBOF-1760	GBOF-1761	GBOF-0366
IBM 3380 Direct Access Storage Introduction, GC26-4491	X	X	X				
IBM 3380 Direct Access Storage Direct Channel Attach Model CJ2 Introduction and Reference, GC26-4497				X	X	X	
Using the IBM 3380 Direct Access Storage in an MVS Environment, GC26-4492	X			X			
Using the IBM 3380 Direct Access Storage in a VM Environment, GC26-4493		X			X		
Using the IBM 3380 Direct Access Storage in a VSE Environment, GC26-4494			X			X	
Maintaining IBM Storage Subsystem Media, GC26-4495	X	X	X	X	X	X	
IBM 3380 Direct Access Storage Reference Summary, GX26-1678	X	X	X	X	X	X	
IBM 3990 Storage Control Introduction, GA32-0098							X
IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide, GA32-0100							X
IBM 3990 Storage Control Reference, GA32-0099							X
Cache Device Administration, GC35-0101	X						X
IBM 3990 Operations Study Guide, GA32-0131							X
IBM 3990 Operations and Recovery Reference, GA32-0133							X
Introduction to Nonsynchronous Direct Access Storage Subsystems, GC26-4519							X
Storage Subsystem Library Master Bibliography, Index, and Glossary, GC26-4496	X	X	X	X	X	X	X
Binder plus 3380 inserts, GX26-3767	X	X	X	X	X	X	
Binder plus 3990 inserts, GX26-3768							X

Storage Subsystem Library Binder Information

Binder kits for the storage subsystem library are available to help organize your library. Kits consist of a binder with identifying cover and spine inserts for either 3380 or 3990 subsets of the storage subsystem library, and are included when you order the following GBOF numbers:

- GBOF-1756 through -1761 each include a binder with 3380 inserts.
- GBOF-0366 includes a binder with 3990 inserts.
- GBOF-1762 includes binders and inserts for both 3990 **and** 3380.

Storage subsystem library binder kits may also be ordered separately.

- Order number GX26-3767 contains a binder and 3380 inserts.
- Order number GX26-3768 contains a binder and 3990 inserts.

Related Publications

The following publications (not part of the Storage Subsystem Library) describe the IBM 3880 Storage Control models to which the 3380 device can also attach:

- *IBM 3880 Storage Control Models 1, 2, 3, and 4 Description Manual*, GA26-1661
- *Introduction to IBM 3880 Storage Control Model 13*, GA32-0062
- *IBM 3880 Storage Model 13 Description*, GA32-0067
- *Introduction to IBM 3880 Storage Control Model 23*, GA32-0082
- *IBM 3880 Storage Control Model 23 Description*, GA32-0083

The *Device Support Facilities: Primer for the User of IBM 3380 and 3390 Direct Access Storage*, GC26-4498, is intended for use with 3380 books in the Storage Subsystem Library.

Other publications that are referenced in this book or provide additional related information are included in the "Bibliography" on page 125. To help you assess the potential usefulness of each reference, the bibliography includes a short description of the relevant contents of each publication.

Summary of Changes

Third Edition, September 1990

This edition includes the following changes:

- 3380 support of ES Connection channels. The 3380 can operate on ES Connection channels when it is attached to a 3990 Storage Control Model 2 or 3 that supports these channels. The 3380 models that support ES Connection channels are: AD4, BD4, AE4, BE4, AJ4, BJ4, AK4, and BK4. For more information on the 3990 ES Connection channel support, see *IBM 3990 Storage Control Introduction*. For more information on the ES Connection channels, see *Introducing Enterprise Systems Connection*.
- 3380 support for the new family of processors, ES/9000*. Contact your IBM marketing representative for the availability date of ES/9000.
- VSE/ESA Version 1 Release 1 support of the 3380. Contact your IBM marketing representative for the availability date of VSE/ESA Version 1.
- VM/ESA Version 1 Release 1 support of the 3380. Contact your IBM marketing representative for the availability date of VM/ESA Version 1.

Second Edition, September 1988

Technical Changes

The following feature numbers have been changed to engineering changes:

- 9003 - 3990 AA4 Installation/Maintenance Update Feature has been changed to engineering change EC444944 ECA130.
- 9052 - 3990 AD4/AE4 Installation/Maintenance Update Feature has been changed to engineering change EC465359 ECA131.

Other Changes

This book has also been revised with minor technical updates. The book, *Cache Device Administration*, has also been added to the Storage Subsystem Library and an acronym list has been added to this book.

* ES/9000 is a trademark of the International Business Machines Corporation.

First Edition, September 1987

Library Structure

This is a new manual. Some of the material in this manual was formerly contained in the following manuals that are no longer available:

- *IBM 3380 Direct Access Storage: General Information*, GC26-4193
- *IBM 3380 Direct Access Storage: Planning and Use Guide*, GC26-4208

The reformatting of this material is part of an overall restructure of disk storage documentation.

Technical Updates

The material on which this manual is based has been expanded to include the following new hardware and hardware features:

- IBM 3380 Direct Access Storage Models AJ4, BJ4, AK4, and BK4
- IBM 3380 Direct Access Storage Direct Channel Attach Model CJ2
- The 3380 AJ4 and AK4 attachment features for the IBM 3880 Storage Control Models 3 and 23
- IBM 3990 Storage Control Models 1, 2, and 3.

Chapter 1. Introducing the IBM 3380 Direct Access Storage

The IBM 3380 Direct Access Storage Device can provide performance benefits for your storage subsystem, increase data availability, and fill the need for additional disk storage capacity. With the available programming support, the 3380 meets the requirements of most data storage applications and has distinct advantages over other types of IBM direct access storage.

3380 Models

The twelve models of 3380 Direct Access Storage form four model groups. Several models offer increased storage capacity. However, all models of the 3380 have the same number of bytes per track and the same number of tracks per cylinder.

Model	Single Capacity	Double Capacity	Triple Capacity
Standard	A04 AA4 B04		
Extended Capability	AD4 BD4	AE4 BE4	
Enhanced Subsystem	AJ4 BJ4		AK4 BK4
Direct Channel Attach	CJ2		

Extended Capability Model

Compared to the Standard models, the **Extended Capability** models offer improved performance and availability and can provide concurrent transfer of data on two paths, from any two devices in the string. In addition, Models AE4 and BE4 provide twice the capacity of all standard models.

Enhanced Subsystem Model

The **Enhanced Subsystem** models are the most recent members of the 3380 family and provide performance and availability enhancements. For example, the Enhanced Subsystem models have a faster seek time than other 3380 models, and when attached to certain models of the 3990 Storage Control, these 3380s can provide higher performance and availability for your data than ever before with concurrent data transfer on four paths. Furthermore, the triple capacity of the Models AK4 and BK4 offers the 3380 family's lowest cost on a per-megabyte basis.

Direct Channel Attach Model

The 3380 **Direct Channel Attach** Model CJ2 provides both 3380 direct access storage and storage control function in a single unit called a "C-unit." The C-unit contains two single-capacity volumes, and thus has half the capacity of other single capacity models (which contain four single-capacity volumes). The direct access storage functions of the Model CJ2 provide two paths for simultaneous data transfer and have improved seek characteristics when compared to 3380 Standard and Extended Capability Models. The 2-path storage control function that is included provides for direct attachment to a host processor channel. As many as three Enhanced Subsystem B-units may be attached to a Model CJ2. This manual describes 3380 A-units and B-units only. For further information on the 3380 Model CJ2, see *IBM 3380 Direct Access Storage Direct Channel Attach Model CJ2 Introduction and Reference*.

Highlights

The next few pages describe the highlights of the 3380.

Performance

All models of the 3380 incorporate functions such as rotational position sensing and command retry which are successful in improving disk storage performance. The Enhanced Subsystem models have faster seek times than other 3380 models, and when configured as a 4-path string, they offer additional performance advantage by providing **four** data transfer paths to a single device. See Figure 6 on page 22, and also see "Chapter 2. Functional Characteristics" on page 25 for detailed descriptions of the DASD and storage subsystem functions that improve performance.

Data Capacity

The 3380 A-units and B-units are available in models that provide different data capacities. Single capacity models provide approximately 2.52 gigabytes (GB) per four-volume unit. (GB equals 10^9 bytes.) Double capacity models provide approximately 5.04 GB per unit. Triple capacity models provide approximately 7.56 GB per unit. For additional details, see "Data Capacity" on page 21.

Supports ES Connection Channels

The 3380 can operate on ES Connection channels when it is attached to a 3990 Storage Control Model 2 or 3 that supports these channels. The 3380 models that support ES Connection channels are: AD4, BD4, AE4, BE4, AJ4, BJ4, AK4, and BK4.

The ES Connection channels use fiber optic cables to attach the processor to the 3990 Storage Control. These fiber optic cables can be up to three kilometers in length when the 3990 is directly attached to a channel. Switching devices (ES Connection Directors) can retransmit data, effectively extending the range up to nine kilometers (cable distance) from a channel. The fiber optic cables are easier to install and require less space than copper cables.

Other advantages of fiber optic cables are:

- More data can be moved per second with fiber optic cable than with bus-and-tag cable (a peak of 10 million bytes per second (MBs per second) compared to 4.5 million bytes per second).
- Because fiber optic cables transmit light rather than electricity, the problem of electrical noise interference is eliminated.

The data transfer rate of the 3990 Storage Control Model 3 is 10 megabytes per second. The data transfer rate of the 3990 Storage Control Model 2 is 4.5 megabytes per second. Performance with cache hits on ES Connection channels will normally be somewhat better than with parallel channels at equal distances. Extended channel distance causes minor performance degradation.

For more information on ES Connection channel support and ES Connection Directors, see *Introducing Enterprise Systems Connection*. For more information on 3990 Storage Control support of ES Connection channels, see *IBM 3990 Storage Control Introduction*.

Model Intermix on Strings

Models of varying data capacity can be intermixed on a 3380 string, within a particular model group. See "Strings" on page 19 for detailed information on string composition.

String Intermix on Storage Controls

There is a wide range of configuration options for attaching 3380 strings to IBM storage controls. As you add Enhanced Subsystem models to meet your capacity, performance, and availability needs, you may intermix Enhanced Subsystem strings on the 3880 or 3990 storage controls with strings of other model groups. See "Chapter 3. Support and Attachment" on page 33 for a description of the options for intermixing strings in storage subsystem configurations.

Storage Control Attachment

The 3380 A-unit models attach to IBM 3880 Storage Controls (Models 2, 3, 13, and 23). The 3380 A-unit models also attach to the IBM 3990 Storage Controls, a family of storage controls that provides increased performance and reliability over the 3880 models.

- The 3990 Model 1 provides string attachment capability comparable to a 3880 Model 3, with two storage paths to the DASD.
- The 3990 Model 2 has the equivalent string attachment capability of two cross-configured 3880 Model 3s, with the ability to provide four separate paths to the DASD.
- The 3990 Model 3 provides cache storage and has comparable attachment capability of a dual-frame 3880 Model 23, providing four separate paths to the DASD.

See *IBM 3990 Storage Control Introduction* for information on the 3990 Storage Controls.

Multiple Data Transfer Paths

Each 3380 A-unit or B-unit includes four devices that function independently. All 3380 models *except* A04 permit concurrent data transfer, on two paths, to devices within the string. Enhanced Subsystem models can provide concurrent data transfer on ***four*** paths within a four-path string configuration. The A-unit (head-of-string) and the storage control model to which it is attached determine whether the devices are serviced by one, two, or four data paths. See "Chapter 2. Functional Characteristics" on page 25 for detailed descriptions of the 3380 and storage subsystem functions that support multiple data transfer paths.

Reliability, Availability, and Serviceability

The reliability, availability, and serviceability of 3380 Direct Access Storage is improved in comparison to previous IBM disk storage products. In addition, the reliability, availability, and serviceability within the 3380 family has improved with each model group.

- Reliability
  - The 3380 has been designed with fewer components.
  - There is improved manufacturing control of media and accessing components.
- Availability
  - For all 3380 models *except* A04, multiple data transfer paths provide the ability to sustain operation of a 3380 model even if one of the paths becomes unavailable.
- Serviceability
  - Diagnostic run time is reduced.
  - Each storage control now has an error log to analyze intermittent faults.

Nondisruptive DASD Installation

When an Enhanced Subsystem Model AJ4 or AK4 is attached to a 3990 Storage Control Model 2 or 3 in 4-path string configuration, it is possible to add B-units to the string without disrupting operation and availability of existing devices on the string. Additionally, a second 4-path string can be attached to the 3990 Storage Control without disrupting the operation and availability of an existing 4-path string. During this nondisruptive DASD installation process, only one of the four paths to the existing DASD string is offline to the host. See "Chapter 4. Planning for Installation and Use" on page 67 for further information on taking advantage of the nondisruptive DASD installation capabilities.

Media Maintenance

With the 3380, you can maintain your own storage media. Tools for controlling the assignment of skip displacements allow you to bypass defective areas[1] on a track. Areas that are bypassed do not affect user data space calculations. For further information, see *Maintaining IBM Storage Subsystem Media* and *Device Support Facilities: Primer for the User of IBM 3380 Direct Access Storage*.

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1 A defective area is a part of a data track on which consistently readable data cannot be written.

Concurrent Media Maintenance

Device Support Facilities Release 11 (and subsequent releases) allows you to perform concurrent media maintenance on a 3380 track, while maintaining user access to the data originally residing on that track. With the ICKDSF INSPECT PRESERVE command, data on a track is temporarily relocated to an alternate track, which the user can access while maintenance operations are performed on the original track. After media maintenance on that track is complete, the data is restored to the track and verified. For more information on concurrent media maintenance, see *Maintaining IBM Storage Subsystem Media* and *Device Support Facilities: Primer for the User of IBM 3380 and 3390 Direct Access Storage.*

Model Upgrade

Within a model group, the 3380 can be upgraded at your data processing center to provide increased capacity as your needs grow. For example, a Model BJ4 can be upgraded to a Model BK4. (However, B-units cannot be upgraded to A-units.) See "Upgrading" on page 20 for additional details.

Operator Panel

Extended Capability and Enhanced Subsystem A-units have operator panels that simplify problem determination and system recovery procedures. "Chapter 5. Operation" on page 73 illustrates the operator panels and describes their use.

Space and Environment

Floor space and power consumption are significant considerations in today's data processing environment. The 3380 provides increased storage capacity without additional floor space requirements. Compared to previous disk storage products, the 3380 also provides savings in power consumption and heat load on a per-byte basis. These factors reduce the total cost of owning 3380 Direct Access Storage. "IBM DASD Comparisons" on page 23 provides comparative figures on floor space and power consumption. See "Chapter 4. Planning for Installation and Use" on page 67 for specific floor space and power requirements for installing 3380 storage.

Data Transfer Rate

All 3380 models transfer data at 3.0 megabytes per second (MB/sec) on parallel channels.

Product Description

Each 3380 **unit** described in this manual contains two sets of magnetic disks and four sets of access arms that position the read/write heads over the disk surfaces. The film-head technology used in the 3380 allows reading and writing of data recorded at higher densities than those of previous disk storage devices.

Each set of magnetic disks and its two sets of access arms with read/write heads are enclosed in a **head-disk assembly (HDA)** to protect the disk surfaces. There are two HDAs in an A-unit or B-unit. Although permanently mounted within the 3380 unit to maintain critical head and track alignments for normal operation, an HDA can be removed by a service representative for replacement.

Each set of access arms along with its associated disk surfaces and electronic circuitry comprises a storage **device**. There are two devices in an HDA and four devices in an A-unit or B-unit. Each device has a unique address and operates

independently of other devices in the unit. A device in a 3380 Extended Capability or Enhanced Subsystem unit can be enabled or disabled at the operator panel, independently of the other devices in the unit.

A device is supported by the mechanical and electrical systems needed to operate the disk and to locate, read, and write user data. Information used by the 3380 for seeking, track following, data clocking, index point signal generation, and rotational position sensing is recorded on a disk surface for each device when the 3380 is manufactured.

The DASD space associated with a device (that is, the disk surfaces accessed by one set of access arms) is referred to as a **volume**. Figure 2 shows the relationships of HDAs, access arms, and devices (or volumes) within an A-unit or B-unit.

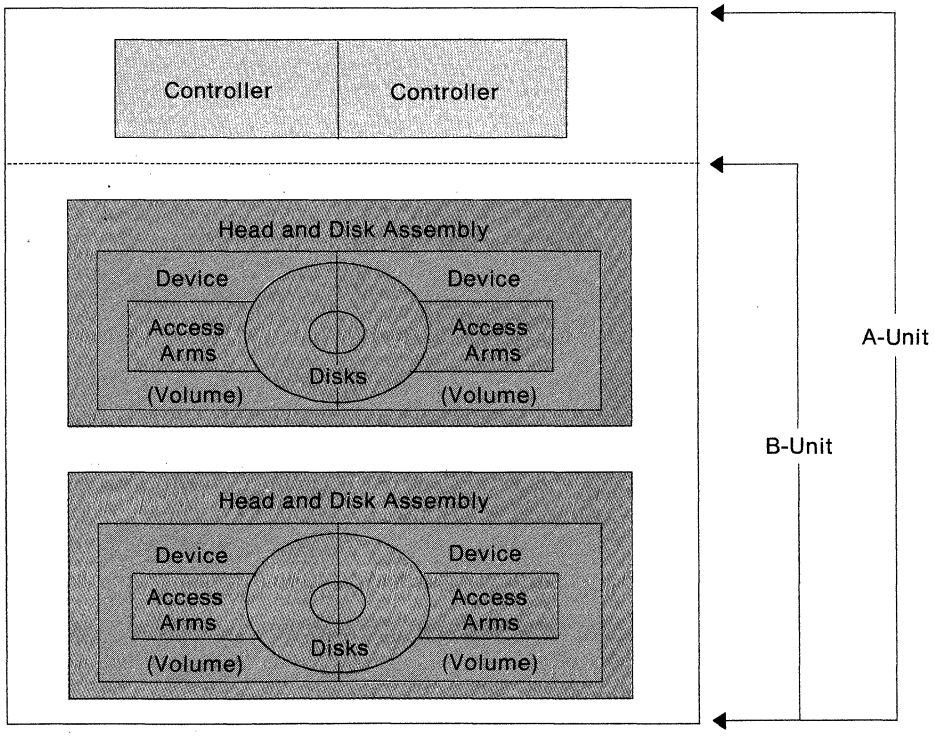


Figure 2. The 3380 A-Unit and B-Unit (excluding Model A04)

In addition to four devices enclosed in two HDAs, the 3380 A-units also contain **controllers**. There is one controller in a Model A04, while all other A-units contain two controllers. (See Figure 2.) The controller hardware performs the following functions:

- Interprets and processes commands issued by a storage control
- Controls the writing and interpretation of the track format on a field basis
- Clocks and serializes or deserializes data as it is transferred between the 3380 and the storage control
- Protects data integrity through error detection and correction information
- Furnishes status information to the storage control.

Strings

As many as three 3380 B-units can be attached to an A-unit to form a string. The Model A04 provides a single path string, while the Model AA4 and Extended Capability models provide the capability for 2-path strings. The Enhanced Subsystem models can be configured as either 2-path or 4-path strings. A 4-path string consists of a minimum of two A-units, and can have as many as six B-units attached.

Single Path Strings

The Standard A04 string consists of one 3380 Model A04 unit and as many as three Model B04 units. An A04 string has one controller and from four to 16 devices, in multiples of four.

2-Path Strings

Each 2-path string consists of two controllers and from four to 16 uniquely addressable devices, in multiples of four. All units in a string must belong to the same model group.

When Extended Capability or Enhanced Subsystem units are configured as 2-path strings, the storage subsystem runs in device-level selection (DLS) support mode, providing two paths for concurrent transfer of data to each string. See "Chapter 2. Functional Characteristics" on page 25 for a description of the DLS function.

Standard 2-Path Strings

As many as three Model B04 units can be attached to one 3380 Model AA4 unit. Two controllers provide two paths for concurrent data transfer to the string on two devices that do not share the same internal transfer path.

Extended Capability 2-Path Strings

As many as three B-units can be attached to either a Model AD4 or a Model AE4 unit. The three B-units may be any combination of 3380 Model BD4 and Model BE4 units. Two data transfer paths per string are provided, and each device may be accessed on either of two paths. These data transfer capabilities allow any two devices on the string to transfer data simultaneously.

Enhanced Subsystem 2-Path Strings

As many as three B-units can be attached to either a Model AJ4 or a Model AK4 unit. The three B-units may be any combination of 3380 Model BJ4 and Model BK4 units. Two data transfer paths per string are provided, and each device may be accessed on either of two paths. These data transfer capabilities allow any two devices on the string to transfer data simultaneously. When Enhanced Subsystem models are configured as a 2-path string, an appropriate attachment feature, dependent on the storage control type, must be used with the A-unit. See "Storage Control and 3380 Attachment Features and Engineering Changes" on page 36 for information on Enhanced Subsystem attachment features and engineering changes. For information on use of BJ4 and BK4 units in Model CJ2 2-path strings, see *IBM 3380 Direct Access Storage Direct Channel Attach Model CJ2 Introduction and Reference*.

4-Path Strings

Only Enhanced Subsystem models can be configured in 4-path strings. An attachment feature must be installed on the two AJ4 and/or AK4 units to logically and physically connect the A-units to each other. See "Storage Control and 3380 Attachment Features and Engineering Changes" on page 36 for information on the attachment feature and engineering changes.

As many as three B-units, any mixture of BJ4 and BK4 models, can be connected to each of the A-units. A 4-path string includes four controllers (two in each A-unit) and from eight to 32 uniquely addressable devices, in multiples of four. One A-unit and the B-units attached to it comprise a substring.

Enhanced Subsystem models can be configured in 4-path strings only when attached to a 3990 Model 2 or 3 Storage Control that is running in device level selection enhanced (DLSE) support mode. DLSE supports four concurrent transfer paths for data on the string. When 2-path Standard or Extended Capability strings are intermixed with Enhanced Subsystem 4-path strings on the same 3990 Storage Control, the storage subsystem runs in DLSE support mode. See "Chapter 2. Functional Characteristics" on page 25 for information on the DLSE function.

Figure 3 is an example of a 4-path string with the maximum number of B-units.

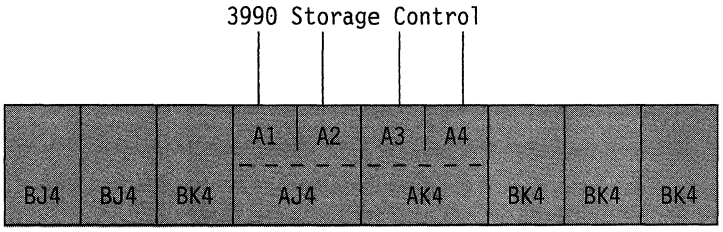


Figure 3. Enhanced Subsystem Models 4-path String

Upgrading

A service representative can upgrade models of the 3380 within a model group to increase the storage capacity of the unit. The Enhanced Subsystem A-units may be upgraded from 2-path to 4-path capability.

Capacity Upgrading: The 3380 models can be upgraded as follows:

Original Model	Upgraded Model
AD4	AE4
BD4	BE4
AJ4	AK4
BJ4	BK4

Capacity upgrades can be performed only within a model group. An A-unit can be upgraded to another A-unit, and a B-unit only to another B-unit.

Functional Upgrading: An AJ4 or AK4 can be upgraded from a 2-path model to a 4-path model by applying the feature for 4-path capability. See "Storage Control and 3380 Attachment Features and Engineering Changes" on page 36 for information on DASD attachment features and engineering changes. A Model A04

can be upgraded to a Model AA4 to provide a 2-path string capability through a second controller.

Data Capacity

Models of the 3380 are available with single, double, and triple storage capacities. Figure 4 summarizes data capacity for the 3380 models, when using standard record zero (R0).

Data Capacity	A04 AA4 B04 AD4 BD4 AJ4 BJ4	AE4 BE4	AK4 BK4
MB per device	630	1 260	1 890
MB per unit	2 520	5 041	7 562
GB per 4-unit string (1 A-unit, 3 B-units)	10.08	20.16	30.25
Note: MB equals 10^6 bytes, and GB equals 10^9 bytes.			

Figure 4. Data Capacity Summary of 3380 Models

3380 Characteristics Summary

Physical Characteristics of 3380 Models

Figure 5 summarizes the physical characteristics of 3380 models. Capacity figures assume use of standard R0.

Physical Characteristic	A04 AA4 B04 AD4 BD4 AJ4 BJ4	AE4 BE4	AK4 BK4
Devices per unit	4	4	4
Data cylinders per device	885	1 770	2 655
Alternate data cylinders per device	1	1	1
Service cylinders per device	1	1	1
Data tracks per cylinder	15	15	15
Data tracks per device	13 275	26 550	39 825
Alternate data tracks per device	15	15	15
Bytes per track	47 476	47 476	47 476
Bytes per cylinder	712 140	712 140	712 140
MB per device	630	1 260	1 890
MB per unit	2 520	5 041	7 562
Note: MB equals 10^6 bytes.			

Figure 5. Physical Characteristics Summary of 3380 Models

Performance Summary for 3380 Models

Figure 6 compares the performance attributes of 3380 models.

Performance Characteristic	A04 AA4 B04	AD4 BD4	AE4 BE4	AJ4 BJ4	AK4 BK4
Single cylinder seek time (ms)	3	3	3	2	2
Average seek time (ms)	16	15	17	12	16
Maximum seek time (ms)	30	28	31	21	29
Full track rotation time (ms)	16.6	16.6	16.6	16.6	16.6
Average rotational delay (ms)	8.3	8.3	8.3	8.3	8.3
Data transfer rate (MB/sec)	3.0	3.0	3.0	3.0	3.0
Note: ms (milliseconds) equals 10^{-3} seconds, and MB/sec equals 10^{6} bytes per second.					

Figure 6. Performance Summary for 3380 Models

Average seek time is approximately equivalent to the time required to seek over one-third of the cylinders. Models AK4 and BK4 have three times the number of data cylinders as the Models AJ4, BJ4, AD4, and BD4 (and 50% more than Models AE4 and BE4). Models AK4 and BK4 can seek over a finite set of data cylinders faster than all other 3380 models.

Here are some of the key terms used to describe performance characteristics in Figure 6:

Seek time, or access motion time: The time required to move the access arm from one cylinder to another. More precisely defined, the seek time is the time interval beginning when the channel issues a Seek command (requiring access motion) and ending when the 3380 responds with a Seek Complete indication to the storage control.

Average seek time: The seek time is obtained by moving the access arm from each individual cylinder to every other individual cylinder and then taking the average move time for all combinations.

An alternative method sometimes used for approximating average seek time is to move the access arm across one-third of the cylinders.

Average rotational delay: The average time required for the disk to rotate, to position the desired data record under the read/write head so data transfer can begin. This is sometimes called *average latency*. Average rotational delay is one half of the time for a full track rotation.

Data transfer rate: The rate at which data is transferred between the storage control and channel.

IBM DASD Comparisons

The following figures show how IBM 3380 models compare to other IBM DASD and how the latest 3380 models provide continuing improvements.

Performance and Physical Characteristics Comparisons

Figure 7 compares performance and physical characteristic of 3380 models with IBM 3350 DASD. Capacity figures assume use of standard R0.

Performance and Physical Characteristics	3350	3380 A04	3380 AA4 B04	3380 AD4 BD4	3380 AE4 BE4	3380 AJ4 BJ4	3380 AK4 BK4
Maximum concurrent data transfer paths	1	1	2	2	2	4	4
Average seek time (ms)	25	16	16	15	17	12	16
Full track rotation (ms)	16.7	16.6	16.6	16.6	16.6	16.6	16.6
Average rotational delay (ms)	8.3	8.3	8.3	8.3	8.3	8.3	8.3
Data transfer rate (MB/sec)	1.198	3.0	3.0	3.0	3.0	3.0	3.0
MB per device	317.5	630	630	630	1 260	630	1 890
MB per HDA	317.5	1 260	1 260	1 260	2 520	1 260	3 780
MB per Unit	635.0	2 520	2 520	2 520	5 041	2 520	7 562
MB per fixed head unit	2.28	—	—	—	—	—	—
Data cylinders per device	555	885	885	885	1 770	885	2 655
Tracks per cylinder	30	15	15	15	15	15	15
Bytes per track	19 069	47 476	47 476	47 476	47 476	47 476	47 476
Bytes per cylinder	572 070	712 140	712 140	712 140	712 140	712 140	712 140
Note: ms (milliseconds) equals 10^{-3} seconds, and MB equals 10^{6} bytes.							

Figure 7. Characteristics Comparison of IBM DASD

Power Consumption Comparisons

Figure 8 compares the power consumption of 3380 models with that of the 3350. These comparisons assume 200-208 volts at 60Hz. Information on other voltages and frequencies are available in *IBM System/360*, System/370*, 4300, and 9370 Processors Input/Output Equipment Installation Manual – Physical Planning.* Capacity figures assume use of standard R0.

* System/360 and System/370 are trademarks of the International Business Machines Corporation.

	3350 A2	3380 A04 AA4 B04	3380 AD4 BD4	3380 AE4 BE4	3380 AJ4 BJ4	3380 AK4 BK4
MB per 4-unit string	2 450	10 083	10 083	20 167	10 083	30 251
KVA	8.0	8.2	8.2	8.2	6.6	6.6
MB per KVA	306.3	1 229.6	1 229.6	2 459.3	1 527.7	4 583.4
Note: MB equals 10^6 bytes, and KVA (kilovolt x ampere), is the product of the effective values of the voltage and current, and is sometimes referred to as **apparent power**.						

Figure 8. Power Consumption Comparison: IBM 3380 and 3350

Floor Space Versus Data Capacity Comparisons

Figure 9 and Figure 10 compare floor space requirements of 3380 models with those of IBM 3350 DASD for comparable data capacities. For these comparisons, 3380 models are grouped by capacity.

3380 Single Capacity models are A04, B04, AA4, AD4, BD4, AJ4, and BJ4.

3380 Double Capacity models are AE4 and BE4.

3380 Triple Capacity models are AK4 and BK4.

Figure 9 compares the 3380 models with the 3350 to show the amount of floor space (***not*** including service clearance) needed for approximately the same amount (15 gigabytes) of 3380 data capacity.

Requirements for 15.2 GB	3350	3380 Single Capacity	3380 Double Capacity	3380 Triple Capacity
Number of units	24	6	3	2
Area in square meters	22.96	5.14	2.57	1.74
Area in square feet	247.2	55.4	27.7	18.8
Note: GB equals 10^9 bytes.				

Figure 9. Floor Space Requirement for Equivalent Data Capacity: IBM 3350 versus 3380 Models

Figure 10 compares the 3380 models with the 3350 to show the amount of data capacity per square meter and per square foot of floor space. Capacity figures assume use of standard R0.

	3350	3380 Single Capacity	3380 Double Capacity	3380 Triple Capacity
MB per square meter	663.7	2 942.7	5 885.5	8 693.0
MB per square foot	61.6	273.0	546.0	804.5
Note: MB equals 10^6 bytes.				

Figure 10. Data Capacity versus Floor Space

Chapter 2. Functional Characteristics

While 3380 has essentially the same external operating characteristics as other IBM disk storage devices, the 3380 Extended Capability models and Enhanced Subsystem models offer additional functions that provide better performance and availability than 3380 Standard models. This chapter describes the following functions and characteristics of the various 3380 models:

- Count-Key-Data Record Format
- Standard Functions
- Internal Paths
- Device Reserve, Release, and Reset Allegiance Commands
- Dynamic Path Selection (DPS)
- Device Level Selection (DLS)
- Device Level Selection Enhanced (DLSE)

See the following manuals for specific information on the level of support provided by each operating system for the functions described in the chapter:

Using the IBM 3380 Direct Access Storage in an MVS Environment
Using the IBM 3380 Direct Access Storage in a VM Environment
Using the IBM 3380 Direct Access Storage in a VSE Environment

Count-Key-Data Record Format

All models of the 3380 use the count-key-data (CKD) record format. A record written to a 3380 device may contain three areas: count, key, and data. The record always includes a count area and a data area; the key area is optional. Each area within a record is separated by a gap, and two adjacent records are separated by a gap. Figure 11 shows the typical layout of record areas on a track.

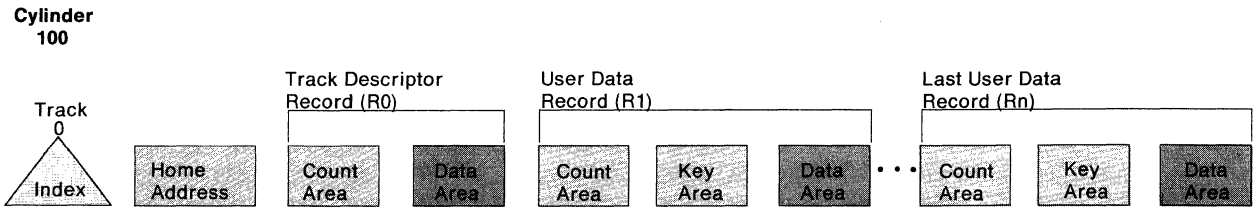


Figure 11. Track and Record Format, Simplified Representation

When the 3380 is manufactured, each track is initialized with the home address (HA) of the track and the track descriptor record, standard record zero (R0).

I/O operations are initiated when the processor issues a set of channel command words (CCWs), some of which might be read or write CCWs that support the CKD record format. Error checking and correcting (ECC) code bytes, used for detecting and correcting read errors, are added to each area of the record whenever a record is written.

See Appendix B, "Record Format, Track Format, and Space Calculations" on page 97 for a detailed description of record format considerations.

Standard Functions

All models of the 3380 support the standard storage subsystem functions described below.

Command Retry is a channel and storage director procedure that causes a channel command to be retried when some types of errors occur. The command retry does not cause an I/O interrupt in the processor; programmed error recovery procedures are not required. Command retry is used to correct some types of data and seek errors without involving system recovery procedures.

End-of-File is a record that defines the end of a group of records. An end-of-file record is written by issuing a Write Count, Key, and Data (Write CKD) channel command with a data length in the count field set to zero.

Multiple Track Operations allow the searching or reading of several tracks, in sequence. During Search operations and most Read operations, it is sometimes desirable to continue the operation to the next sequential track. When the end of a track is reached, the storage director can select the next sequentially numbered read/write head during all Search and most Read commands. This eliminates the need for Seek Head commands in a chain of Search or Read commands.

Format Write Release (or Write Padding) frees the channel, storage director, and string controller, while the device writes filler characters (pads) to the end of the track after a Format Write command (Write Home Address, Write R0, or Write CKD).

Rotational Position Sensing (RPS) allows a Search command to be started just before the required record comes under the read/write head, instead of starting the search at a random location on the track. RPS is based on a division of the track into evenly spaced sectors. The channel and storage director can disconnect while the track rotates to a specified sector location. This permits some I/O operations to be overlapped. For example, the 3380 can read or write data from one device while waiting for the track under a read/write head of another device to rotate to a specified sector location.

Further information on these standard storage subsystem functions is available in the following storage control manuals:

IBM 3880 Storage Control Models 1, 2, 3, and 4 Description Manual
IBM 3880 Storage Control Model 13 Descriptipn
IBM 3880 Storage Control Model 23 Description
IBM 3990 Storage Control Reference

Note that the 3380 does ***not*** support record overflow, sometimes referred to as track overflow.

Device Reserve, Release, and Reset Allegiance Commands

All models of 3380 are capable of supporting the Device Reserve and Release function. The Device Reserve channel command causes an entire volume (the data accessible by one device) to be reserved for the channel. This prevents access by any other channel, until the device is released with a Device Release channel command. The device reserve function can be handled on a channel-path-group basis, not just by one unique channel. See "Dynamic Path Selection (DPS)" on page 30 for related information.

The device reserve function is intended to prevent simultaneous attempts to update data on a volume. For example, a Device Reserve channel command is used when a VTOC or a catalog is to be updated. With a Device Reserve command, the device is reserved for use only over the single, selected path (as long as dynamic path selection is not active), or the path group when DPS is active.

An Unconditional Reserve channel command allows the resetting of an existing reserve condition on the original reserving path and applying the reserve to the path over which the Unconditional Reserve was received. This allows access to the device when there is no access over the original reserving path.

With the 3990, the Reset Allegiance command is added as a replacement for the Unconditional Reserve command. While the Unconditional Reserve command is still supported, use of the Reset Allegiance command is recommended. The Reset Allegiance command ends a device's allegiance to a channel path or path group, if the device is reserved to that channel path or path group. This command does not reset allegiance if the device is reserved to a different channel path or path group.

Internal Paths

Each 3380 A-unit model (except A04) contains two controllers, and each controller has four paths for accessing the devices on the string. Each successive 3380 model group provides improved access path capabilities between the controllers and the devices on the string. The diagrams on the following pages show the access paths from the controllers to the devices on the string for Standard models (not including A04), Extended Capability models, and Enhanced Subsystem models. "Dynamic Path Selection (DPS)" on page 30, "Device Level Selection (DLS)" on page 31, and "Device Level Selection Enhanced (DLSE)" on page 32 describe the performance and availability functions that are provided by the internal path access capabilities of the model groups.

Standard Model Internal Paths

With Standard Model AA4 strings, the internal controller paths are connected so that either controller can provide access to each device. Each of the four internal controller paths can access as many as four specific device addresses, as shown in Figure 12. The two controllers can access different devices on the string simultaneously, provided the devices are serviced on different internal paths. For example, if the device at address 0 is being used by controller A1, controller A2 may not access the device at address 1, 8, or 9 because the path is busy, but any of the devices serviced by another internal path could be selected by controller A2.

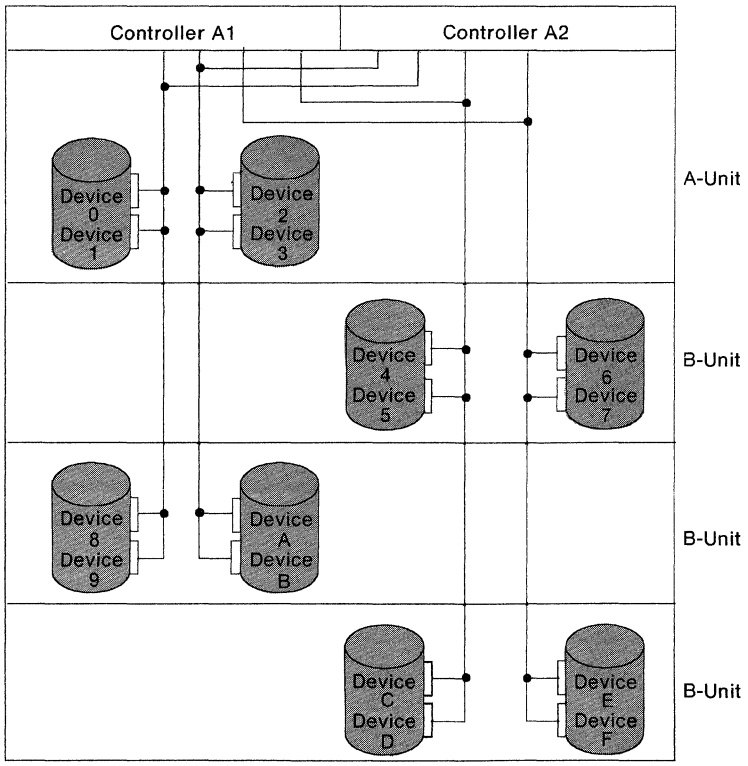


Figure 12. Internal Paths for Standard Model AA4 String

This internal path structure supports the DPS function. DPS controls which of the paths will be used by the controllers. See "Dynamic Path Selection (DPS)" on page 30 for further information.

Extended Capability Model Internal Paths

Extended Capability strings provide internal paths from the controllers to the devices on the string that allows any device on the string to be selected by either controller on any internal path. When one device is busy, all other devices in the 2-path string remain accessible to the other controller via remaining internal paths. ***Any two*** devices in the string may be selected concurrently, one by each controller. Figure 13 is a simplified schematic showing how any device in an Extended Capability model string is accessible to a controller, regardless of which other device may be busy on the other controller. See Appendix A, "Device Addressing and Identification" on page 87 for information on device address designations.

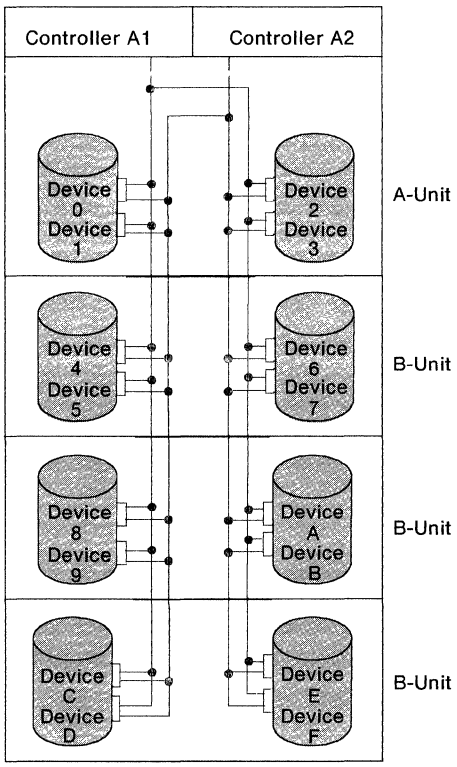


Figure 13. Internal Paths for 3380 Extended Capability String

The 2-path capability that is provided with these models provides Device Level Selection (DLS) capability; that is, any two devices may read or write data simultaneously. See "Device Level Selection (DLS)" on page 31 for additional information.

Note that when 2-path strings of Extended Capability models are intermixed with a 4-path Enhanced Subsystem string on a 3990 Model 2 or 3 Storage Control, the storage subsystem runs in DLSE support mode, and the 2-path strings have DLS capability.

Enhanced Subsystem Model Internal Paths

Enhanced Subsystem strings provide internal path capabilities that allow any device on the string to to be selected by any controller on any path. The concurrent device access capabilities for Enhanced Subsystem models depend upon how the units are configured.

- **When Enhanced Subsystem models are configured as 2-path strings,** the path capabilities are similar to those of Extended Capability models. There are two controllers that can access any of the devices (as many as 16) on any of the internal paths. ***Any two*** devices in the string may be selected concurrently, one by each controller. See Figure 13 on page 29. The resulting capability is DLS; see "Device Level Selection (DLS)" on page 31.
- **When Enhanced Subsystem models are configured as 4-path strings,** there are four controllers that can access any device on the string (as many as 32) on any of the internal paths. ***Any four*** devices on the string can be accessed simultaneously, one by each controller. This capability is called DLSE; see "Device Level Selection Enhanced (DLSE)" on page 32. Figure 14 is a simplified schematic showing how any device in an Enhanced Subsystem model 4-path string is accessible to a controller, regardless of which other three devices may be busy on the other three controllers. See Appendix A, "Device Addressing and Identification" on page 87 for information on device address designations.

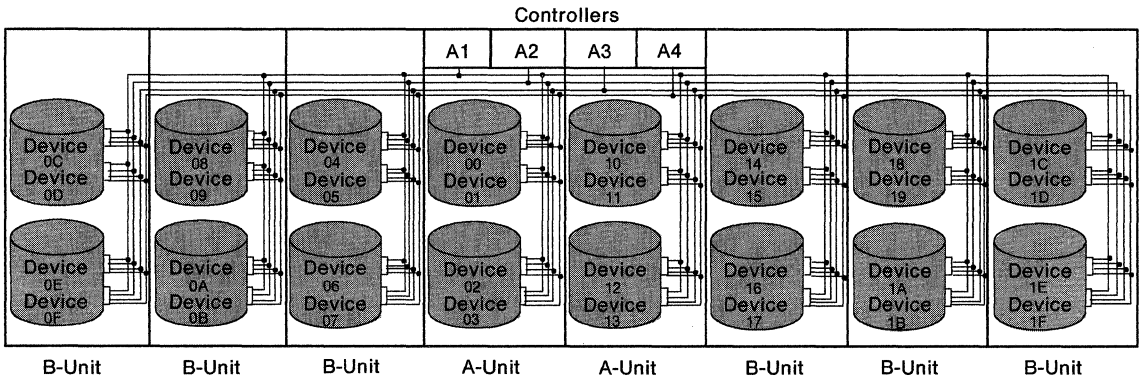


Figure 14. Internal Paths for 3380 Enhanced Subsystem 4-Path String

The appropriate configuration feature or engineering change must be used with the Enhanced Subsystem A-units. See "Storage Control and 3380 Attachment Features and Engineering Changes" on page 36 for a description of these features and engineering changes.

Dynamic Path Selection (DPS)

Dynamic path selection (DPS) is based on the DASD string having two controllers providing data transfer paths from the 3380 string to the storage directors, with selection of an alternate controller if one controller is unavailable. The storage directors, in turn, attach to two or more channels, thereby achieving multiple paths for transferring commands and data. The DPS functions are:

- Alternate controller selection
- Simultaneous transfer of data for two devices over two paths, provided that the two devices are on separate internal paths within the string

- Volume reserve (System-Related Reserve) for use by a specific **group** of paths rather than for use by a single path
- Dynamic path reconnect to the first available path (on Extended Architecture hosts only)

If two 3380 2-path strings are sequentially connected together, both sets of controllers are attached to the same pair of paths, providing two paths for data transfer to the two strings.

For system-initiated communication, a second I/O operation to the string can always be started, provided the two devices are on separate internal paths within the string. If the 3380 controller designated in the I/O address is busy or inoperative, the operating system or channel subsystem making the request is notified and can then select a path to the other controller to access 3380 data. The DPS function allows an alternate path to be established through another storage director and the other controller.

DPS is different from the string switching of other direct access storage types. String switching permits transfer of data over only one path at a time to a given string. Data can be transferred to one string, and another data transfer operation to a second string can occur simultaneously over a different storage director-channel path when both channel and string switching are available. DPS uses two entirely independent paths. Each path can transfer data at the same time to a given string.

Device Level Selection (DLS)

Device level selection (DLS) is a capability of the 3380 Model AD4, AE4, AJ4, and AK4 strings that provides two data transfer paths, one from each controller, to each device in the 2-path string (as many as 16 addresses). DLS enhances the capabilities of DPS by allowing **any two** devices in the 2-path string to read or write data simultaneously.

When attaching 2-path AJ4 or AK4 strings to a 3990 Storage Control, DLS support mode must be set by the service representative at hardware installation time. See *IBM 3990 Storage Control Introduction* for more information on 3990 DLS support mode.

The Enhanced Subsystem A-units must have the appropriate attachment feature or engineering change. See "Storage Control and 3380 Attachment Features and Engineering Changes" on page 36 for information on 3380 features and engineering changes.

DLS uses two storage directors. Each of the storage directors in the 3880 Storage Control provides a data path to each device in the 2-path string. With the 3990 Storage Control, each of the storage directors operates as a single-path storage director. A 2-path string attaches to two single-path storage directors.

The 3380 models with DLS offer improved data availability and overall system performance when compared to Standard models. If the selected device is not busy, it may be accessed even if another device on the 2-path string is reading or writing data. When one device on the 2-path string is busy, any of the remaining devices can be selected. This can reduce the amount of time an operating system needs to wait for a path to a device to become available.

Device Level Selection Enhanced (DLSE)

Device level selection enhanced (DLSE) is a capability of the 3380 Models AJ4 and AK4 that requires two interconnected A-units and provides four data transfer paths, one from each controller, to each device in the 4-path string (as many as 32 addresses). DLSE extends the capabilities of both DPS and DLS by allowing **any four** devices in the 4-path string to read or write data simultaneously.

The 4-path string attaches only to a 3990 Storage Control Model 2 or 3, with the storage directors operating as multipath storage directors to provide four data transfer paths. The 3990 runs in DLSE support mode, which is set by the service representative at hardware installation time. See *IBM 3990 Storage Control Introduction* for more information on 3990 DLSE support mode.

The Enhanced Subsystem A-units must have the appropriate feature or engineering change. See "Storage Control and 3380 Attachment Features and Engineering Changes" on page 36 for information on features or engineering changes.

3380 models with DLSE offer improved data availability and overall system performance when compared to both Standard and Extended Capability models. If the selected device is not busy, it may be accessed even if any three other devices on the 4-path string are reading or writing data. For example, when heavy batch sequential applications or dump/restore activity ties up a path from a channel to a device, DLSE reduces disruption in throughput performance to the remaining devices in the 4-path string. With DLSE, end-user response can be more consistent during heavy workload periods.

DLSE allows any one of the four paths to be quiesced (set offline to the host) without disrupting availability of the devices on the other paths. This means that additional B-units can be added to the 4-path string without disrupting availability of the existing devices, or that an additional 4-path string may be added to the 3990 Storage Control without disrupting use of an established string. See "Chapter 4. Planning for Installation and Use" on page 67 and Appendix A, "Device Addressing and Identification" on page 87 for additional information on the nondisruptive DASD installation capability associated with DLSE.

Chapter 3. Support and Attachment

The IBM 3380 Direct Access Storage models are supported in the MVS, VM, VSE, and TPF operating environments by a variety of large and intermediate-range processors. The 3380 A-unit models attach to the processor by means of both IBM 3880 and 3990 Storage Controls, and the 3380 units can be installed in several configuration arrangements.

This chapter specifies:

- The operating systems and processors that support models of the 3380 ("Operating System and Processor Support" on page 34)
- The attachment features or engineering changes for 3380 A-unit models and storage controls that are required for certain configuration capabilities ("Storage Control and 3380 Attachment Features and Engineering Changes" on page 36)
- The configuration ground rules for attaching 3380 units to 3880 Storage Controls, with examples ("3380 Attachment Options with 3880 Storage Controls" on page 40)
- The configuration ground rules for attaching 3380 units to 3990 Storage Controls, with examples ("3380 Attachment Options with 3990 Storage Controls" on page 52)

The channel switch options for the IBM storage controls provide capabilities for multiple channel access from single or multiple processors to 3380 strings. With a 3880 or a 3990 Model 1 Storage Control, as many as 8 different processor channels may access a 3380 string. With 3990 Model 2 or 3 Storage Controls, as many as 16 processor channels may access a 3380 string. For information on channel switch options, see:

Introduction to IBM 3880 Storage Control Model 23
IBM 3880 Storage Control Model 13 Description
IBM 3880 Storage Control Model 23 Description
IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide

Operating System and Processor Support

Programming support for 3380 strings is contained in the following IBM operating systems:

- MVS/Extended Architecture (MVS/XA*)
- MVS/Enterprise Systems Architecture (MVS/ESA*)
- MVS/370
- OS/VS1 (for Standard Models only)
- Virtual Machine/System Product (VM/SP)
- Virtual Machine/System Product High Performance Option (VM/SP HPO)
- Virtual Machine/Extended Architecture Systems Facility (VM/XA SF)
- Virtual Machine/Enterprise Systems Architecture (VM/ESA)
- Virtual Storage Extended/System Package (VSE/SP)
- Virtual Storage Extended/Advanced Functions (VSE/AF)
- Virtual Storage Extended/Enterprise Systems Architecture (VSE/ESA)
- Transaction Processing Facility (TPF) Version 2
- Transaction Processing Facility (TPF) Version 3

The Environmental Record Editing and Printing (EREP) Program and the Device Support Facilities (ICKDSF) must be installed to support the 3380. It is recommended that you use the latest release of these programs for all models. Release 9.0 of ICKDSF and 3.3.2 of EREP are the minimum required levels for use with the Enhanced Subsystem Models.

For the versions and release levels of the operating systems that support ES Connection channels, see *IBM 3990 Storage Control Introduction*.

Most operating systems provide support for all models of the 3380. For environment-specific information on any support restrictions, on minimum software release levels required to support the 3380 models, and on processor support see:

Using the IBM 3380 Direct Access Storage in an MVS Environment
Using the IBM 3380 Direct Access Storage in a VM Environment
Using the IBM 3380 Direct Access Storage in a VSE Environment

Figure 15 on page 35 lists the processors that provide support for the various types of 3380 strings, along with the storage control types that may be used for attaching the various 3380 models to the processors. See "Storage Control and 3380 Attachment Features and Engineering Changes" on page 36 for information on the features or engineering changes required for attaching the 3380 A-units to the storage controls.

* MVS/XA and MVS/ESA are trademarks of the International Business Machines Corporation.

Figure 15 (Page 1 of 2). IBM Processors and Storage Controls Compatible with 3380 Strings

String Type	IBM Storage Control Model Attachment[1]	IBM Processors[7]
A04	3880 Model 2 (Storage Director 2) 3880 Model 3	Standard Processors[2] 4381, 308x, and 3090[6] Processor[3] 4361 Processor[4] System/370 Models 158, 158-3 System/370 Models 168, 168-3 9375 and 9377 Processors ES/9000 Processors
AA4	3880 Model 2 (Storage Director 2) 3880 Model 3 (AA4 string(s) only)	Standard Processors[2] 4381, 308x, and 3090 Processor[3] 4361 Processor[4] System/370 Models 158, 158-3 System/370 Models 168, 168-3 9375 and 9377 Processors ES/9000 Processors
	3880 Model 3 (with AD4 or AE4 string)	Standard Processors[2] 4381, 308x, and 3090 Processor[3] 4361 Processor[4] 9375 and 9377 Processors ES/9000 Processors
	3880 Model 13, 23	Standard Processors[1] 4381, 308x, and 3090 Processor[3] 9375 and 9377 Processors ES/9000 Processors
	3990 Models 1, 2, 3[5]	4381, 308x, and 3090 Processor[3] 9375 and 9377 Processors ES/9000 Processors
AD4 AE4	3880 Model 3	Standard Processors[2] 4381, 308x, and 3090 Processor[3] 4361 Processor[4] 9375 and 9377 Processors ES/9000 Processors
	3880 Model 23	Standard Processors[2] 4381, 308x, and 3090 Processor[3] 9375 and 9377 Processors ES/9000 Processors
	3990 Models 1, 2, 3	4381, 308x, and 3090 Processor[3] 9375 and 9377 Processors ES/9000 Processors

Figure 15 (Page 2 of 2). IBM Processors and Storage Controls Compatible with 3380 Strings

String Type	IBM Storage Control Model Attachment[1]	IBM Processors[7]
AJ4 AK4	3880 Model 3	Standard Processors[2] 4381, 308x, and 3090 Processor[3] 4361 Processor[4] 9375 and 9377 Processors ES/9000
	3880 Model 23	Standard Processors[2] 4381, 308x, and 3090 Processor[3] 9375 and 9377 Processors ES/9000 Processors
	3990 Models 1, 2, 3	4381, 308x, and 3090 Processor[3] 9375 and 9377 Processors ES/9000 Processors

Notes:

1. Required features or engineering changes for attaching 3380 models to the storage controls are described in "Storage Control and 3380 Attachment Features and Engineering Changes" on page 36.
2. The Standard Processors include 3031, 3032, 3033, 4341, and the 3042 Attached Processor Model 2.
3. The 3090 Models 300E, 500E, and 600E run VM/XA or MVS/XA (with the Processor Resource/Systems Manager[6] (PR/SM[6]) feature, non-XA operating systems can be run).
4. Supported on 3-megabyte channel.
5. Attachment to a 3990 requires that the Model AA4 have a serial number of 15000 or greater for 60 Hz units or X0300 or greater for 50 Hz units.
6. 3090, Processor Resource/Systems Manager, and PR/SM are trademarks of the International Business Machines Corporation.
7. For information on processors that support ES Connection channels, see *Introducing Enterprise Systems Connection*.

Storage Control and 3380 Attachment Features and Engineering Changes

In certain cases, attachment of the 3380 model A-unit to the storage control requires that specific hardware features or engineering changes be applied to the storage control and/or to the A-unit. The feature and engineering change requirements are specified here for attaching the 3380 both to 3880 and to 3990 Storage Controls. Figure 16 on page 39 is a summary table of the attachment features and engineering changes.

3880 Storage Control Features for 3380 Attachment

Modifications that may need to be made to your 3880 depend on the type of the 3380 strings you want to attach. The 3880 attachment features are described briefly here. For further details, see:

Introduction to IBM 3880 Storage Control Model 23
IBM 3880 Storage Control Model 13 Description
IBM 3880 Storage Control Model 23 Description

Contact an IBM marketing representative about the qualifications for upgrading a 3880 Storage Control.

- Speed Matching Buffer for 3380, Feature 6550

  To allow a 3380 Model A04 or AA4 string to attach to channels with a 1.5 or 2 MB/second data transfer rate, this feature must be installed on any storage directors to which the A04 or AA4 string is attached. This may be Storage Director 2 of the 3880 Model 2 or either storage director of 3880 Model 3. For AA4 strings, this feature is required on **both** storage directors to which the AA4 is attached. If one storage director 3880 Model 3 has this feature installed, the other storage director in that 3880 Model 3 must also have this feature.

- 3380 Extended Attachment, Feature 8173

  This feature, along with two 3380 Extended Specify codes 9208 and a new microcode load are necessary to attach a 3380 Model AD4 or AE4 to a 3880 Model 3. Note that the Speed Matching Buffer For 3380 feature, if installed, must be removed when feature 8173 is installed. A 3880 Model 3 unit ***cannot*** have both feature 6550 and feature 8173 installed at the same time.

- 3380 AJ4/AK4 Model 3 Support, Feature 3005

  This feature must be installed on the 3880 Model 3 to attach a 3380 Model AJ4 or AK4 2-path string. If feature 3005 is installed, the Speed Matching Buffer For 3380 feature ***cannot*** be installed and 3380 Model A04 or AA4 strings ***cannot*** be attached. The 3380 Extended Attachment, Feature 8173, **cannot** be installed with Feature 3005, but Model AD4 and AE4 strings **can** be attached. Two corequisite features 9050, one for each storage director, are required with feature 3005. Feature 9431 is required on the 3380 AJ4 or AK4 unit; see "Features of the 3380 for Attachment to 3880 Storage Controls."

- 3380 AJ4/AK4 Model 23 Support, Feature 3010

  This feature must be installed on the 3880 Model 23 to attach a 3380 Model AJ4 or AK4 2-path string. If feature 3010 is installed, 3380 Model A04 or AA4 strings ***cannot*** be attached. However, Model AD4 and AE4 strings **can** be attached. Two corequisite features 9055, one for each storage director, are required with feature 3010. Feature 9431 is required on the 3380 AJ4 or AK4 unit; see "Features of the 3380 for Attachment to 3880 Storage Controls."

Features of the 3380 for Attachment to 3880 Storage Controls

A feature is required on certain 3380 A-units for attachment to the 3880:

- AJ4/AK4 3880 Storage Control Attachment, Feature 9431

  This feature must be installed on the 3380 AJ4 or AK4 unit that is attached to a 3880 Model 3 or 23 Storage Control. Feature 3005 or 3010 must be installed on the 3880 Model 3 or 23, respectively.

Features and Engineering Changes of the 3380 for Attachment to 3990 Storage Controls

Depending on the configuration of the AJ4 or AK4 string, one of two specific features must be applied to these A-units for attachment to a 3990 Storage Control. An update feature or engineering change is required when attaching Models AA4, AD4, or AE4 to a 3990 Storage Control.

- 3380 AJ4/AK4 2-Path String Attachment, Feature 9432

  This feature must be installed on the 3380 AJ4 or AK4 unit that attaches to a 3990 Storage Control Model 1, 2 or 3 when the 3380 units are configured as a 2-path string.

- 3380 AJ4/AK4 4-Path String Attachment, Feature 9433

  This feature must be installed on each 3380 AJ4 or AK4 unit that attaches to a 3990 Storage Control Model 2 or 3 when the 3380 units are configured as a 4-path string. Note that both 3380 AJ4 or AK4 units required for a 4-path string must have this feature installed.

- 3380 AA4 Installation/Maintenance Update, Engineering Change EC444944 ECA130

  This engineering change contains the updated installation and maintenance instructions and materials for attaching a 3380 Model AA4 to 3990 Storage Controls.

- 3380 AD4/AE4 Installation/Maintenance Update, Engineering Change EC465359 ECA131

  This engineering change contains the updated installation and maintenance instructions and materials for attaching a 3380 Model AD4 or AE4 to 3990 Storage Controls.

Feature or EC Number	Name of Feature or Engineering Change	Purpose of Feature or Engineering Change	Applied to
6550	Speed Matching Buffer Feature for 3380	Allows 3380 A04 or AA4 strings to attach to channels with 1.5 or 2 MB/second data rate.	3880 Models 2, 3
8173	3380 Extended Attachment	Allows AD4 or AE4 strings to attach to 3880 Model 3; requires two 3380 EXTENDED Specify codes 9208 and a new microcode load.	3880 Model 3
3005	3380 AJ4/AK4 3880 Model 3 Support Feature	Allows AJ4 or AK4 2-path string to attach to 3880 Model 3; requires two corequisite features 9050; requires feature 9431 on AJ4 or AK4.	3880 Model 3
3010	3380 AJ4/AK4 3880 Model 23 Support Feature	Allows AJ4 or AK4 2-path string to attach to 3880 Model 23; requires two corequisite features 9055; requires feature 9431 on AJ4 or AK4.	3880 Model 23
9431	3380 AJ4/AK4 3880 Storage Control Attachment Feature	Allows AJ4 or AK4 2-path string to attach to 3880 Model 3 or 23; requires feature 3005 or 3010 on 3380 Model 3 or 23, respectively.	3380 AJ4, AK4
9432	3380 AJ4/AK4 2-Path String Attachment Feature	Provides the capability for attaching 3380 AJ4 or AK4 2-path strings to a 3990 Storage Control.	3380 AJ4, AK4
9433	3380 AJ4/AK4 4-Path String Attachment Feature	Provides the capability for attaching 3380 AJ4 or AK4 4-path strings to a 3990 Storage Control Model 2 or 3.	3380 AJ4, AK4
EC444944 ECA130	3380 AA4 Installation/Maintenance Update Engineering Change	Provides the instructions and material for attaching a 3380 Model AA4 to a 3990 Storage Control.	3380 AA4
EC465359 ECA131	3380 AD4/AE4 Installation/Maintenance Update Engineering Change	Provides the instructions and material for attaching a 3380 Model AD4 or AE4 to a 3990 Storage Control.	3380 AD4, AE4

Figure 16. Summary of Attachment Features and Engineering Changes

3380 Attachment Options with 3880 Storage Controls

Models of the 3380 can attach to 3880 Models 2, 3, 13, and 23. Not all 3380 models attach to all models of the 3880; see Figure 15 on page 35 for attachment details and the following manuals for complete descriptions of these storage controls:

Introduction to IBM 3880 Storage Control Model 23
IBM 3880 Storage Control Model 13 Description
IBM 3880 Storage Control Model 23 Description

The 3880 Model 13 and Model 23 contain an area of electronic storage called ***cache*** to retain frequently used application data for faster access by the processor.

Each IBM 3880 storage control contains storage directors, which attach to block multiplexer channels. All 3380 models transfer data at a rate of 3.0 MB/second. A 3380 Model A04 or AA4 string can attach to channels with a slower data transfer rate, if attached to the appropriate 3880 Storage Control with the Speed Matching Buffer for 3380 feature. 3380 Extended Capability and Enhanced Subsystem Models can attach through the appropriate storage control only to channels capable of data streaming.

General 3880 Attachment Guidelines

One or two 3380 strings can be attached to a 3880 storage director, with as many as 32 separately addressable devices available through each storage director. A 3880 storage director can attach:

- One or two 3380 Model A04 strings
- One or two 3380 Model AA4 strings
- One or two 3380 Model AD4 or AE4 strings
- One or two 3380 Model AJ4 or AK4 2-path strings
- One 3380 Model AD4 or AE4 string and one Model AA4 string
- One 3380 Model AD4 or AE4 string and one Model AJ4 or AK4 2-path string

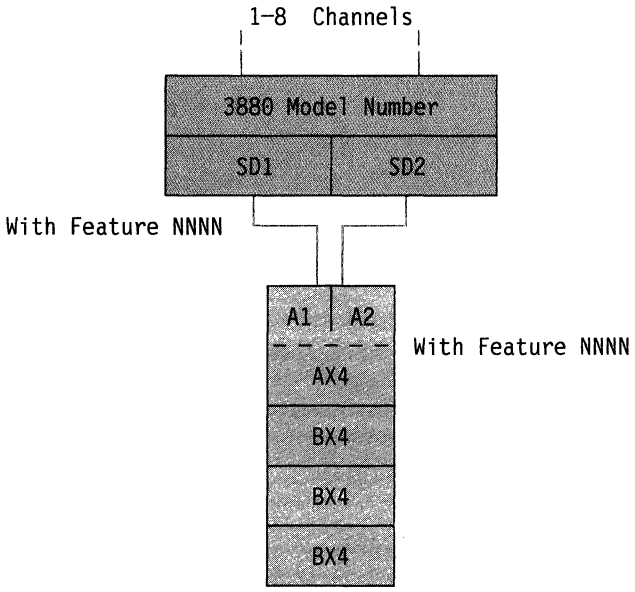
A 3880 storage director ***cannot*** attach both a Model A04 or AA4 and a Model AJ4 or AK4 string.

Two storage directors ***must*** be attached to different channels to provide two separate paths for the 3380 string. The channels may be on the same or different processors. If two 3380 strings are connected together sequentially, both strings must attach to the same two 3880 storage directors.

The attachment requirements and configuration options for each type of 3380 string are presented on the following pages. Examples are provided for some of the configuration options.

Figure 17 presents the general format of these diagrams and defines the abbreviations that are used in subsequent 3380-3880 configuration examples. Note that:

- All sample configuration diagrams show maximum-length strings, with three B-units.
- The A-unit represents the string type.
- Unless otherwise noted, processor channels are block multiplexer channels capable of handling the DASD data transfer rate of 3.0 MB/second.
- When specific hardware attachment features are required for a configuration, they are noted in the diagrams.



KEY:
SD = Storage Director
A1 = Controller 1
A2 = Controller 2
NNNN = Required feature number, if applicable
X = DASD model designation, for example: D, E, J, K

Figure 17. Format for 3380-3880 Configuration Examples

3380 Model A04 Strings Attached to 3880 Storage Controls

The controller in a 3380 Model A04 attaches to:

- Storage Director 2 of a 3880 Model 2
- Either storage director of a 3880 Model 3 (without feature 3005)

If necessary, the 3880 can include the Speed Matching Buffer for 3380 feature. The Speed Matching Buffer for 3380 feature (installed on the storage director of a 3880 Storage Control) allows a 3380 Model A04 string to attach to channels with a 1.5 or 2 MB/second data transfer rate.

Figure 18 is an example of two 3380 Model A04 strings sequentially connected to storage director 2 of a 3880 Model 2. Model A04 controllers ***cannot*** be sequentially connected to other 3380 controller models. In this example, Storage Director 2 has the Speed Matching Buffer (SMB) for 3380 feature.

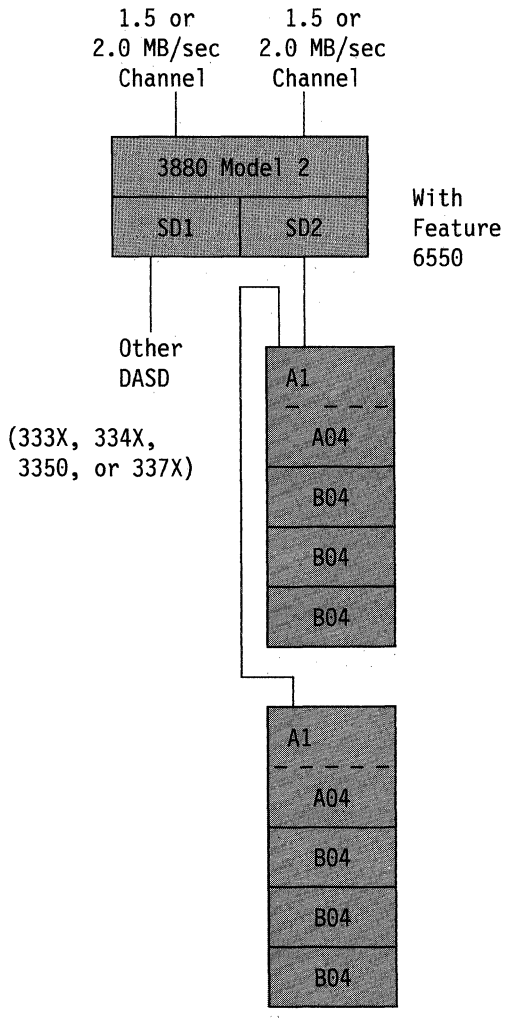


Figure 18. Example of 3380 Model A04 Strings Attached to a 3880 Model 2

3380 Model AA4 Strings Attached to 3880 Storage Controls

The two controllers in a 3380 Model AA4 attach to two 3880 storage directors that can be:

- Storage Director 2 of a 3880 Model 2 and
  - Storage Director 2 of another 3880 Model 2, or
  - Either storage director of a 3880 Model 3
- Both storage directors in the same 3880 Model 3
- Either storage director in two different 3880 Model 3s
- Both storage directors in the same 3880 Model 13
- Either of the paired storage directors in two different 3880 Model 13s in a dual-frame configuration
- Both storage directors in the same 3880 Model 23
- Either of the paired storage directors in two different 3880 Model 23s in dual-frame configuration

Figure 19 is an example of two 3380 AA4 strings sequentially connected to Storage Director 2 of a 3880 Model 2 and Storage Director 1 of a 3880 Model 3. In this example and in Figure 21, potential for greater availability is achieved by attaching the controllers to storage directors in separate 3880s.

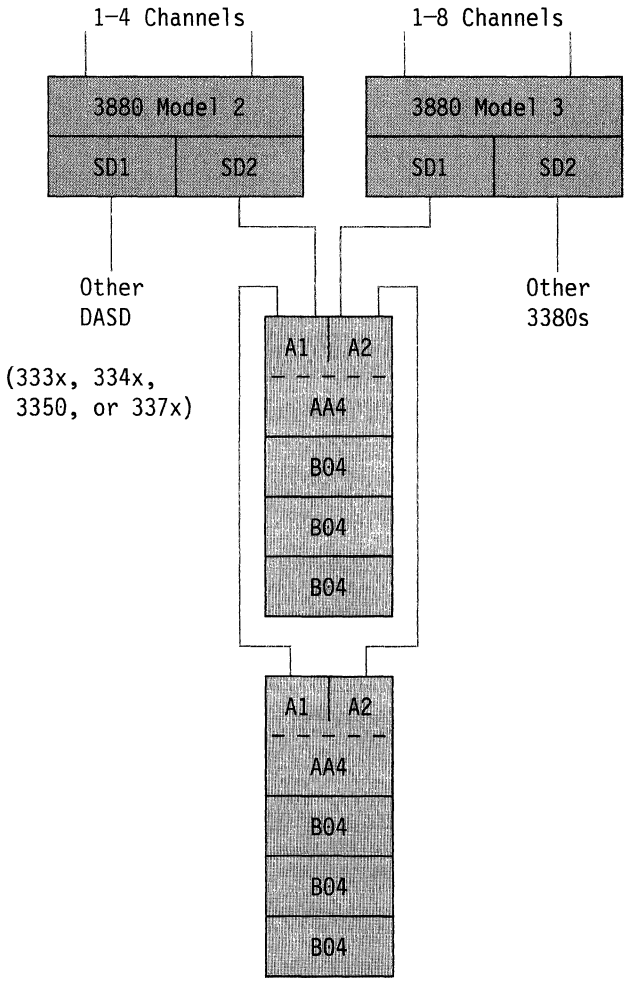


Figure 19. Example of 3380 Model AA4 Strings Attached to 3880 Model 2 and 3 Storage Directors

Figure 20 shows two 3380 AA4 strings sequentially connected to both storage directors of a 3880 Model 3, 13 or 23.

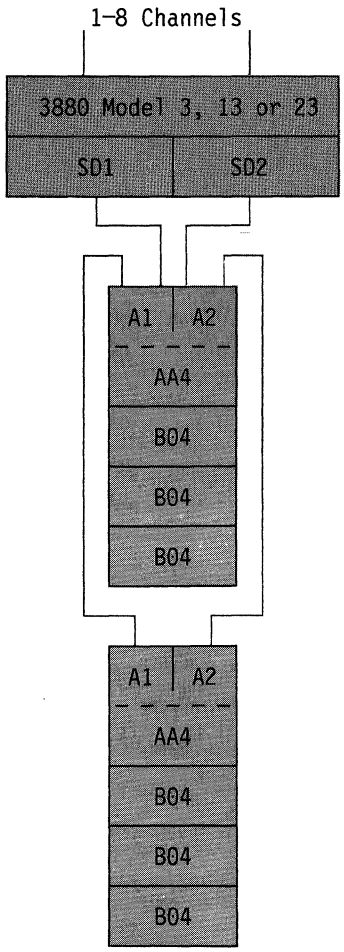


Figure 20. Example of 3380 Model AA4 Strings Attached to a 3880 Model 3, 13, or 23

Figure 21 is an example of two 3380 AA4 strings sequentially connected to two storage directors in different 3880 Model 13s or 23s in dual-frame configuration. The 3380 strings must be connected to Storage Director 1 of one 3880 and Storage Director 2 of the other. If these were 3880 Model 3 storage controls, the 3380 strings could be attached to either storage director of either 3880. See the appropriate storage control manual for information on dual-framing.

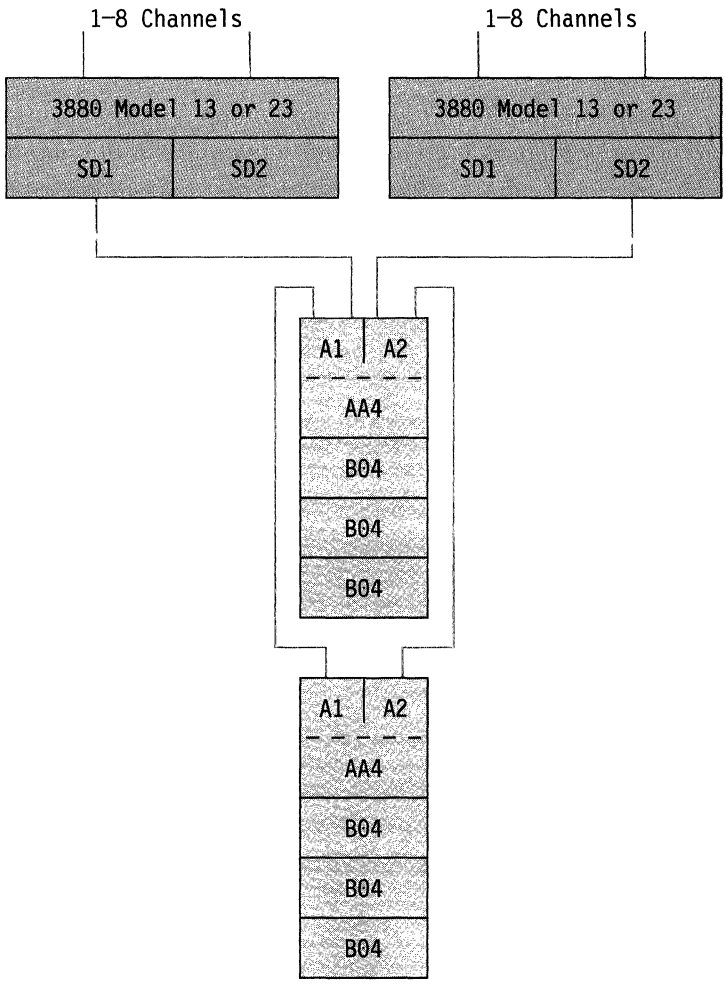


Figure 21. Example of 3380 Model AA4 Strings Attached to Two 3880 Models 13 or 23

3380 Model AD4 or AE4 Strings Attached to 3880 Storage Controls

The two controllers in a 3380 Model AD4 or AE4 attach to two 3880 storage directors that can be:

- Both storage directors in the same 3880 Model 3
- Either storage director in two different 3880 Model 3s
- Both storage directors in the same 3880 Model 23
- Either of the paired storage directors in two different 3880 Model 23s in dual frame configuration

The 3880 Model 3 to which a 3380 Model AD4 or AE4 string attaches ***cannot*** have the Speed Matching Buffer for 3380 feature. For more information about attachment of 3380 Model AD4 or AE4 strings to 3880 Model 3, see "Storage Control and 3380 Attachment Features and Engineering Changes" on page 36.

Figure 22 is an example of an AD4 and an AE4 string sequentially connected to both storage directors of a 3880 Model 3. In this example, each string contains a mixture of BD4 and BE4 units.

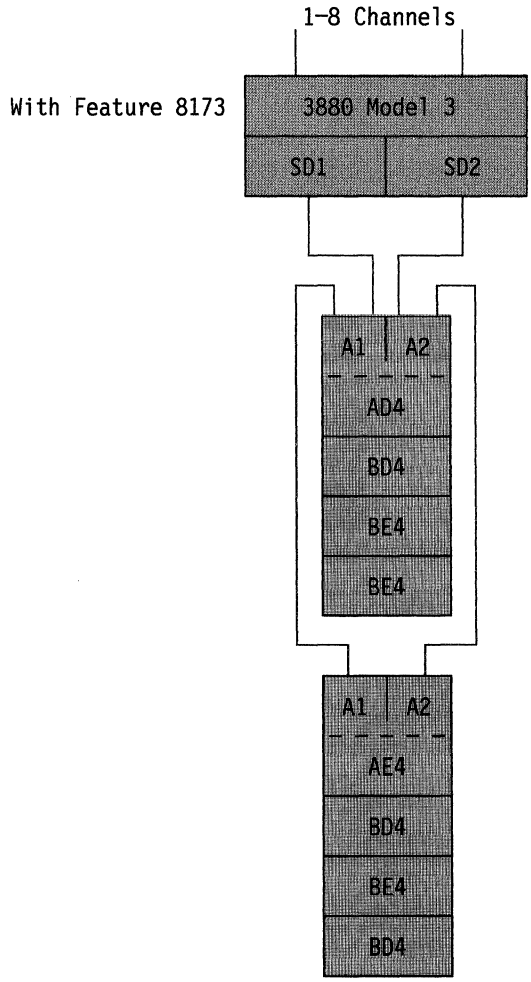


Figure 22. Example of 3380 Model AD4 and AE4 Strings Attached to a 3880 Model 3

Figure 23 is an example of two AE4 strings sequentially connected to two storage directors in two 3880 Model 23s in dual-frame configuration. With dual-frame configuration, the 3380 string must be connected to Storage Director 1 of one 3880 and Storage Director 2 of the other. In this example, potential for greater availability is achieved through attaching the controllers to storage directors in separate 3880s.

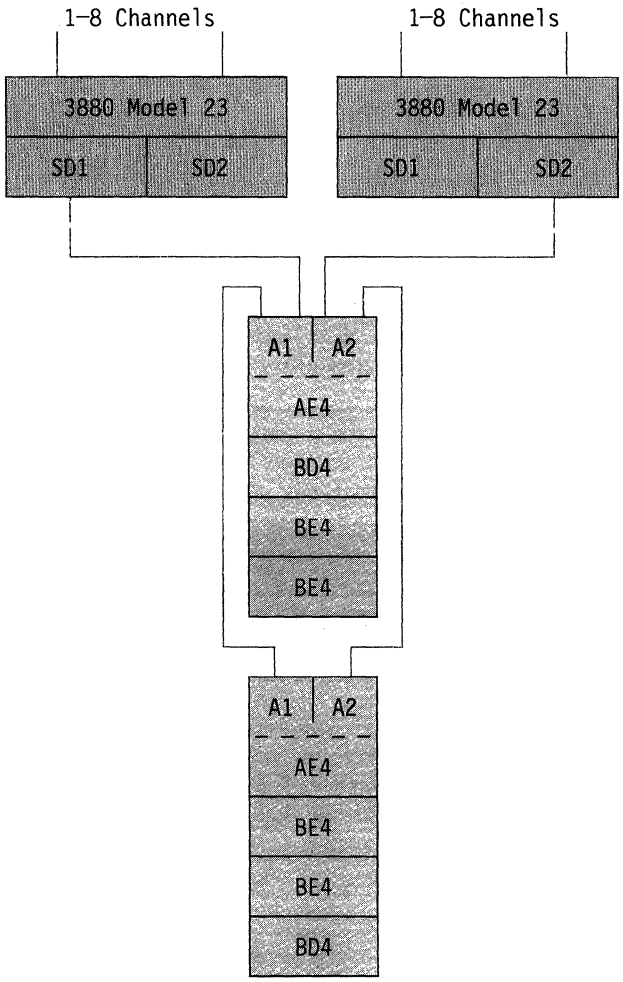


Figure 23. Example of 3380 Model AE4 Strings Attached to Dual-Framed 3880 Model 23s

3380 Model AJ4 or AK4 Strings Attached to 3880 Storage Controls

The two controllers in a 3380 Model AJ4 or AK4 2-path string attach to two 3880 storage directors that can be:

- Both storage directors in the same 3880 Model 3, with feature 3005
- Either storage director in two different 3880 Model 3s, with feature 3005
- Both storage directors in the same 3880 Model 23, with feature 3010
- Either of the paired storage directors in two different 3880 Model 23s in dual-frame configuration, with feature 3010

The 3880 Model 3 to which a 3380 Model AJ4 or AK4 string attaches ***cannot*** have the Speed Matching Buffer for 3380 feature.

The Model AJ4 or AK4 units must have feature 9431 to attach to the 3880 Model 3 or 23.

Figure 24 is an example of two 3380 2-path strings sequentially connected to both storage directors of a 3880 Model 3. In this example, one string contains a 3380 Model AJ4 controller, the other, a Model AK4 controller and a mixture of BJ4 and BK4 units on both strings.

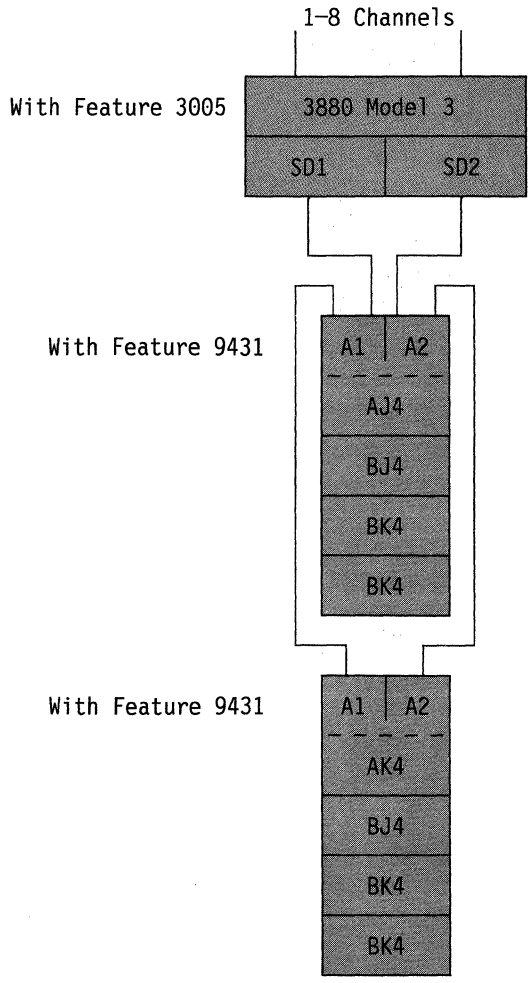


Figure 24. Example of 3380 Model AJ4 and AK4 2-Path Strings Attached to a 3880 Model 3

Figure 25 is an example of two 3380 2-path strings sequentially connected to two storage directors in different Model 23s in dual-frame configuration. The 3380 strings must be connected to Storage Director 1 of one 3880 and Storage Director 2 of the other. The 3880 Model 23 storage directors must have feature 3010 to attach 3380 Model AJ4 or AK4 2-path strings.

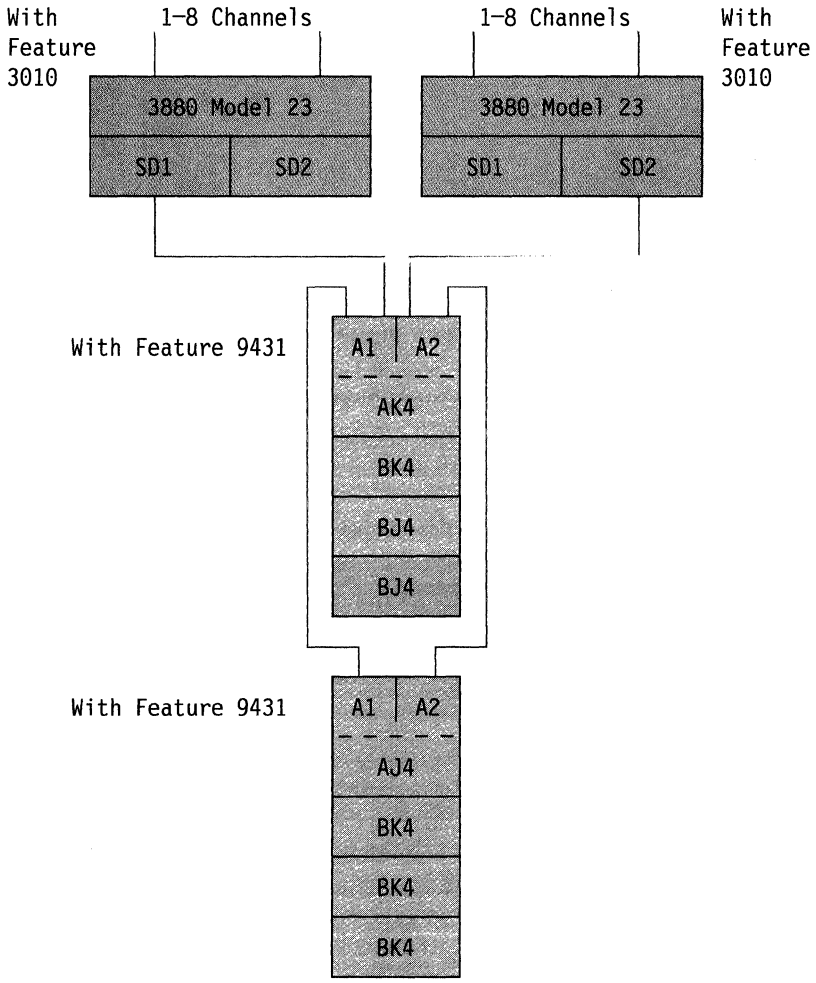


Figure 25. Example of 3380 Model AJ4 and AK4 2-Path Strings Attached to Dual-Framed 3880 Model 23s

Intermixed Strings Attached to 3880 Storage Controls

As described in "General 3880 Attachment Guidelines" on page 40, there are two ground rules for intermixing strings of different model groups on the same 3880 storage director.

- One 3380 Model AD4 or AE4 string can be attached along with one Model AA4 string.
- One 3380 Model AD4 or AE4 string can be attached along with one Model AJ4 or AK4 string.

Figure 26 shows an example of a Model AE4 string and an AJ4 2-path string mixed on one set of storage directors, and an AK4 2-path string and an AD4 string mixed on the other set of storage directors. The strings are attached to different Model 23s in dual-frame configuration. Note that one pair of strings (AJ4 and AE4) attaches to Storage Director 1 of the left 3880 and to Storage Director 2 of the right 3880. The other pair of strings (AK4 and AD4) attaches to Storage Director 2 of the left 3880 and to Storage Director 1 of the right 3880.

The storage directors must have feature 3010 on the 3880 Model 23 to attach 3380 Model AJ4 or AK4 2-path strings. The Model AJ4 and AK4 units must have feature 9431.

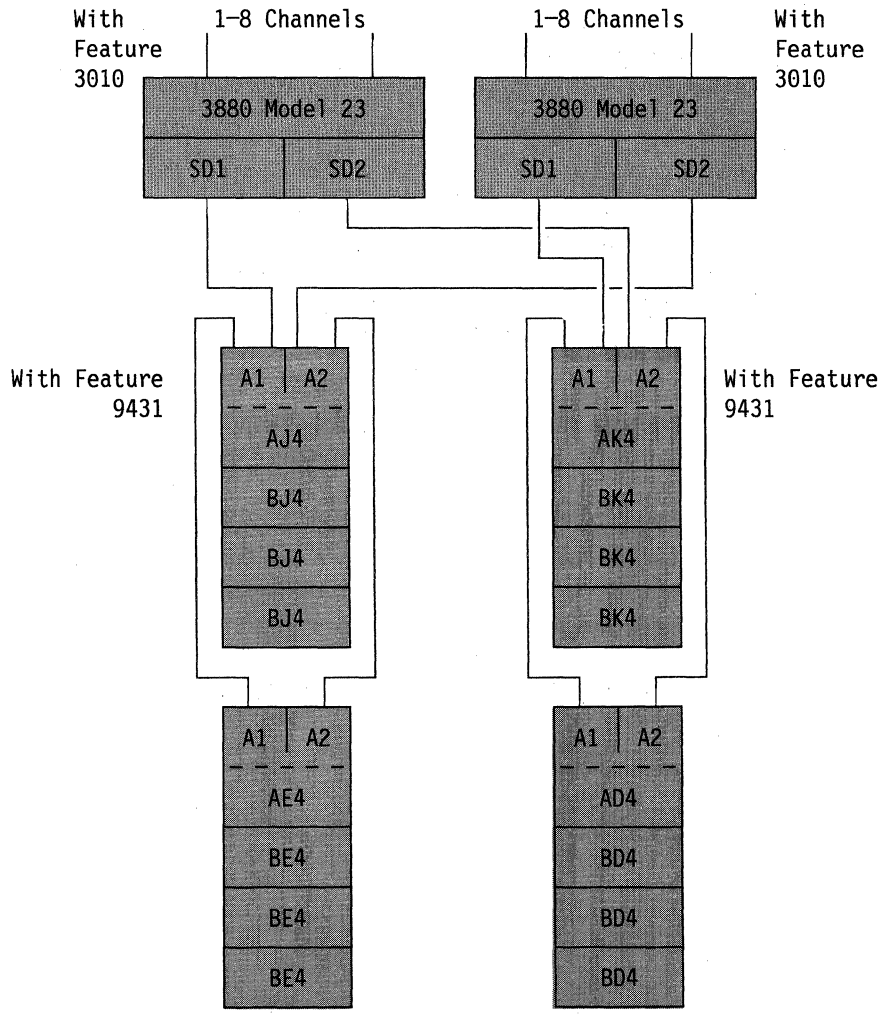


Figure 26. Example of Intermixed AD4, AE4, AJ4, and AK4 Strings Attached to Dual-Framed 3880 Model 23s

3380 to 3880 Attachment Summary

In summary, the major concepts and ground rules for attaching 3380 strings to 3880 storage directors are:

- A 3380 Model A04 or AA4 string can include as many as three Model B04 units, but cannot include units of other 3380 models.
- Both storage directors that attach a 3380 Model AA4 string must have the Speed Matching Buffer for 3380 feature, and if one storage director on a 3880 Model 3 has this feature, the other storage director must also have this feature.
- A 3380 Model AD4 and/or AE4 string can include as many as three Model BD4 and/or BE4 units, but cannot include units of other 3380 models.
- 3380 Model BD4 and BE4 units can be attached on the same string.
- A 3380 Model AJ4 or AK4 string can include as many as three Model BJ4 or BK4 units, but cannot include units of other 3380 models.
- 3380 Model BJ4 and BK4 units can be attached on the same string.
- A 3380 Model A04 string can be sequentially connected only to another 3380 Model A04 string.
- A 3380 Model AA4 string can be sequentially connected to another AA4 string, or to a 3380 Model AD4, or AE4 string.
- A 3380 Model AD4 or AE4 string can be sequentially connected to another AD4 or AE4 string, or to a 3380 Model AJ4 or AK4 string.
- A 3380 Model AJ4 or AK4 string may be sequentially connected to another AJ4 or AK4 string.
- A 3380 Model AA4 string can be connected to different storage directors in two 3880 Model 3s or two 3880 Models 13 or 23 in dual-frame configuration.
- A 3380 Model AD4, AE4, AJ4, or AK4 string can be connected to two 3880 Model 3s or to two 3880 Model 23s in dual-frame configuration.
- The two 3880 storage directors can reside in the same 3880 unit or in different 3880 units (3880 Model 13s and 23s must be in dual-frame configuration), and can attach to the same processor or to different processors.
- Two 3380 strings that are sequentially connected must attach to the same two 3880 storage directors.

See "Storage Control and 3380 Attachment Features and Engineering Changes" on page 36 for information on the attachment features or engineering changes required for 3380 configurations attached to 3880 Storage Controls.

3380 Attachment Options with 3990 Storage Controls

Models of the 3380 attach to 3990 Models 1, 2, and 3. Not all 3380 models attach to the 3990 Storage Controls; see Figure 15 on page 35 for attachment details.

The 3990 Models G03, J03, L03, and Q03 (referred to as Model 3 in this manual), contain an area of electronic storage called ***cache*** to retain frequently used application data for faster access by the processor. Each of these models offers a different size cache storage facility. The *cache fast write* function can be effective in enhancing performance for applications with high-use temporary data sets, for example, sort work data sets.

The cache together with nonvolatile storage can provide additional functions. *DASD fast write* and *dual copy* are available as Extended Function with appropriate software support.

See *IBM 3990 Storage Control Introduction* for further information on the 3990 Storage Control models and capabilities.

The 3990 Storage Control Models 2 and 3 can be run in either DLS support mode or in DLSE support mode. The 3990 Model 1 runs in DLS support mode only. This mode is set by the service representative at hardware installation time and is directly related to the configuration of the attached DASD strings. DLS support mode handles 2-path DASD strings, while DLSE support mode is required for 4-path strings (Enhanced Subsystem models only).

The general configuration format for 2-path strings ("General 3990 Attachment Guidelines for Single-Path Storage Directors" on page 53) and for 4-path strings ("General 3990 Attachment Guidelines for Multipath Storage Directors" on page 55) are presented here, followed by the specific attachment requirements and configuration options for each 3380 string type. Examples are provided for some of the configuration options. See "Chapter 2. Functional Characteristics" on page 25 and *IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide* for additional information on DLS and DLSE support modes of operation. Use the glossary of this manual to gain familiarity with 3990 hardware terminology.

ES Connection Channel Support

The 3990 Storage Control Models 2 and 3 support ES Connection channels. For more information on 3990 ES Connection channel support, see *IBM 3990 Storage Control Introduction*.

The data transfer rate of the 3990 Storage Control Model 3 is 10 megabytes per second. The data transfer rate of the 3990 Storage Control Model 2 is 4.5 megabytes per second. Performance with cache hits on ES Connection channels will normally be somewhat better than with parallel channels at equal distances. Extended channel distance causes only minor performance degradation.

General 3990 Attachment Guidelines for Single-Path Storage Directors

With DLS support mode, each ***storage cluster*** of a 3990 contains two ***single-path storage directorss***, each of which is associated with one ***storage path***. One or two 3380 2-path strings can be attached to a 3990 single-path storage directors, with as many as 32 separately addressable devices accessible through a pair of single-path storage directorss. A 3990 single-path storage directors can attach:

- One or two Model AA4[2] strings
- One or two Model AD4 or AE4 strings
- One or two Model AJ4 or AK4 2-path strings
- One Model AA4 string and one Model AD4 or AE4 string
- One Model AA4, AD4, or AE4 string and one Model AJ4 or AK4 2-path string

Figure 27 presents the general format of the 3990 Model 2 and 3 2-path configuration diagrams and defines the abbreviations that are used in subsequent 3380-3990 configuration examples. Note that:

- All sample configuration diagrams show maximum-length strings, with three B-units.
- The A-unit represents the string type.
- Processor channels are block multiplexer channels capable of handling a DASD data transfer rate of 3.0 MB/second.
- When specific hardware attachment features are required for a configuration, they are noted in the diagrams.
- 3990 Model 1 contains one storage cluster only, unlike this general format example, that resembles Models 2 and 3.

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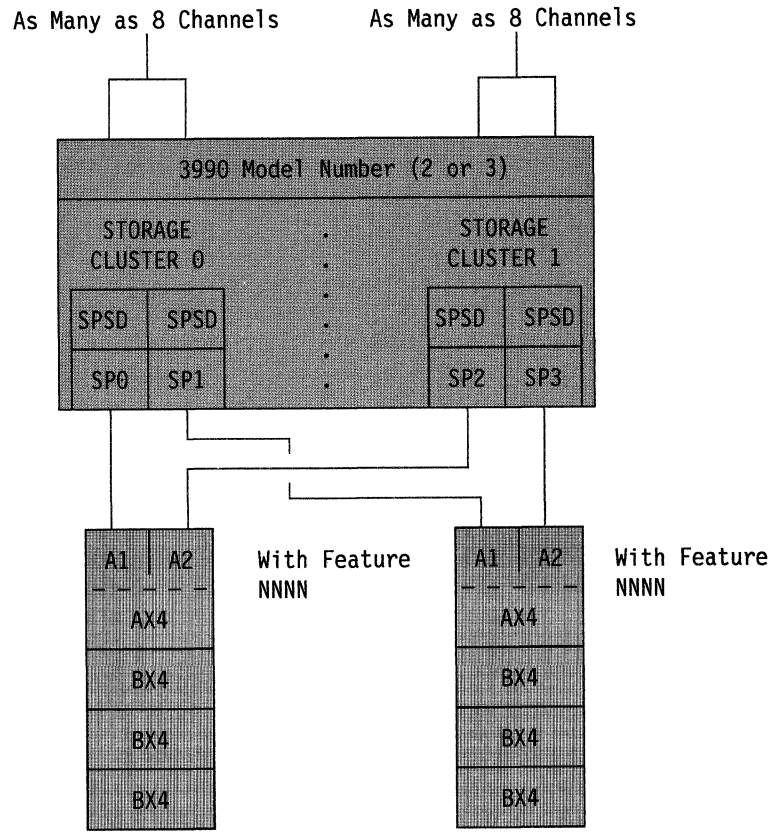
2 Attachment to a 3990 requires that the Model AA4 have a serial number of 15000 or greater for 60 Hz units or X0300 or greater for 50 Hz units.



KEY:
SPSD = Single Path Storage Director
SP = Storage Path
A1 = Controller 1
A2 = Controller 2
NNNN = Required feature number, if applicable
X = DASD model designation, for example: D, E, J, K

. Indicates power and service boundary

Figure 27. Format for 3380-3990 Single-Path Storage Director Configuration Examples

General 3990 Attachment Guidelines for Multipath Storage Directors

With DLSE support mode, each ***storage cluster*** of a 3990 contains one ***multipath storage director***, each of which is associated with two ***storage paths***. Two 3380 2-path strings and one 4-path string, or two 3380 4-path strings can be attached to a 3990 multipath storage director with as many as 64 separately addressable devices available through each multipath storage director. A 3990 multipath storage director can attach:

- Two Model AA4[3] strings and one Model AJ4 or AK4 4-path string
- Two Model AD4 or AE4 strings and one Model AJ4 or AK4 4-path string
- One Model AA4 string and one Model AD4 or AE4 string and one Model AJ4 or AK4 4-path string
- Two Model AJ4 or AK4 4-path strings

Models AJ4 or AK4 configured as 2-path strings **cannot** be intermixed with Model AJ4 or AK4 4-path strings on the same multipath storage director.

Figure 28 on page 56 presents the general format of the 3990 4-path configuration diagrams and defines the abbreviations that are used in subsequent 3380-3990 configuration examples. Note that:

- All sample configuration diagrams show maximum-length strings, with six B-units.
- Processor channels are block multiplexer channels capable of handling a DASD data transfer rate of 3.0 MB/second.
- Hardware attachment feature 9433 is required on Model AJ4 or AK4 units in 4-path strings.
- 3990 Model 1 cannot be configured for attachment of 4-path strings.

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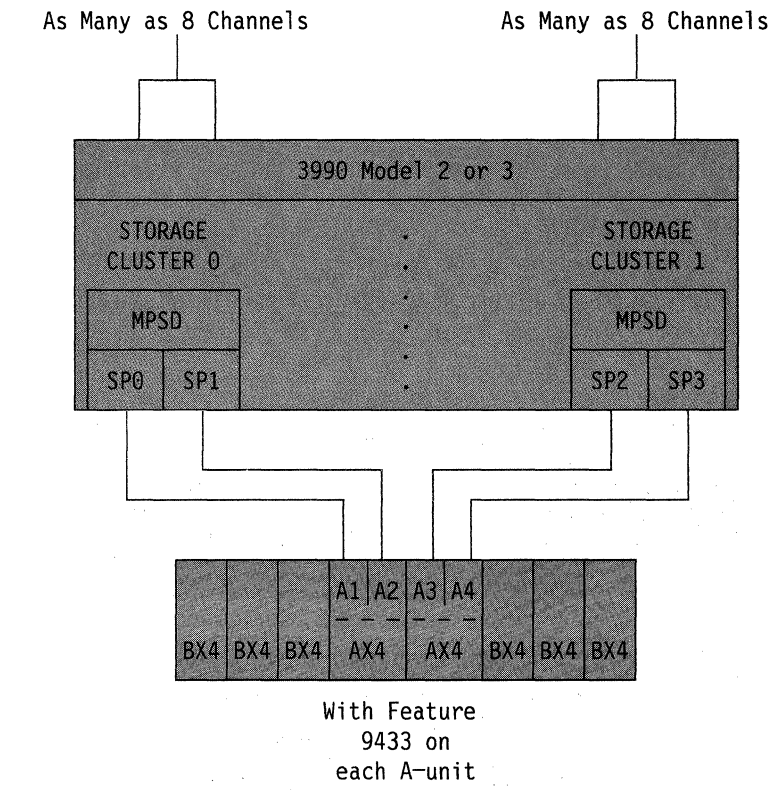
3 Attachment to a 3990 requires that the Model AA4 have a serial number of 15000 or greater for 60 Hz units or X0300 or greater for 50 Hz units.



KEY:
MPSD = Multipath Storage Director
SP = Storage Path
A1 = Controller 1
A2 = Controller 2
A3 = Controller 3
A4 = Controller 4
X = DASD model designation, J or K

. Indicates power
. and service
. boundary

Figure 28. Format for 3380-3990 Multipath Storage Director Configuration Examples

3380 Model AA4 Strings Attached to 3990 Storage Controls

The two controllers in a 3380 Model AA4[4] attach to two 3990 storage paths that can be:

- Storage path 0 and storage path 1 in the same 3990 Model 1
- Storage path 0 and 2 or storage path 1 and 3 in the same 3990 Model 2 or 3

Figure 29 is an example of four 3380 AA4 strings, with two strings sequentially connected to each of the paired storage paths in the same 3990 Model 2 or 3. Storage Path 0 and Storage Path 2 are paired, as are Storage Path 1 and Storage Path 3.

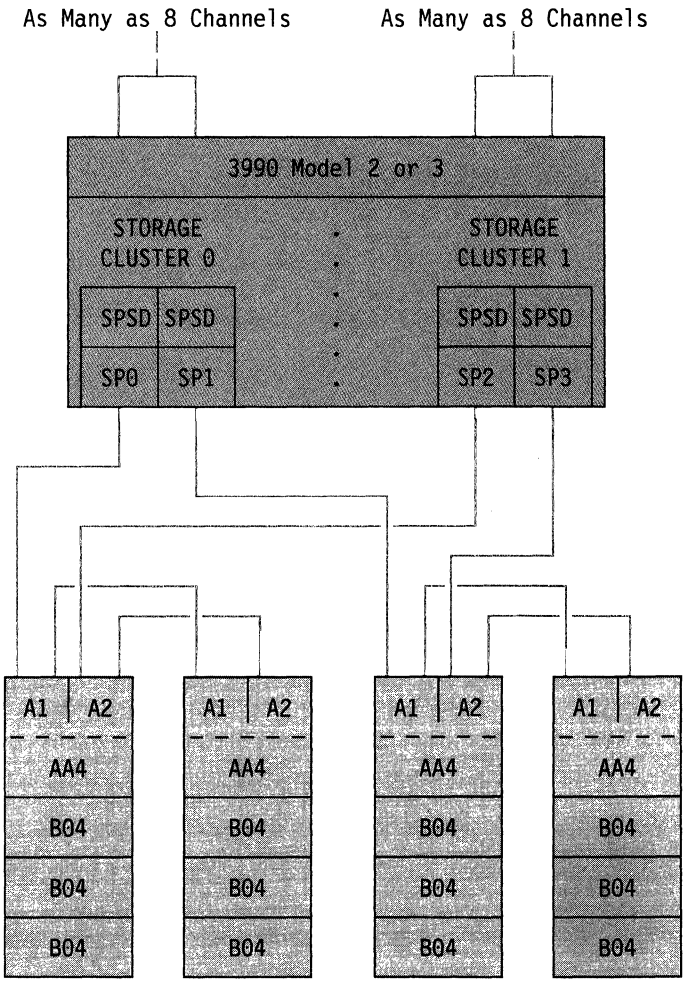


Figure 29. Example of 3380 Model AA4 Strings Attached to a 3990 Model 2 or 3

[4] Attachment to a 3990 requires that the Model AA4 have a serial number of 15000 or greater for 60 Hz units or X0300 or greater for 50 Hz units.

3380 Model AD4 or AE4 Strings Attached to 3990 Storage Controls

The two controllers in a 3380 Model AD4 or AE4 attach to two 3990 storage paths that can be:

- Storage path 0 and storage path 1 in the same 3990 Model 1
- Storage path 0 and 2 or storage path 1 and 3 in the same 3990 Model 2 or 3

Figure 30 is an example of four 3380 strings, with two strings sequentially connected to each of the paired storage paths in the same 3990 Model 2 or 3.

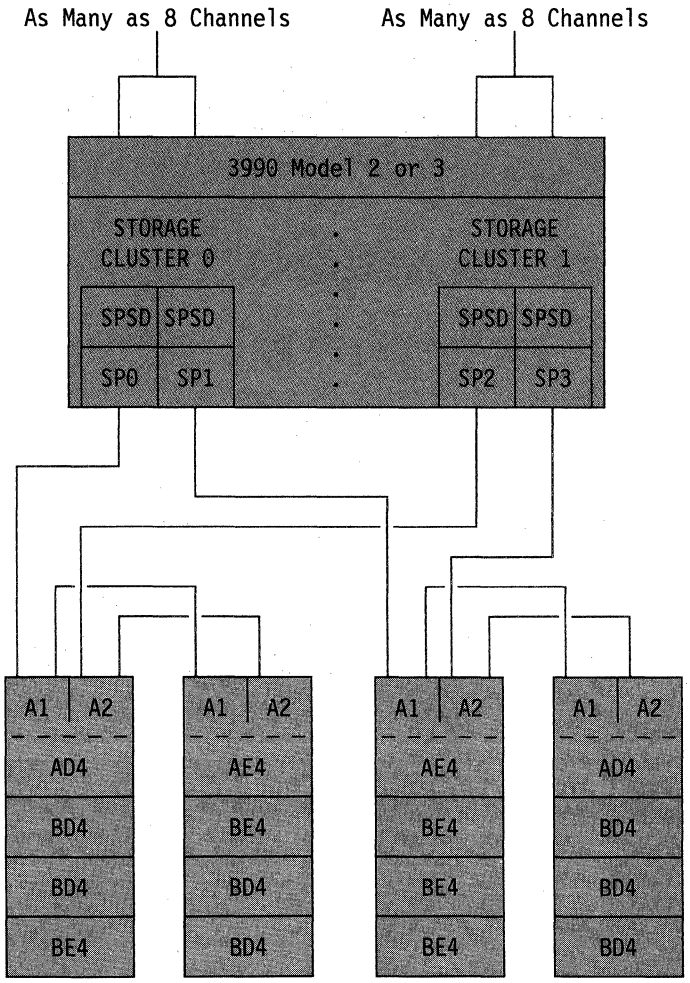


Figure 30. Example of 3380 Model AD4 and AE4 Strings Attached to a 3990 Model 2 or 3

3380 Model AJ4 or AK4 Strings Attached to 3990 Storage Controls

The two controllers in a 3380 Model AJ4 and AK4 attach to two 3990 storage paths that can be:

- Storage path 0 and storage path 1 in the same 3990 Model 1 (note that 3990 Model 1s cannot be dual-framed).
- Storage path 0 and 2 or storage path 1 and 3 in the same 3990 Model 2 or 3 for a 2-path string
- Storage path 0, 1, 2, and 3 in the same 3990 Model 2 or 3, for a 4-path string

Figure 31 is an example of an AJ4 2-path string and an AK4 2-path string sequentially connected to Storage Paths 0 and 1 in the same 3990 Model 1.

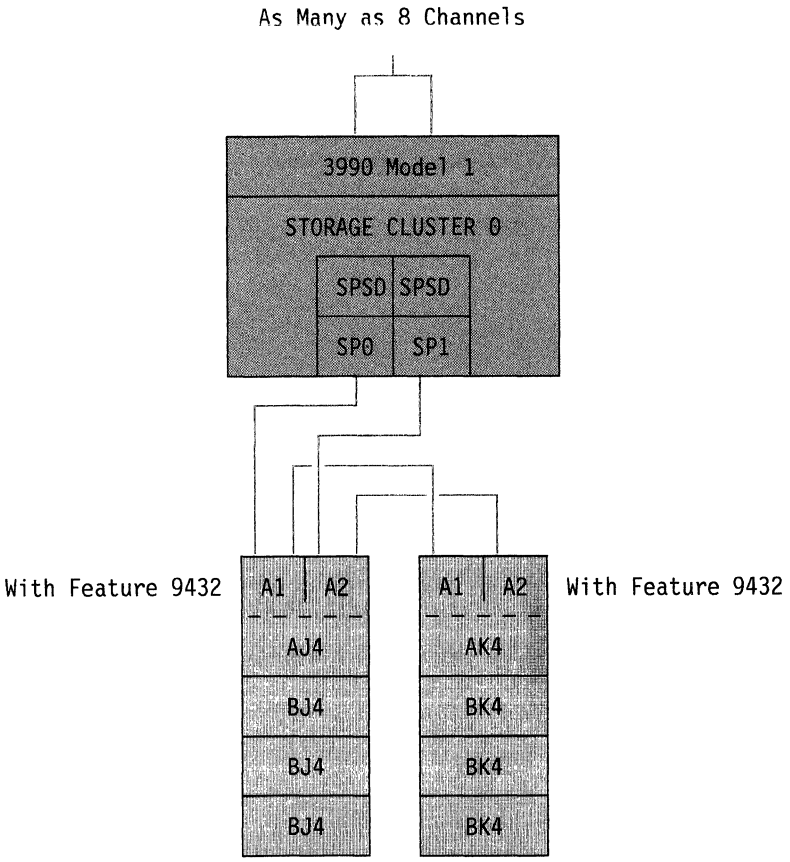


Figure 31. Example of 3380 Model AJ4 and AK4 2-Path Strings Attached to a 3990 Model 1

Figure 32 is an example of two 3380 4-path strings sequentially connected to the paired storage paths in the same 3990 Model 2 or 3.

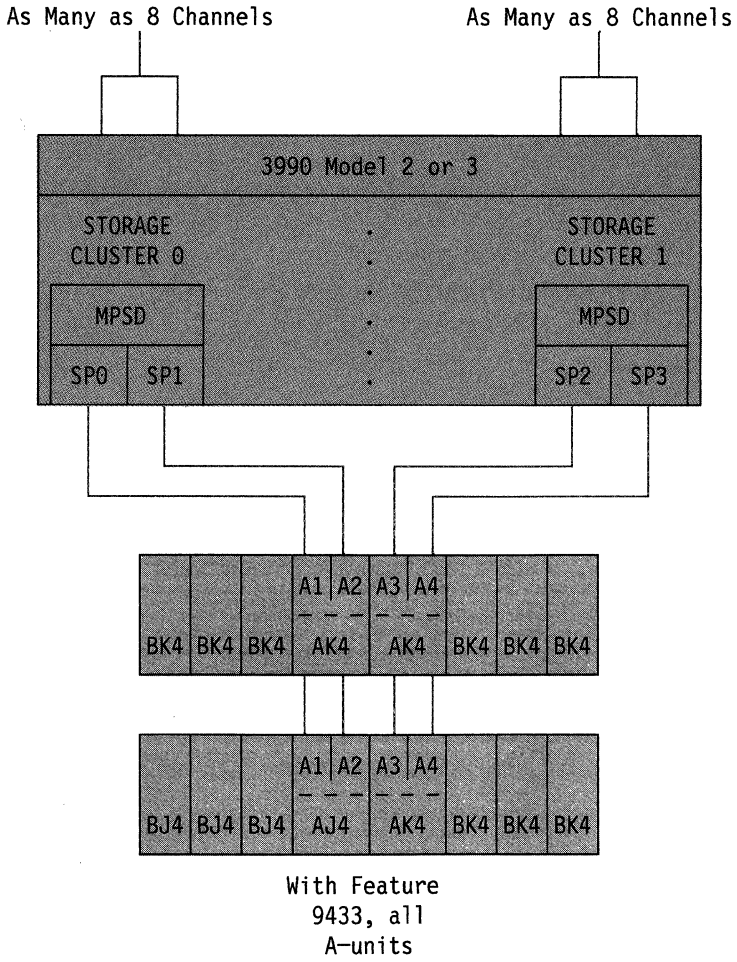


Figure 32. Example of 3380 Model AJ4 and AK4 4-Path Strings Attached to a 3990 Model 2 or 3

Intermixed Strings on 3990 Single-Path Storage Directors

As mentioned previously in "General 3990 Attachment Guidelines for Single-Path Storage Directors" on page 53, there are two ground rules for intermixing strings of different model groups on the same single-path storage directors:

- One Model AA4[5] string can be attached with one Model AD4 or AE4 string.
- One Model AA4, AD4, or AE4 string can be attached with one Model AJ4 or AK4 2-path string.

Figure 33 is an example of four 3380 2-path strings, with two strings sequentially connected to each of the paired storage paths in the same 3990 Model 2 or 3.

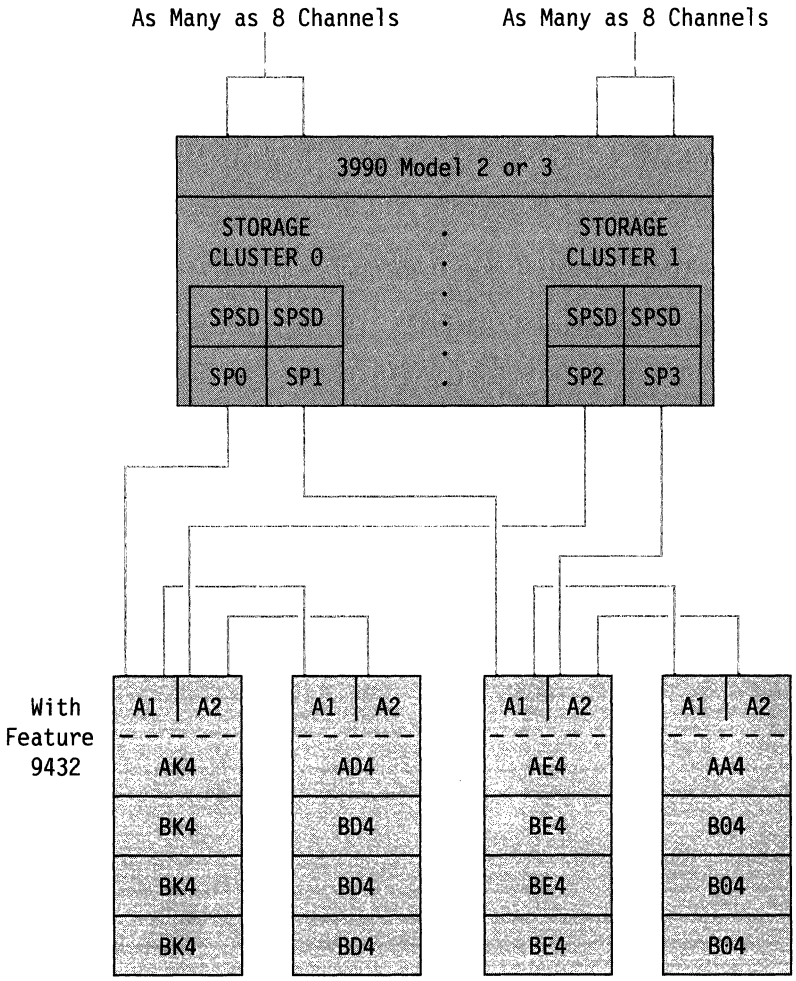


Figure 33. Example of Intermixed 3380 2-Path Strings Attached to a 3990 Model 2 or 3

5 Attachment to a 3990 requires that the Model AA4 have a serial number of 15000 or greater for 60 Hz units or X0300 or greater for 50 Hz units.

Intermixed Strings on 3990 Multipath Storage Directors

As mentioned previously in "General 3990 Attachment Guidelines for Multipath Storage Directors" on page 55, there are three ground rules for mixing strings of different model groups on 3990 storage controls configured with multipath storage directors. There must be at least one Enhanced Subsystem model 4-path string. The valid options for mixing other string types with the AJ4 and/or AK4 4-path string are:

- One or two Model AA4[6] strings can be attached with one Model AJ4 or AK4 4-path string.
- One or two Model AD4 or AE4 strings can be attached with one Model AJ4 or AK4 4-path string.
- One Model AA4 string and one Model AD4 or AE4 string can be attached with one Model AJ4 or AK4 4-path string.

Figure 34 is an example of an AA4 string and an AE4 string and one 4-path string, sequentially connected to two paired storage paths in a 3990 Model 2 or 3.

6 Attachment to a 3990 requires that the Model AA4 have a serial number of 15000 or greater for 60 Hz units or X0300 or greater for 50 Hz units.

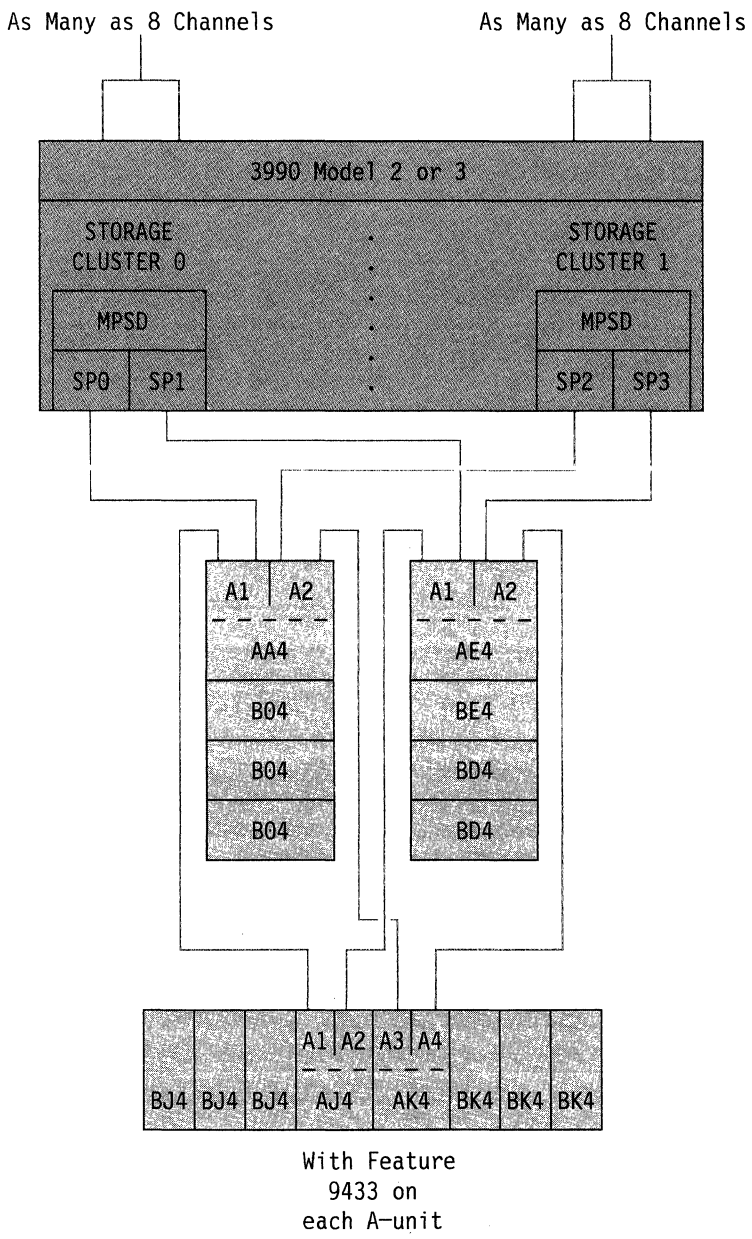


Figure 34. Example of 3380 2-Path and 4-Path Strings Attached to a 3990 Model 2 or 3

Figure 35 is an example of a 3380 4-path string and AE4 and AD4 strings sequentially connected to two paired storage paths in a 3990 Model 2 or 3.

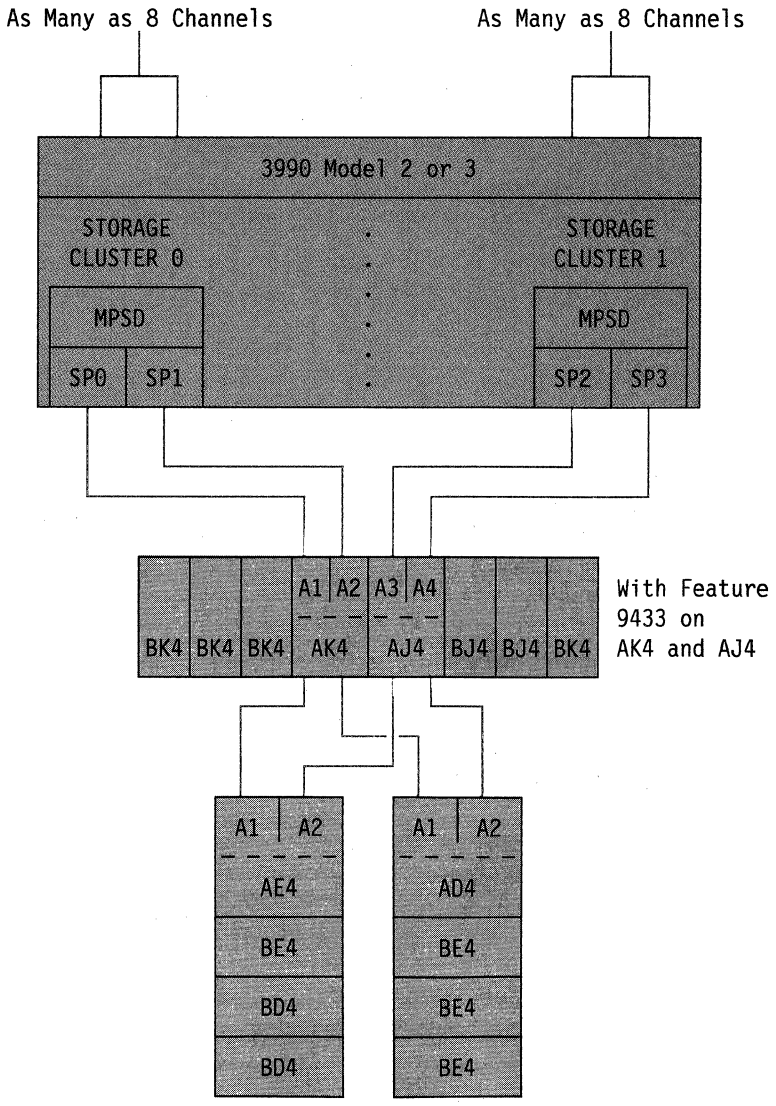


Figure 35. Example of 3380 4-Path and 2-Path Strings Attached to a 3990 Model 2 or 3

3380 to 3990 Attachment Summary

In summary, the major concepts and ground rules for attaching 3380 strings to 3990 Storage Controls are:

- A 3380 Model A04 cannot attach to a 3990.
- A 3380 Model AA4 string requires an AA4 unit with serial number of 15000 or greater for 60 Hz units or X0300 or greater for 50 Hz units, and it can include as many as three Model B04 units, but cannot include units of other 3380 models.
- A 3380 Model AD4 or AE4 string can include as many as three Model BD4 or BE4 units, but cannot include units of other 3380 models.
- 3380 Model BD4 and BE4 units can be attached on the same string.
- A 3380 Model AJ4 or AK4 2-path string can include as many as three Model BJ4 or BK4 units, but cannot include units of other 3380 models.
- A 3380 Model AJ4 or AK4 4-path string includes two A-units (either AJ4 or AK4) with as many as three Model BJ4 or BK4 units attached to each A-unit (six total), but cannot include units of other 3380 models.
- 3380 Model BJ4 and BK4 units can be attached on the same string.
- A 3380 Model AA4 string can be sequentially connected to another AA4 string, or to a 3380 Model AD4, AE4, AJ4 2-path, or AK4 2-path string.
- A 3380 Model AD4 or AE4 string can be sequentially connected to another AD4 or AE4 string, or to a 3380 Model AJ4 2-path or AK4 2-path string.
- A 3380 Model AJ4 or AK4 2-path string may be sequentially connected to another AJ4 or AK4 2-path string.
- A 3380 Model AJ4 or AK4 4-path string may be sequentially connected to another AJ4 or AK4 4-path string or to as many as two AA4, AD4, or AE4 strings (but not to AJ4 or AK4 2-path strings).
- One 3990 Model 2 may be dual-framed with another Model 2, and a Model 3 may be dual-framed with another Model 3. See *IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide* for further information on attachment of DASD to dual-framed 3990 Storage Controls. The 3990 Model 1 cannot be dual-framed, but a Model 1 can be upgraded to a Model 2.
- Two 3380 sequentially connected strings attach to the same pair of 3990 storage paths with single-path storage directors configurations (SP0 and SP2 or SP1 and SP3), and to all four storage paths (SP0-SP3) with a multipath storage director configuration.

See "Storage Control and 3380 Attachment Features and Engineering Changes" on page 36 for information on the attachment features or engineering changes required for 3380 configurations attached to 3990 Storage Controls.

Chapter 4. Planning for Installation and Use

This chapter provides information related both to physical planning activities associated with the actual installation of 3380 units and to overall storage subsystem planning techniques that can help you to accommodate orderly growth of your storage resources. I/O addressing, which is also a key aspect of storage hardware planning, is described in Appendix A, "Device Addressing and Identification" on page 87.

Physical Planning Considerations

Careful physical planning is part of ensuring smooth installation and use of 3380 units. An IBM installation planning representative can assist with this aspect of planning, and you can get detailed physical planning information in *IBM Input/Output Equipment: Installation - Physical Planning for System/360, System/370, and 4300 Processors* and in *IBM 9370 Information System Installation Manual - Physical Planning*. The information presented here highlights some of the major considerations that require planning in advance so that you can make optimum use of available floor space and accomplish quick and smooth installation of new storage hardware.

Power Requirements

Primary AC power for a 3380 is obtained through a single power attachment from the customer's 3-phase power system. Except for the power attachment cord, there is no other provision for supplying primary AC power to the unit. Any power buffering systems (for example, an uninterruptible power system) must be provided by the customer and connected to operate in conjunction with the customer's electrical power outlet.

Main AC power is controlled through the main circuit breaker in the 3380 A-unit. Power switches inside the 3380 Model A04 or AA4 unit are accessible only to a service representative and provide power to the controllers. Two power switches on the operator panel provide power to the two controllers in the 3380 Model AD4, AE4, AJ4, or AK4 unit. These, in turn, indirectly control power to the power supplies in the other units of the string.

A Local/Remote switch, set by the service representative, provides for local power control at the AD4, AE4, AJ4, or AK4 operator panel or remote power control from the 3880 or 3990 Storage Control. Local power control for A04 or AA4 models is inside the covers of the 3380.

4-Path String Considerations

When the 3380 AJ4 or AK4 is installed in a 4-path configuration with two A-units bolted together, each A-unit has its own independent line cord and requires separate attachment from the customer's 3-phase power system. For each substring of a 4-path configuration (an A-unit and the B-units bolted to it), the B-units are dependent on the A-unit and its line cord for AC power. The AC power is not interconnected between the two substrings. Emergency power off switches of both A-units are interconnected so that if any switch is turned off, all distributed AC power is removed from all units of the 4-path string.

The powering on of any controller, either remotely or locally, will power up the entire 4-path string. Conversely, only with all four controllers powered off, can you normally power down the entire 4-path string.

Floor Space Requirements

The 3380 can be installed on standard or raised floors. A 4-unit, 2-path string requires 3.41 square meters (36.7 square feet) of floor space. An 8-unit, 4-path string requires 8.1 square meters (87.2 square feet). Additional floor space is required to allow for access by the service representative and may be required for floor load distribution. With AJ4 and AK4 strings, no end service clearance is required for access to operator panels, because these panels are located at the front of the AJ4 or AK4 units.

Cable Requirements

CTL-I Cables

Standard cable entry and exit points for 3380 units are located at the base of 3380 A-units. The maximum length signal cable that can be used to connect as many as two 3380 controllers to a storage control is 61 meters (200 feet).

Power Sequence Control Cables

For Standard (A04 and AA4) strings, it is a requirement that strings be configured with power sequence control cables.

For Extended Capability (AD4 and AE4) strings and Enhanced Subsystem (AJ4 and AK4) strings, power sequence control cables are optional. If you are planning to have both remote and local power sequencing capability, you must use the power sequence control cables. Without these cables, only local power-up and power-down sequencing is possible.

Planning for Effective Use

A variety of factors affect efficient use of storage space, responsiveness and performance of the storage subsystem, and availability of data. Several of the general considerations in planning for effective use of 3380 disk storage are outlined here. However, the specific application workload and the operating system environment create a set of characteristics and needs that influence storage planning decisions. It is essential to refer to one of the following manuals in planning for the most effective use of 3380 storage in your specific environment:

- *Using the IBM 3380 Direct Access Storage in an MVS Environment*
- *Using the IBM 3380 Direct Access Storage in a VM Environment*
- *Using the IBM 3380 Direct Access Storage in a VSE Environment*

Block Size, or Physical Record Size

Selection of an appropriate block size for data stored on the 3380 is essential both for using space efficiently and for achieving optimum performance. Generally, wasted space on a track is minimized when a larger block size is used because there are fewer inter-record gaps. In addition, performance can be improved with larger block sizes because more data can be read or written with a single I/O operation. The needs of the application must also be considered in selecting an appropriate block size, but in general, larger block sizes are more efficient than smaller ones. See Appendix B, "Record Format, Track Format, and Space

Calculations" on page 97 for a more detailed description of block size considerations and techniques for block size calculation.

Data Placement and Distribution

Depending on the application and on the operating environment, performance can be influenced by such factors as:

- Which volume contains high-use data
- Location of the data on the volume
- Amount of free space on the volume

Spreading high-use data among multiple volumes and placing this data on strings with multiple access capabilities provides both performance and availability advantage. For example, placing data that is accessed by end-user interactive applications on an Enhanced Subsystem 4-path string can help to maintain consistent end-user response time even during heavy workload periods or when there is contention with batch workload.

The arrangement and amount of data on the volumes themselves are considerations that vary with the different operating environments. For example, with MVS, the free space objectives for a volume and the ratios of used-to-allocated space and allocated-to-available space influence effective use of the disk storage.

Configuration of the Storage Subsystem

Careful configuration planning is essential not only for achieving current performance and availability objectives but also for the future expansion of storage resources in an orderly fashion as your capacity needs grow. There are numerous hardware options to consider in planning the storage subsystem configuration:

- Access to storage resources via multiple processors
- Storage controls with a variety of:
  - Channel switching capabilities
  - Cache memory sizes and extended capabilities like fast write and dual copy
  - Levels of multiple pathing support
- 3380 direct access storage models with:
  - Varying levels of multiple transfer path support
  - Different storage capacities

The latest members of the IBM 3380 family, the Enhanced Subsystem models, and the recent 3990 family of IBM storage controls have been designed to provide configuration options that allow you flexibility in implementing current configuration plans while migrating to new hardware. The latest DASD models may be attached to existing 3880 Storage Controls or to the new 3990 family, and the recent 3990 Storage Controls can accommodate both older 3380 models and the new Enhanced Subsystem strings. As explained in "Chapter 3. Support and Attachment" on page 33, an intermix of string types is possible on the 3880 and even on the 3990 Model 2 or 3 with an Enhanced Subsystem 4-path string.

Benefits of 4-Path Configurations

The 3990 Storage Controls and the 3380 Enhanced Subsystem direct access storage models create a variety of new configuration options to consider in your planning. The 4-path capability of the 3990 Models 2 and 3 when attached to Enhanced Subsystem 3380 models provides the maximum potential for data availability and for subsystem performance, especially with an Extended Architecture (XA) processor. This 4-path configuration has the potential for providing the following benefits:

1. A more economic subsystem through longer string length

2. More consistent end-user response time during heavy workload periods
3. Nondisruptive DASD installation (see "Planning for Future Growth")
4. Improved availability during path-level maintenance
5. Reduced disruption in availability and performance during heavy batch sequential workload or dump/restore activity

Planning for Future Growth

In planning for future growth of your storage resources, it is important to plan not only for meeting your capacity needs but also for installing new units with minimum disruption to your normal operations. Among the approaches for expanding your storage capacity are:

- Migrating or upgrading to larger capacity models

  Increased capacity may be achieved by migrating from single capacity models to double or triple capacity models. Within the Extended Capability and Enhanced Subsystem model groups, it is possible to migrate from a single capacity device to a larger capacity. See "Data Capacity" on page 21 and "Upgrading" on page 20 for pertinent details.

- Expanding existing strings

  Planning for growth of strings to maximum length over time, as capacity needs increase, is a technique for accommodating future growth in an orderly fashion. With the 4-path configurations of the Enhanced Subsystem models, this approach can be especially effective by providing needed capacity without disruption to normal operation. See "Nondisruptive DASD Installation" for additional information.

- Adding new strings

  Adding new DASD strings provides both capacity potential and availability through the additional controllers in the A-unit(s). A second Enhanced Subsystem 4-path string can be added to a subsystem without disruption to an existing 4-path string.

- Upgrading from 2-path to 4-path Enhanced Subsystem strings

  Enhanced Subsystem AJ4 or AK4 models that are originally installed in a 2-path configuration may be upgraded to 4-path capability. If you are planning to use this approach for future growth, consider physically connecting the A-units at initial installation time. This eliminates the need to move the units and can reduce the amount of time required for upgrading to the 4-path configuration.

Nondisruptive DASD Installation

In subsystems configured for 4-path strings, the 3380 Enhanced Subsystem models can be installed without disrupting the availability of other storage resources. Models BJ4 and BK4 can be added to an existing string, or a second Model AJ4 or AK4 4-path string can be added, without disrupting the availability of the existing string. This is possible with a 4-path configuration, because the host recognizes multipath storage directors; thus if one storage path is offline, processing continues.

The service representative installs the B-unit(s) or a second 4-path string incrementally, one path at a time, until all four paths have been completed. This process is managed within the 3990 Storage Control Model 2 or 3, independent of the host processor and does not require operator interaction. The storage control

does not quiesce a path unless an alternate path is available for DASD access. Because this function is handled totally within the DASD subsystem, any operating system, Extended Architecture or System/370, that is connected to a 4-path subsystem can take advantage of this capability.

To take advantage of the nondisruptive DASD installation capability, you must perform certain activities in advance. It is a requirement that the devices planned for future installation have pre-assigned addresses that are pre-defined to the operating system. The devices planned for later installation must be included in the 3990 configuration vital product data.

Once new units have been installed, the volumes may be made available to the operating system and prepared for use by means of the normal processes. See the following manuals for details:

Using the IBM 3380 Direct Access Storage in an MVS Environment
Using the IBM 3380 Direct Access Storage in a VM Environment
Using the IBM 3380 Direct Access Storage in a VSE Environment

Chapter 5. Operation

The operator panels on the 3380 A-units include a number of switches and lights to assist in monitoring the status of the 3380. This chapter illustrates the operator panels for the various A-unit models and explains how to set the switches and interpret the indicator lights for turning the power on or off for the DASD strings.

Operational procedures are provided for each model group, Standard (A04 and AA4), Extended Capability (AD4 and AE4), and Enhanced Subsystem (AJ4 and AK4) models. The following control panel illustrations are provided:

- Model A04 in Figure 36 on page 74
- Model AA4 in Figure 37 on page 75
- Models AD4 and AE4 in Figure 38 on page 77
- Models AJ4 and AK4 attached to a 3880 storage control in Figure 41 on page 81
- Models AJ4 and AK4 attached to a 3990 as 2-path strings in Figure 42 on page 82
- Models AJ4 and AK4 attached to a 3990 as 4-path strings in Figure 43 on page 83

Most 3380 operations are controlled from a system operator console instead of from the 3380 operator panels. System commands are issued from the system operator console to control 3380 operations and to obtain its operational status.

It is essential that 3380 volumes be made unavailable to the operating system before making changes to the current switch settings on the operator control panels and before performing any hardware maintenance. For information on specific operating system commands to make volumes available or unavailable to the system, or to check the status of a volume (device), see:

Using the IBM 3380 Direct Access Storage in an MVS Environment
Using the IBM 3380 Direct Access Storage in a VM Environment
Using the IBM 3380 Direct Access Storage in a VSE Environment

Operating the 3380 Model A04 and AA4

There is one control panel on the end cover of the 3380 Model A04 and AA4 units. (The Model B04 unit does not have a control panel.) The control panel is used primarily by a service representative, but it is also used by the operator to turn off power in an emergency.

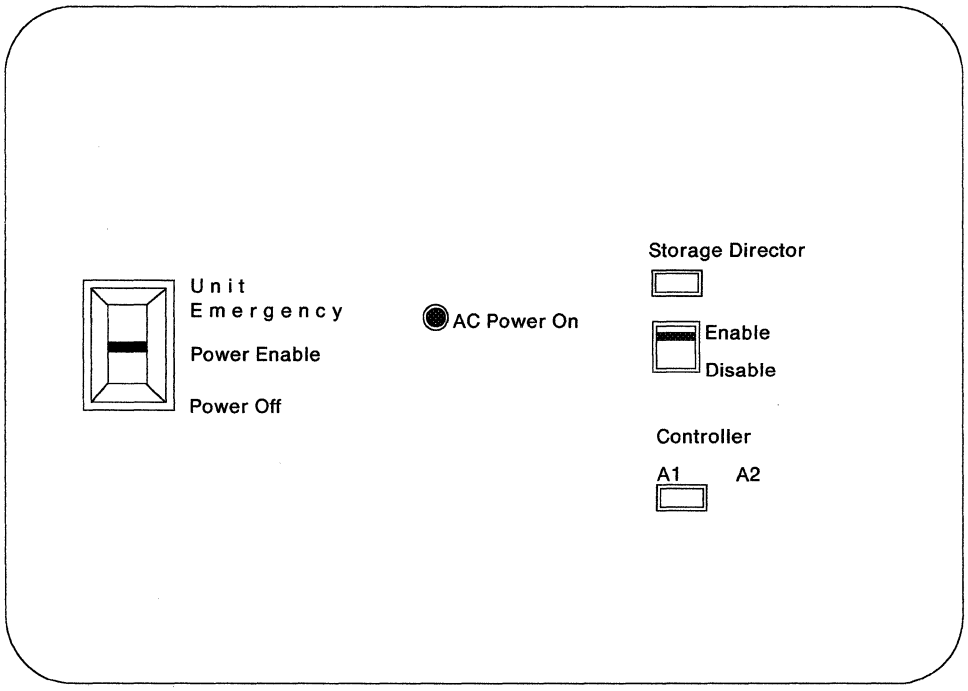


Figure 36. 3380 Model A04 Operator Control Panel

The 3380 Model A04 operator panel illustrated in Figure 36 has:

- One Unit Emergency switch for emergency power off
- One Enable/Disable switch for the controller
- One red AC Power On light that indicates AC power to the unit

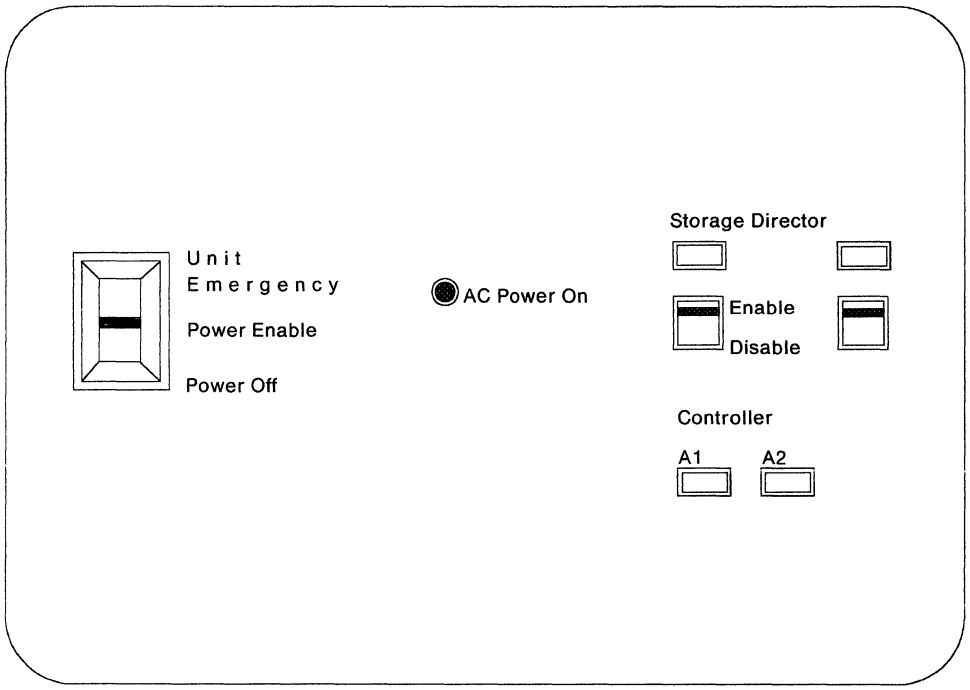


Figure 37. 3380 Model AA4 Operator Control Panel

The 3380 Model AA4 operator panel illustrated in Figure 37 has:

- One Unit Emergency switch for emergency power off
- One Enable/Disable switch for each controller
- One red AC Power On light, which indicates AC power to the unit

Turning Power On and Off for 3380 Model A04 and AA4

Primary AC power for a 3380 string is obtained through a single power attachment cord, connected by the service representative. to the 3-phase power system at the installation.

Power for 3380 A04 and AA4 strings is controlled **remotely** from the storage control. Power sequence control cables are required for attaching A04 and AA4 strings to the storage control. When the storage control receives power, the attached A04 or AA4 string receives a signal from the storage control and starts its power-up sequence. The internal Local/Remote switch on the A04 and AA4 units is for use by the service representative only.

Reading the AC Power On Indicator

The AC Power On indicator light is on when the unit is connected to the AC power and the 3380 main circuit breaker is on. Even when it is illuminated, the AC Power On light does not indicate that the 3380 string has completed its power-on cycle or is operational.

Note: When the storage control Power Sequence light is illuminated, power sequencing for all 3380 strings attached to the storage control may not be complete. Wait 6 more minutes after the storage control Power Sequence light comes on before assuming that all 3380s attached to that storage control have completed the power-on sequence. If you attempt to perform initial program load (IPL) before all 3380s have completed the power-on sequence, the IPL may not be successful, and resulting system messages are unpredictable.

Starting the Power-Off Sequence

Remember that before turning the power off a 3380 string, you need to make the devices unavailable to the operating system. **To allow for a complete power-off sequence after turning the power off the storage control operator panel, wait at least 90 seconds before turning the power back on.** The 3380 power-off sequence occurs concurrently with the storage control power-off sequence.

Turning the Power Off in an Emergency

In an **EMERGENCY-only** situation, turn the Unit Emergency Power Enable/Off switch to Off to immediately disconnect primary power to the 3380 string. Never use the Unit Emergency switch for routinely turning the power off and on for the string.

Do **not** use the Unit Emergency Power Enable/Off switch to turn power back on. An attempt to do this could result in incorrect power sequencing. Call the service representative to restore power.

Enabling and Disabling Controllers for 3380 Models A04 and AA4

The Controller Enable/Disable switches control the physical availability of paths and devices on the 3380 string. Always make the devices unavailable to the operating system, before using these switches. The 3380 Model A04 has only one controller and thus there is only one Controller Enable/Disable switch installed.

Operating the 3380 Model AD4 and AE4

All operator switches and lights are located on the 3380 Model AD4 and AE4 operator control panel, on the end of the unit. (3380 Model BD4 and BE4 units do not have an operator control panel.)

Important: Ensure that 3380 devices are offline to all operating systems before making changes to the current switch settings on the operator control panel or before any hardware maintenance is performed.

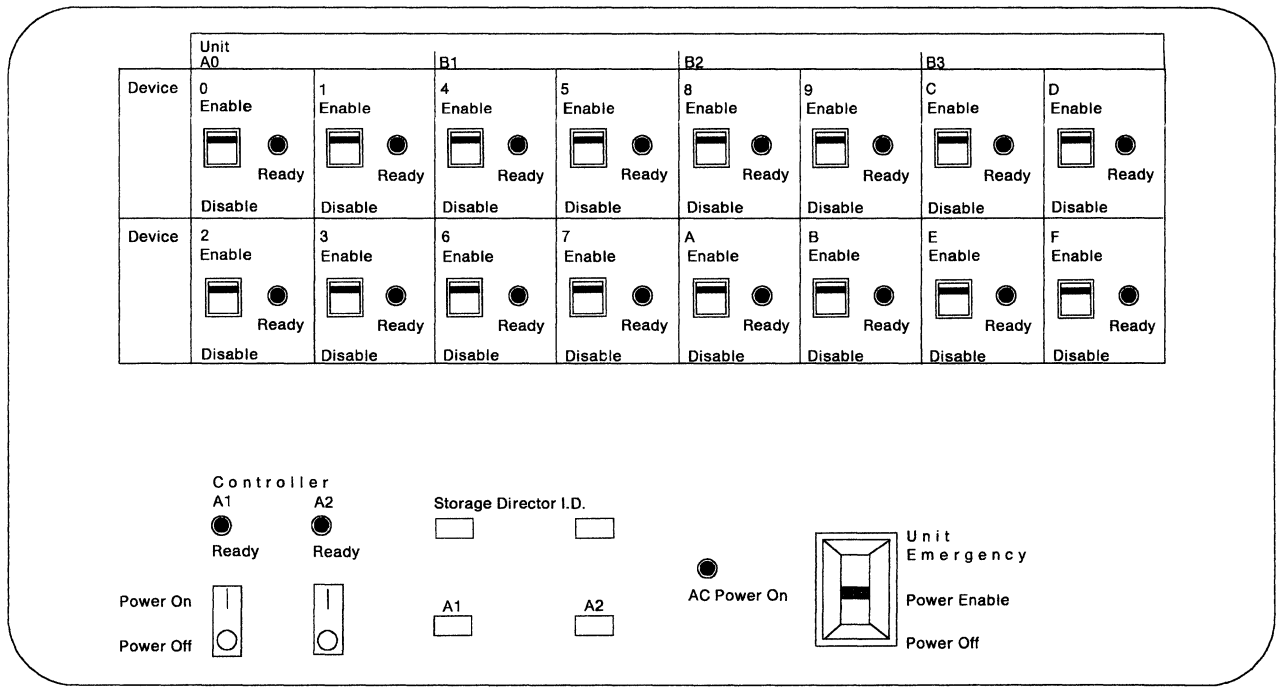


Figure 38. 3380 Model AD4 and AE4 Operator Control Panel

The operator panel of the 3380 Model AD4 or AE4 illustrated in Figure 38 has:

- One Unit Emergency switch for emergency power off
- One Power On/Off switch and a green Ready light for each controller
- One Enable/Disable switch and a green Ready light for each device
- One red AC Power On light, which indicates AC power to the unit
- Identifiers for storage directors and controllers (A1 and A2)

Turning Power On and Off for 3380 Model AD4 and AE4

Primary AC power for a 3380 string is obtained through a single power attachment cord, connected by the service representative. to the 3-phase power system at the installation.

Power for 3380 strings can be controlled either remotely or locally, depending on the setting of a Local/Remote switch on an internal control panel, accessible to the service representative. Request that your service representative set the switch to suit the procedural needs of your computing complex.

- **Remote** power control from the storage control

  Use of power sequence control cables for attaching the string to the storage control is required for remote power sequence capability. When the storage control turns the power on, it signals the attached controller to turn power on. If one of the Controller Power On/Power Off switches is in the "Power On" position, that controller turns the power on for the devices in the string. If the Power On/Power Off switch for the other controller on the A-unit is not on, the string still turns the power on and begins operations by means of the active controller. Both controllers' power switches must be on to have both transfer paths active.

- **Local** power control at the A-unit

  In Local mode, when the Power On/Power Off switch for either controller is set to "Power On," all the devices on the string is turned on. If the switch for one of the controllers is set to "Power Off," the power to the string is not affected. Both controllers must have the power on to have both paths active. The devices on the string turn the power off only if both controllers are turned off.

Reading the AC Power On Indicator

The AC Power On indicator light is on when the unit is connected to the AC power and the 3380 main circuit breaker is on. Even when it is illuminated, the AC Power On light does not indicate that the 3380 string has completed its power-on cycle or is operational.

Note: When the storage control Power Sequence light is illuminated, power sequencing for all 3380 strings attached to the storage control may not be complete. Wait 6 more minutes after the storage control Power Sequence light comes on before assuming that all 3380s attached to that storage control have completed the power-on sequence. If you attempt to perform initial program load (IPL) before all 3380s have completed the power-on sequence, the IPL may not be successful, and resulting system messages are unpredictable.

Reading the Ready Lights

There is a green Ready light for each controller and for each device in an AD4 or AE4 3380 string. These lights turn on to indicate that a controller or device has completed its power-on sequence and is ready to operate.

Starting the Power-Off Sequence

This section describes the power-off sequence for both remote and local power control.

- **Remote** power control

  You can turn the string power off either at the storage control or at the A-unit. Remember that before you turn the power off for a 3380 string, you need to make the devices unavailable to the operating system. **To allow for a complete power-off sequence after the power is turned off on the storage control operator panel, wait at least 90 seconds before turning the power back on.**

  The 3380 remote power-off sequence occurs concurrently with the storage control power-off sequence, provided that the 3380 Power On/Power Off switch for a controller attached to that storage control remains on and the other 3380 controller Power On/Power Off switch is off if the 3380 is attached to a different storage control that is powered on. If both 3380 Power On/Power Off switches are turned off, the 3380 string will turn the power off independently of the attached storage control.

- **Local** power control

  For local power down of the string, turn off both 3380 Power On/Power Off switches.

Turning the Power Off in an Emergency

In an **EMERGENCY-only** situation, turn the Unit Emergency Power Enable/Off switch to off to immediately disconnect primary power to the 3380 string. Never use the Unit Emergency switch for routinely turning the power off and on for the string.

Do **not** use the Unit Emergency Power Enable/Off switch to turn power back on. An attempt to do this could result in incorrect power sequencing. Call the service representative to restore power.

Turning Controller Power On and Off

Each controller at the head of a 3380 Model AD4 or AE4 string can individually turn the power on and off through switches at the operator control panel. When the controller is ready, the green Controller Ready light is on. Figure 39 describes the various meanings of the Controller Ready light in conjunction with the Power On/Power Off switch.

Note: One or both of the Controller Power On/Power Off switches must be in the "On" position before you can make 3380 volumes available to the operating system. A Controller Power On/Power Off switch should not be set to "Off" until the controller (that is, all paths through the controller) have been made unavailable to the operating system.

If the Controller Ready light is ...	**and the Power On/Power Off switch is ...**	**then, the controller is ...**
Off	On	Disabled because of an error condition.
Off	Off	Disabled intentionally.
Flashing on and off	On	Proceeding through its normal warm-up cycle.
On and dull	On	Enabled, but not being used by the system.
Flickering, or steadily bright	On	Enabled and in use by the system.

Figure 39. Interpreting Controller Ready Lights on Models AD4 and AE4

Enabling and Disabling Devices for Models AD4 and AE4

The Device Enable/Disable switches on the 3380 Model AD4 and AE4 control panels control the availability of each individual device on the 3380 string. You can set these switches to the Enable or Disable position. For normal operation, the switches for all devices in a 3380 string are in the "Enable" position.

Note: The Device Enable/Disable switch must be in the "Enable" position before you can make the 3380 volumes available to the operating system. None of these switches should be set to "Disable" until the volume has been made unavailable to the system. Otherwise, an intervention-required condition will occur.

Each switch also has a Device Ready light that illuminates when the associated device is ready for use. Figure 40 describes the various meanings of the Device Ready light in conjunction with the Enable/Disable switch.

If the Device Ready light is ...	**and the Enable/Disable switch is ...**	**then, the device is ...**
Off	On	Disabled because of an error condition, is not installed, or power is not on.
Off	Off	Disabled intentionally.
On	On	Enabled, but not being used by the system.
Flickering	On	Enabled and in use by the system.

Figure 40. Interpreting Device Ready Lights on Models AD4 and AE4

A Device Enable/Disable switch can be used to:

- Provide access to a duplicate copy of the system volume, which can be maintained online and disabled. If a system failure occurs that requires re-IPL, the operator can set the switch to "Enable" to make the backup system volume available and recover the system more quickly.
- Provide an additional level of data security. For example, personnel and payroll data can be stored on one volume. The operator can be instructed to keep the device that contains a Personnel and Payroll volume switched to Disable, until that volume is needed for processing.

Operating the 3380 Model AJ4 and AK4

A 3380 Model AJ4 or AK4 has one of three possible operator panels, depending on the attachment feature in use with the A-unit. In contrast to other models of the 3380, the operator control panel on Model AJ4 and AK4 units is located on the front of the unit. A second panel containing a Unit Emergency switch is located on the back of the unit.

Important: Ensure that 3380 devices are offline to all operating systems before making changes to the current switch settings on the operator control panel or before any hardware maintenance is performed.

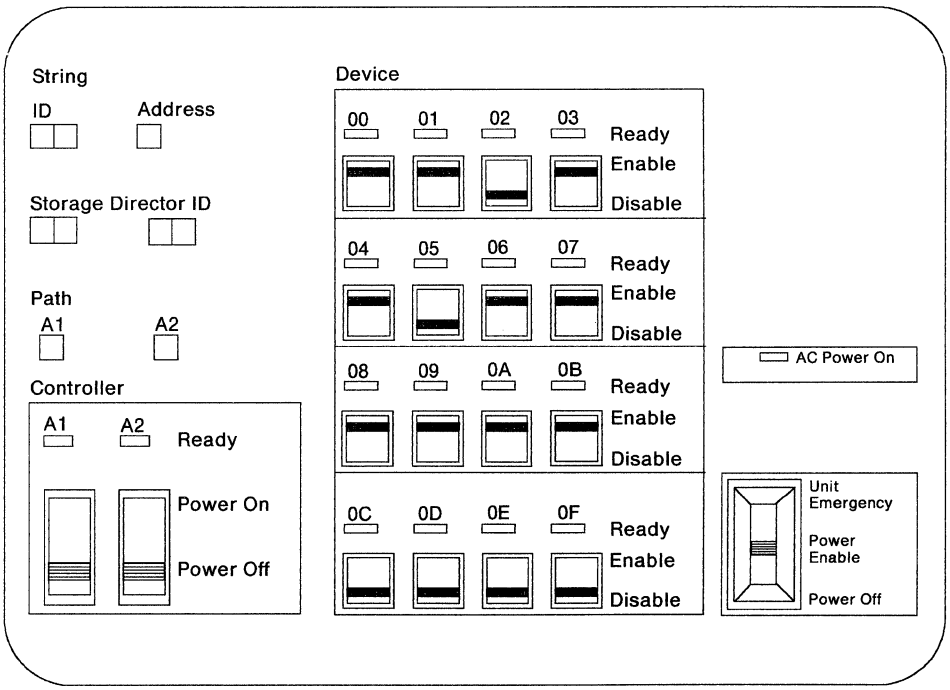


Figure 41. 3380 Model AJ4 or AK4 2-Path Operator Control Panel with Feature 9431. Used for attachment to 3880 Storage Controls.

The operator panel of the 3380 Model AJ4 or AK4 illustrated in Figure 41 assumes attachment to a 3880 and has:

- One Unit Emergency switch for emergency power-off for the string
- One Power On/Off switch and a green Ready light for each controller
- One Enable/Disable switch and a green Ready light for each device
- One green AC Power On light, which indicates AC power to the unit
- Identifiers for string id, address, storage director, and path

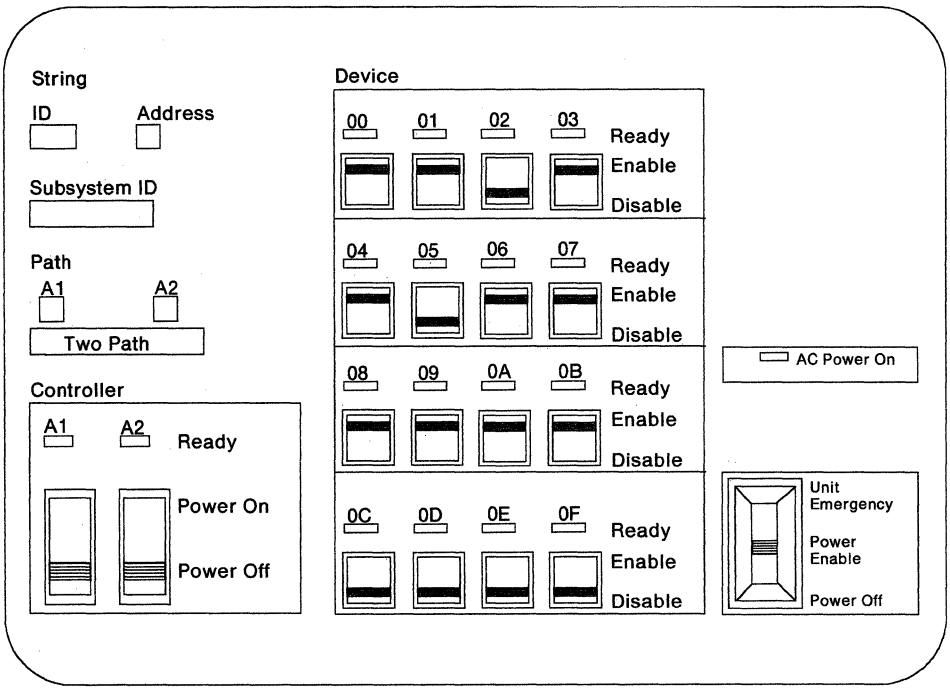


Figure 42. 3380 Model AJ4 or AK4 2-Path Operator Control Panel with Feature 9432. Used for attachment to 3990 Storage Controls.

The operator panel of the 3380 Model AJ4 or AK4 illustrated in Figure 42 assumes attachment to a 3990 in DLS support mode and has:

- One Unit Emergency switch for emergency power-off for the string
- One Power On/Off switch and a green Ready light for each controller
- One Enable/Disable switch and a green Ready light for each device
- One green AC Power On light, which indicates AC power to the unit
- Identifiers for string id, address, subsystem id, and path

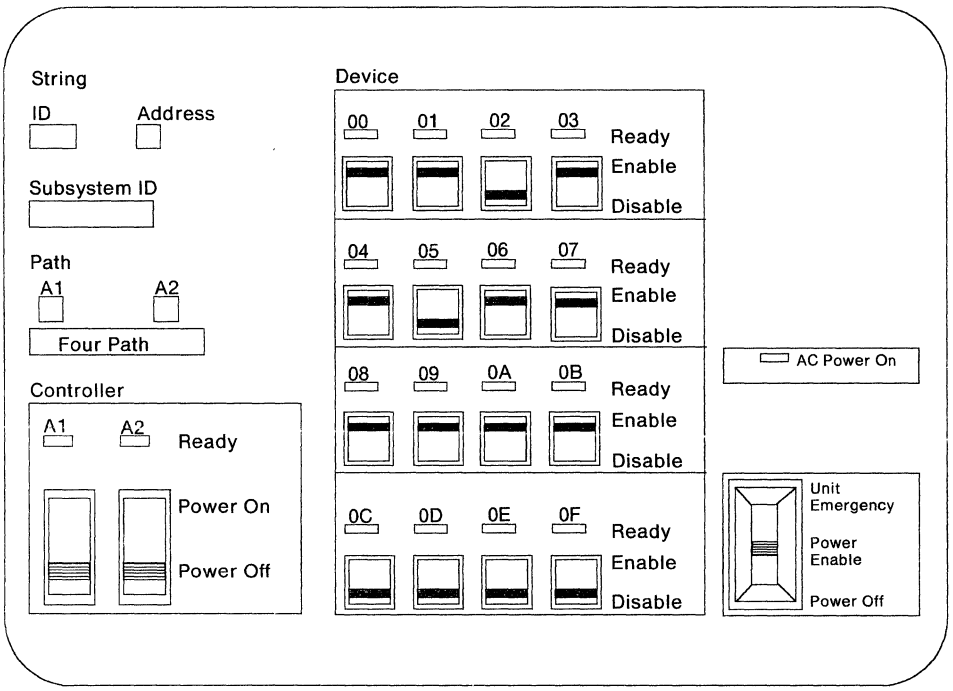


Figure 43. 3380 Model AJ4 or AK4 4-Path Operator Control Panel with Feature 9433. Used for attachment to 3990 Model 2 or 3 Storage Controls. There is a similar panel on the second A-unit that specifies controllers A3 and A4 and devices 10 through 1F.

The operator panel of the 3380 Model AJ4 or AK4 illustrated in Figure 43 assumes attachment to a 3990 Model 2 or 3 in DLSE support mode and has:

- One Unit Emergency switch for emergency power-off for the string
- One Power On/Off switch and a green Ready light for each controller
- One Enable/Disable switch and a green Ready light for each device
- One green AC Power On light, which indicates AC power to the unit
- Identifiers for string id, address, subsystem id, and path

Turning Power On and Off for 3380 Model AJ4 and AK4

Primary AC power for a Model AJ4 or AK4 2-path string is obtained through a single power attachment cord, connected by the service representative. to the 3-phase power system at the installation. However, when two AJ4 or AK4 units are installed in a 4-path configuration with the two A-units bolted together, each A-unit has its own independent line cord and requires separate attachment to the 3-phase power system.

Power for 3380 AJ4 or AK4 strings can be controlled either remotely or locally, depending on the setting of a Local/Remote switch on an internal control panel, accessible to the service representative. Request that your service representative set the switch to suit the procedural needs of your computing complex.

- **Remote** power control from the storage control

  Use of power sequence control cables for attaching the string to the storage control is required for remote power sequence capability. When the storage control turns the power on, it signals the attached controller to turn the power on. If one of the Controller Power On/Power Off switches is in the "Power On" position, that controller turns the power on for the devices in the string. If the Power On/Power Off switch for any other controller on the string is not on, the

string still turns the power on and begins operations by means of the active controller(s). In a 4-path string, if one of the four controllers is on, the power-on sequence for the entire string starts, and the devices become operational. All controllers must be powered on to have all transfer paths active.

- **Local** power control at the A-unit

  In Local mode, when the Power On/Power Off switch for one controller is set to "Power On," the devices on the string turn the power on. If the switch for any other controller(s) is set to "Power Off," the power to the string is not affected. As remaining controllers are turned on, the additional path(s) to the devices become active. If any one controller is turned off, it will not affect the operation of the other controller(s) or the devices. Only if all controllers have the power off do the devices on the string power down.

Reading the AC Power On Indicator

The AC Power On indicator light is on when the unit is connected to the AC power and the 3380 main circuit breaker is on. Even when it is illuminated, the AC Power On light does not indicate that the 3380 string has completed its power-on cycle or is operational.

Note: When the storage control Power Sequence light is illuminated, power sequencing for all 3380 strings attached to the storage control may not be complete. Wait 6 more minutes after the storage control Power Sequence light comes on before assuming that all 3380s attached to that storage control have completed the power-on sequence. If you attempt to perform initial program load (IPL) before all 3380s have completed the power-on sequence, the IPL may not be successful, and resulting system messages are unpredictable.

Reading the Ready Lights

There is a green Ready light for each controller and for each device in the 3380 AJ4 or AK4 string. These lights turn on to indicate that a controller or device has completed its power-on sequence and is ready to operate.

Starting the Power-Off Sequence

This section describes the power-off sequence for both remote and local power control.

- **Remote** power control

  You can turn the string power off either at the storage control or at the A-unit. Remember that before you turn the power off a 3380 string, you need to make the devices unavailable to the operating system. **To allow for a complete power-off sequence after turning the power off the storage control operator panel, wait at least 90 seconds before turning the power back on.**

  The 3380 remote power-off sequence occurs concurrently with the storage control power-off sequence, provided that the 3380 Power On/Power Off switch for a controller attached to that storage control remains in the "On" position and any other 3380 controller Power On/Power Off switches are off for associated storage controls that are powered on. If all 3380 controller Power On/Power Off switches are turned off, the 3380 string will turn the power off independently of the attached storage control.

- **Local** power control

  For local power down of the string, turn off all Controller Power On/Power Off switches.

Turning the Power Off in an Emergency

In an **EMERGENCY-only** situation, turn the Unit Emergency Power Enable/Off switch to the "Off" position to immediately disconnect primary power to the 3380 string. With 4-path strings, the Unit Emergency switches on both A-units are interconnected; thus turning the switch on either A-unit to the "Off" position immediately disconnects power to the entire 4-path string. Never use the Unit Emergency switch for routinely turning the power off and on for the string.

Do **not** use the Unit Emergency Power Enable/Off switch to turn power back on. An attempt to do this could result in incorrect power sequencing. Call the service representative to restore power.

Turning Controller Power On and Off

Each controller at the head of a 3380 Model AJ4 or AK4 string can individually turn the power on and off through switches at the operator control panel. When the controller is ready, the green Controller Ready light is on. Figure 44 describes the various meanings of the Controller Ready light in conjunction with the Power On/Power Off switch.

Note: One or both of the Controller Power On/Power Off switches must be in the "On" position before you can make 3380 volumes available to the operating system. A Controller Power On/Power Off switch should not be set to "Off" until the controller (that is, all paths through the controller) have been made unavailable to the operating system.

If the Controller Ready light is ...	**and the Power On/Power Off switch is ...**	**then, the controller is ...**
Off	On	Disabled because of an error condition.
Off	Off	Disabled intentionally.
Flashing on and off	On	Proceeding through its normal warm-up cycle.
On and dull	On	Enabled, but not being used by the system.
Flickering, or steadily bright	On	Enabled and in use by the system.

Figure 44. Interpreting Controller Ready Lights on Models AJ4 and AK4

Enabling and Disabling Devices for Models AJ4 and AK4

The Device Enable/Disable switches on the 3380 Model AJ4 and AK4 control panels control the availability of each individual device on the 3380 string. You can set these switches to the "Enable" or "Disable" position. For normal operation, the switches for all devices in a 3380 string are in the "Enable" position.

Note: The Device Enable/Disable switch must be in the "Enable" position before you can make the 3380 volumes available to the operating system. A Device Enable/Disable switch should not be set to "Disable" until the device has been made unavailable to the system. Otherwise, an intervention-required condition will occur.

Each switch also has a Device Ready light that illuminates when the associated device is ready for use. Figure 45 describes the various meanings of the Device Ready light in conjunction with the Enable/Disable switch.

If the Device Ready light is ...	**and the Enable/Disable switch is ...**	**then, the device is ...**
Off	On	Disabled because of an error condition, is not installed, or power is not on.
Off	Off	Disabled intentionally.
On	On	Enabled, but not being used by the system.
Flickering	On	Enabled and in use by the system.

Figure 45. Interpreting Device Ready Lights on Models AJ4 and AK4

A device Enable/Disable switch can be used to:

- Provide access to a duplicate copy of the system volume, which can be maintained online and disabled. If a system failure occurs that requires re-IPL, the operator can set the switch to "Enable" to make the backup system volume available and recover the system more quickly.
- Provide an additional level of data security. For example, personnel and payroll data can be stored on one volume. The operator can be instructed to keep the device that contains a Personnel and Payroll volume switched to "Disable," until that volume is needed for processing.

Appendix A. Device Addressing and Identification

Each 3380 volume is uniquely addressable and is assigned specific identifiers so that the channel can select the appropriate device and the physical components can be readily located. Devices have the following kinds of identifiers:

- **Unit Address**

  A unit address is a one-byte designation used by a channel to establish a data transfer path to a specific device. Because multiple channels can be attached to storage directors, a device can be accessed by more than one channel. See "Unit Addresses" for detailed information.

- **Physical Identifier**

  Each device of the DASD subsystem has a physical identifier. These identifiers are useful in interpreting EREP output and console messages. See "Physical Identifiers" on page 96 for further information on physical identifiers.

- **Device Number**

  The device number designation is used in Extended Architecture operating environments only. It is recommended that the unit address and the device number be the same for a specific device. However, this is not a requirement. See *Input/Output Configuration Program User's Guide and Reference* for additional information on device numbers.

- **Subsystem Identifiers (SSIDs)**

  The subsystem identifier (SSID) is a user-assigned value that uniquely identifies each 3990 logical DASD subsystem in the installation. SSIDs are included in each EREP exception report to aid the IBM service representative in identifying reporting components. For more information on SSIDs, see "Subsystem Identifiers" on page 96 and *IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide*.

Unit Addresses

The assignment of unit addresses is an important part of the planning that must take place before new I/O units can be installed. The unit address for each device in each new 3380 unit must be assigned before the storage devices can be defined to the operating system. See the following manuals for further information on the processes for defining devices to the operating system:

Using the IBM 3380 Direct Access Storage in an MVS Environment
Using the IBM 3380 Direct Access Storage in a VM Environment
Using the IBM 3380 Direct Access Storage in a VSE Environment

In addition, the service representative needs to know the unit addresses so the 3880 or 3990 Storage Control and the 3380 devices can be set to recognize the assigned addresses. If there are plans to install additional 3380 strings or to add additional B-units to existing strings at a later time, the unit addresses for the planned storage hardware can be predefined to the operating system and will be automatically marked offline or unavailable during IPL of the system.

If you intend to take advantage of the nondisruptive DASD installation capability of the 4-path Enhanced Subsystem strings, it is a requirement that devices planned for future installation have preassigned addresses that are predefined to the operating system and included in the 3990 configuration vital product data.

A unit address represents a specific device on a given channel.

A 3380 device is described by a one-byte unit address as shown in Figure 46.

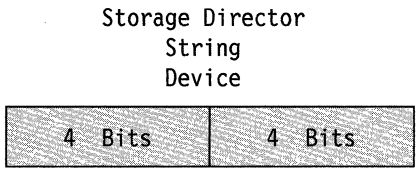


Figure 46. General 3380 Unit Address Format

Unit Addresses for Single or 2-Path Strings

The bit composition for the unit address for single or 2-path strings is shown in Figure 47. For serial channels, the unit address consists of the device address and string address.

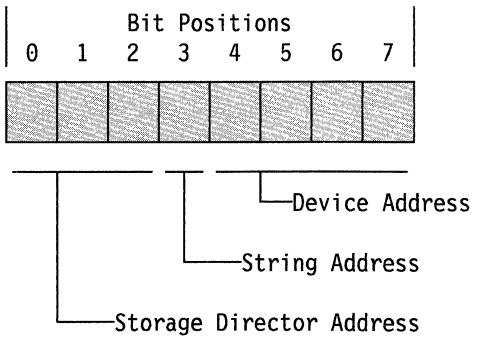


Figure 47. Unit Address Composition for Single or 2-Path 3380 String

The storage director address (bits 0, 1, and 2) represents the address of the 3880 or 3990 storage director in the selection path for the device. Each storage director address is set in the 3880 or 3990 by the service representative.

The string address (bit 3) refers to the address (binary 0 or 1) associated with the controller(s) in the A-unit. It is established by a service representative when the 3380 is installed. The string address depends on the number of 3380 strings attached to a storage director.

- With single-path (A04) strings, the string address for the controller may be either 0 or 1 if only one string is attached to the storage director. If two strings are attached, the controller for one of the strings must be string address 0, and the other must be string address 1.
- For dual-path strings (AA4, AD4, AE4, AJ4 or AK4) the following rules apply for string addresses:
  - Both controllers in the A-unit must have the same string address (either 0 or 1).

- Both controllers in a 3380 A-unit cannot be attached to the same storage director. (A 3880 contains two storage directors.)
- If one string is attached to a storage director, the string address may be either 0 or 1.
- If two strings are attached to a storage director, the string address must be 0 for both controllers of one string and must be 1 for both controllers of the other string.

Each of the controllers (A1 and A2) of a string must be attached to different storage directors. Therefore, the unit address (storage director, string, and device), allows any device in the string to be accessed on either of two paths: one through each of the storage directors. With one or more channels attached to each storage director, each resulting unit address permits access to each device through both storage directors. Figure 50 on page 91 illustrates this concept.

The device address within a string (bits 4 through 7) is specified by a binary value between 0000 through 1111 (hexadecimal 0 through F). In a single- or dual-path string, device addresses must start with 0 and run sequentially from the beginning of the string. Devices in the A-unit have device addresses of hexadecimal 0 through 3. The device addresses of devices in other units of the string have sequential values, depending on their position in the string. An individual device address cannot be changed. If a string with fewer than 16 devices is attached to a storage director, the unused device addresses cannot be assigned to devices on another string.

Note: The device addressing considerations for 3380 strings attached by means of the Direct-Attach Model CJ2 unit *have different rules* than those specified here. See *IBM 3380 Direct Access Storage Direct Channel Attach Model CJ2 Introduction and Reference* for details on these addressing considerations.

Figure 48 shows the valid address ranges for configurations in which one single- or 2-path string is attached to a storage director.

```
00 - 0F
10 - 1F
20 - 2F
30 - 3F
40 - 4F
50 - 5F
60 - 6F
70 - 7F
80 - 8F
90 - 9F
A0 - AF
B0 - BF
C0 - CF
D0 - DF
E0 - EF
F0   FF
```

Figure 48. Valid Address Ranges for One Single- or 2-Path String Attached to a Storage Director

Figure 49 shows the valid address ranges for two strings attached to the same storage director. Figure 50 on page 91 provides an example of valid address range usage.

String A	String B
00 – 0F	10 – 1F
20 – 2F	30 – 3F
40 – 4F	50 – 5F
60 – 6F	70 – 7F
80 – 8F	90 – 9F
A0 – AF	B0 – BF
C0 – CF	D0 – DF
E0 – EF	F0 – FF

Figure 49. Valid Address Ranges for Two Single- or 2-Path Strings Attached to a Storage Director

See "Address Ranges for 4-Path String Intermixed With 2-Path Strings" on page 95 for bit setting and address range considerations for 2-path strings that are intermixed with 4-path strings on the same 3990 Storage Control.

The example in Figure 50 shows two 2-path strings attached to two storage directors. The storage directors have a binary address of 010, and string A has a binary address of 0. The resulting hexadecimal value of 4 is the left-most hexadecimal digit for the valid address range (40 - 4F) for accessing the devices on string A. The hexadecimal digits in the valid address ranges are derived from the sequential device addresses, binary 0000 through 1111, or hexadecimal 0 through F. The hexadecimal address of the first device in the string is 0, regardless of the number of devices in the string. With two 3380 2-path strings attached to the same storage director, the unit address of the first device on string A is always 00, 20, 40, 60, 80, A0, C0, or E0, as described in Figure 49.

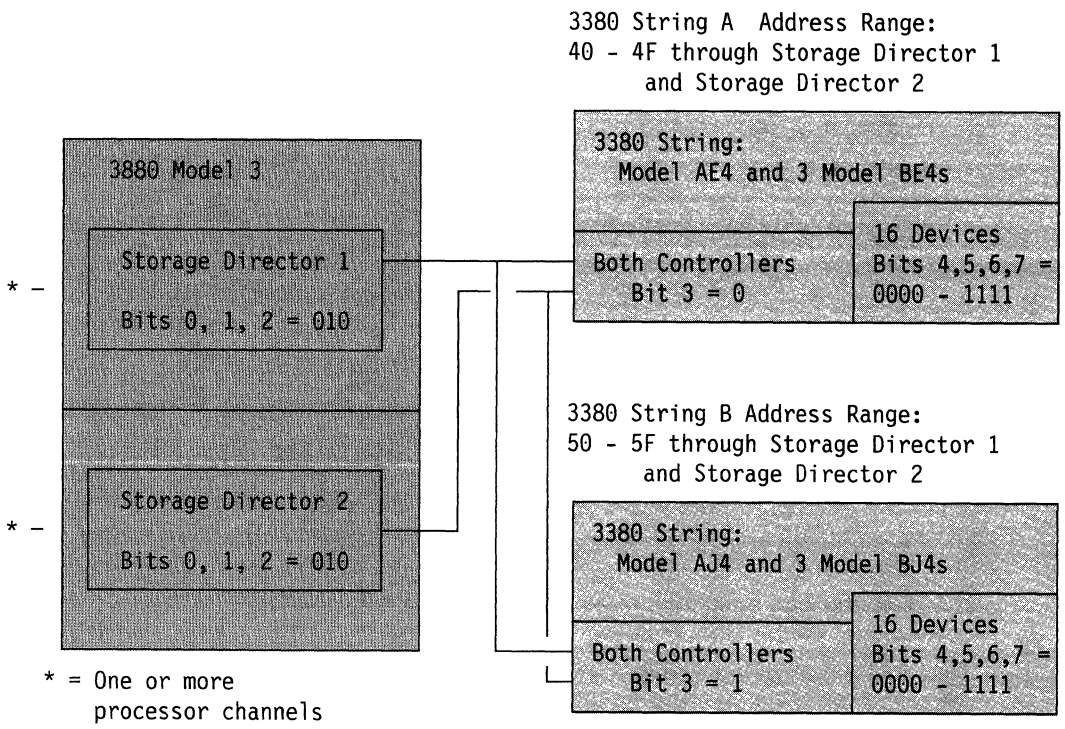


Figure 50. Addressing Example. Two 3380 2-Path Strings (32 Devices) Attached to Two 3880 Storage Directors

Remember that if there are fewer than 16 devices on a string, unused device addresses cannot be used for other devices on another 3380 string. For example, if string B in Figure 50 had only eight devices (addresses 50 through 57), the remaining addresses (58 through 5F) could not be assigned to other devices attached to the same storage director or attached, through another storage director, to the same channel.

Unit Addresses for 4-Path Strings

The bit composition for the unit address for 4-path strings is shown in Figure 51. For serial channels, the unit address consists of the device address and string address.

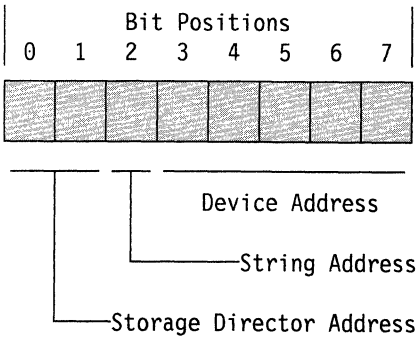


Figure 51. Unit Address Composition for 4-Path 3380 String

The storage director address (bits 0 and 1) represents the address of the 3990 storage director in the selection path of the device. The storage director address is set in the 3990 by the service representative.

The string address (bit 2) refers to the address (binary 0 or 1) associated with the controllers in the A-units. String address is established by a service representative when the 3380 units are installed. The following rules apply for string addresses:

- All controllers (four) in the 4-path string must have the same string address, either 0 or 1.
- Each controller in the string must be attached to a different storage path. The controllers (A1 through A4) must attach in ascending order to storage paths (0 through 3) in the 3990 Storage Control.
- If one 4-path string is attached to the 3990, the string address may be either 0 or 1.
- If two strings are attached, the string address must be 0 for all controllers of one string and must be 1 for all controllers of the other string.

Each of the four controllers in a 4-path string must be attached to a different storage path of a multipath storage director. Therefore, the unit address (storage director, string, and device), allows any device in the string to be accessed on any of four paths: one through each path of each multipath storage director. With one or more channels attached to each storage director, each resulting unit address permits access to each device through both storage paths of both multipath storage directors. Figure 54 on page 94 illustrates this concept.

The device address within a string (bits 3 through 7) is specified by a binary value between 00000 through 11111. In a 4-path string, device addresses are a function of relative position within the string, and an individual device address cannot be changed. If there are strings with fewer than 32 devices, the unused device addresses cannot be assigned to devices on another string.

Figure 52 shows how the unit address relates to the position within the string and substring and provides an example of unit addresses for a 4-path string.

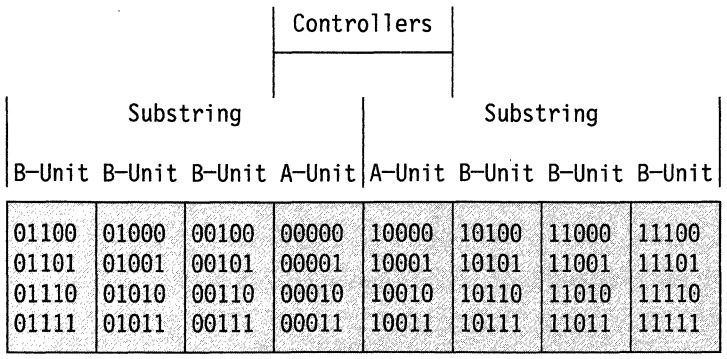


Figure 52. Relative Device Address Positions for 4-Path String (with Example)

Figure 53 shows the valid address ranges for 4-path strings. See Figure 54 on page 94 for an example of the valid range usage.

String A	String B
00 - 1F	20 - 3F
40 - 5F	60 - 7F
80 - 9F	A0 - BF
C0 - DF	E0 - FF

Figure 53. Valid Address Ranges for Two 4-Path Strings Attached to a Storage Director

The example in Figure 54 on page 94 shows two 4-path strings attached to a 3990 Model 2 or 3 Storage Control. The multipath storage directors have an address value of binary 00. The string address is 0 for all controllers on String A and 1 for all controllers on String B. The resulting value for the left-most hexadecimal digit in the valid address range (00 through 1F) for String A is 0 or 1, depending on the setting of bit 3 in the device portion of the address. Similarly, for String B with address range 20 through 3F, the left-most hexadecimal digit has a value of 2 or 3. The value of the right-most hexadecimal digit is derived from the settings of bits 4 through 7 of the device address. Device address bit settings are a function of the relative position of the device in the string.

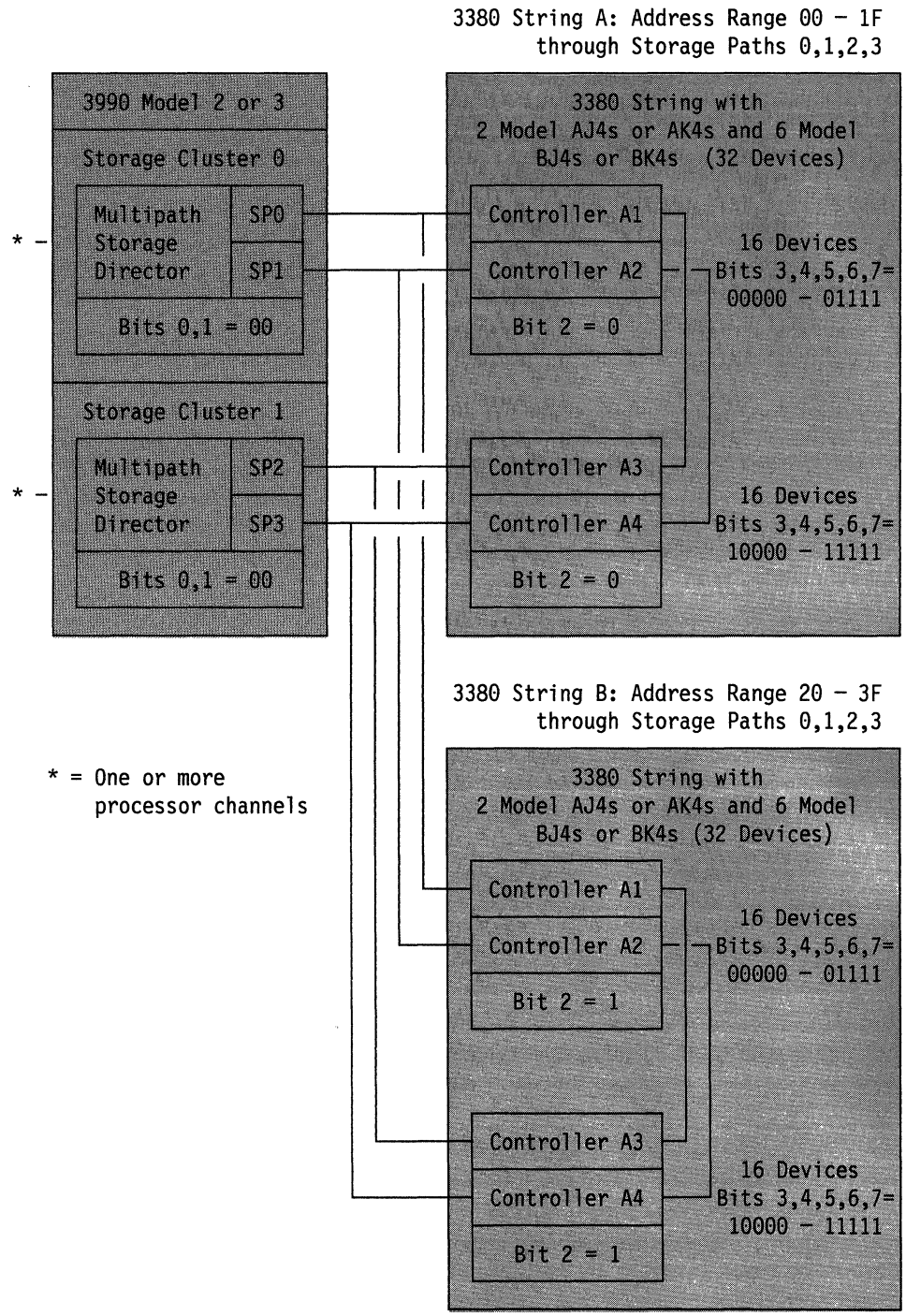


Figure 54. Addressing Example. Two 3380 4-Path Strings (64 Devices) Attached to Two 3880 Storage Directors

Remember that if there are fewer than 32 devices on a 4-path string, unused device addresses cannot be used for other devices on another 3380 string. For example, if String A in Figure 54 had four B-units each, instead of six, addresses 0C through 0F and 1C through 1F would not be used and could not be assigned to other devices attached to the same storage director or attached, through another storage director, to the same channel.

Address Ranges for 4-Path String Intermixed With 2-Path Strings

The 4-path Device Level Selection Enhanced storage subsystem can have as many as 32 devices in one 4-path string, and 16 devices in each of the 2-path strings. For the intermixed 4-path string, the normal unit address bit composition for 4-path strings applies. For the 2-path strings that are intermixed, the following rules apply for the unit address:

- Bits 0 and 1 represent the storage director.
- Bit 2 for the 2-path strings must have the opposite value of the bit-2 setting for the 4-path string.
- Bit 3 represents the string address, as in other 2-path strings.
- Bits 4 through 7 represent the device address, as in other 2-path strings.

The valid address ranges for a configuration of intermixed 2-path and 4-path strings are shown in Figure 55.

Storage Director Address	String 1 4-Path	String 2 2-Path	String 3 2-Path
00	00-1F	20-2F	30-3F
40	40-5F	60-6F	70-7F
80	80-9F	A0-AF	B0-BF
C0	C0-DF	E0-EF	F0-FF
Storage Director Address	**String 1 2-Path**	**String 2 2-Path**	**String 3 4-Path**
00	00-0F	10-1F	20-3F
40	40-4F	50-5F	60-7F
80	80-8F	90-9F	A0-BF
C0	C0-CF	D0-DF	E0-FF

Figure 55. Valid Address Ranges for a 4-Path String Intermixed with Two 2-Path Strings

For each 2-path string, the devices in the A-unit must have the lowest addresses in one of the ranges shown above; the other devices in the string must follow sequentially (no addresses may be skipped). For the 4-path string, the devices in the A-unit have the lowest addresses for each half of the address range; for example, one A-unit has the addresses starting at 00, and the other A-unit has the addresses starting at 10. See Figure 52 on page 92 for an example of the 4-path address sequences. Each of the controllers (A1-A4) in the A-units in the 4-path string have the two low addresses for each half of the range and must attach in ascending order to storage paths 0 to 3 in the 3990 Storage Control. The controllers in each A-unit of the 2-path strings must attach to either storage paths 0 and 2, or 1 and 3.

Remember that the 4-path string **must** be composed of 3380 Enhanced Subsystem models and the 2-path strings **may not** be Enhanced Subsystem models. The 2-path strings may be AD4, AE4, or AA4 strings. (Note that the AA4 model must have a serial number of 15000 or greater for 60 Hz units or X0300 or greater for 50 Hz units.)

Physical Identifiers

A 3380 string can be accessed by one or more processors and by several channels from each processor. As a result, a 3380 device can be accessed by any of several different unit addresses.

To simplify the identification of a specific component, the sense bytes from the storage control include physical identifier information to pinpoint the component that may have a problem. This identification process is especially useful for a program such as Environmental Record Editing and Printing (EREP) that correlates information on specific devices from multiple systems.

When the 3380 J and K models are attached to a 3880 Storage Control, there is a unique physical identifier established for each storage director, string, and device. For all other models, there is a unique physical identifier established for each storage director, controller, and device. When the 3380 is attached to a 3990 Storage Control, the unique physical identifiers describe the logical subsystem, controller, and device.

Devices have pre-assigned physical identifiers that are determined by their physical relationship to the A-unit. Physical identifiers for the storage director or subsystem and for the 3380 controller (that is, the string) are set with switches by the service representative at the time that the unit addresses are set during installation. Spaces are provided on the 3380 A-unit operator control panel to affix labels for the subsystem or storage director identifier and the string identifier (for J and K models). For all other models, the labels are for the subsystem or storage director identifier and the controller identifier.

Subsystem Identifiers

All storage directors within a 3990 logical DASD subsystem must be assigned the same subsystem identifier (SSID). SSID values can be from X'0001' to X'00FF'.

During the 3990 installation the service representative enters the SSID(s) into vital product data storage and attaches SSID labels on the operator panel under each storage path Restart switch. The SSID labels identify the logical DASD subsystem to which each storage is assigned. The service representative also attaches SSID labels on the operator pane of each 3380 A-unit. For more information on SSIDs, see *IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide*.

Appendix B. Record Format, Track Format, and Space Calculations

This appendix describes the physical record format and the track format for the 3380. In addition, a technique for effective space calculation is presented, along with tables to help you select an efficient physical record size to meet your needs. The information in this appendix applies to all models of the 3380.

Physical Record Format

A ***physical record*** is the structure for physically storing data on the 3380. Usually each physical record contains both user data and other types of data for control purposes. The organization of user data in a physical record is not relevant to how the 3380 reads and writes the record.

A ***logical record*** is the structure for data that is recognized and used by the application. One or more logical records might be stored in a physical record. Alternatively, a logical record might be split among two or more physical records. The format of a logical record may be fixed length or variable length.

To use the 3380 effectively, it is important to understand the format of the physical record. A physical record can contain three areas: count, key, and data. Because the key area is optional, records can consist of only two areas: count and data. Each area within a record is separated by a gap, and two adjacent records are separated by a gap. Error checking and correcting (ECC) code bytes that are used to detect and correct read/write errors are added to each area whenever a record is written.

Count Area: The count area indicates the location of a physical record. Each record location is defined by:

- Cylinder number (CC), 2 bytes that represent the following decimal values:
  - 0 to 884 for single capacity models (A04, AA4, B04, AD4, BD4, AJ4, and BJ4),
  - 0 to 1769 for double capacity models (AE4 and BE4)
  - 0 to 2654 for triple capacity models (AK4 and BK4)
- Read/Write Head number (HH), 2 bytes that represent a decimal value from 0 to 14. A record is located on the track (in a cylinder) accessible by read/write head HH.
- Record number (R), one byte value (0 or greater) that specifies the record location relative to other records on the track.

Each count area also specifies the length of the other two areas:

- The key length (KL), or length in bytes of the key area. If the record is written without a key area, the KL value is 0.
- The data length (DL), or the length in bytes of the data area. For an end-of-file (EOF) record, the DL value is 0; see "How Many Records per Track?" on page 100 for additional information on EOF records.

The count area is written when the record is formatted (initially written to the disk) and is not changed until the record is reformatted (written with a modified key length or data length).

Key Area: The key may be used by the application and is optional.

Once you format the key area, you may rewrite its contents without reformatting the record. If you rewrite the key area, you must also rewrite the data area.

If you lengthen or shorten the key area, you must reformat the track with modified count, key, and data areas.

Data Area: The data area contains user data; that is, the logical records of an application.

After the data area is formatted (initially written to the disk), the contents may be rewritten without reformatting the record. If you do not change the data length, you may rewrite the data area without changing or rewriting any other area.

If you lengthen or shorten the data area, you must reformat the track with modified count, key (if any), and data areas.

Track Format

The start and end of each track are defined by a magnetic mark on the disk surface called the *index point*. (Because a track is circular, the same index point defines both the start and end points.) All tracks are written with formatted records, beginning at the index point and ending when the index point comes around again. Each track has the same basic format (as shown in Figure 56): index point, home address (HA), record zero (R0, also called the track descriptor record), and one or more data records (R1 through Rn). All DASD units leave the factory with home address and a standard record zero on every track.

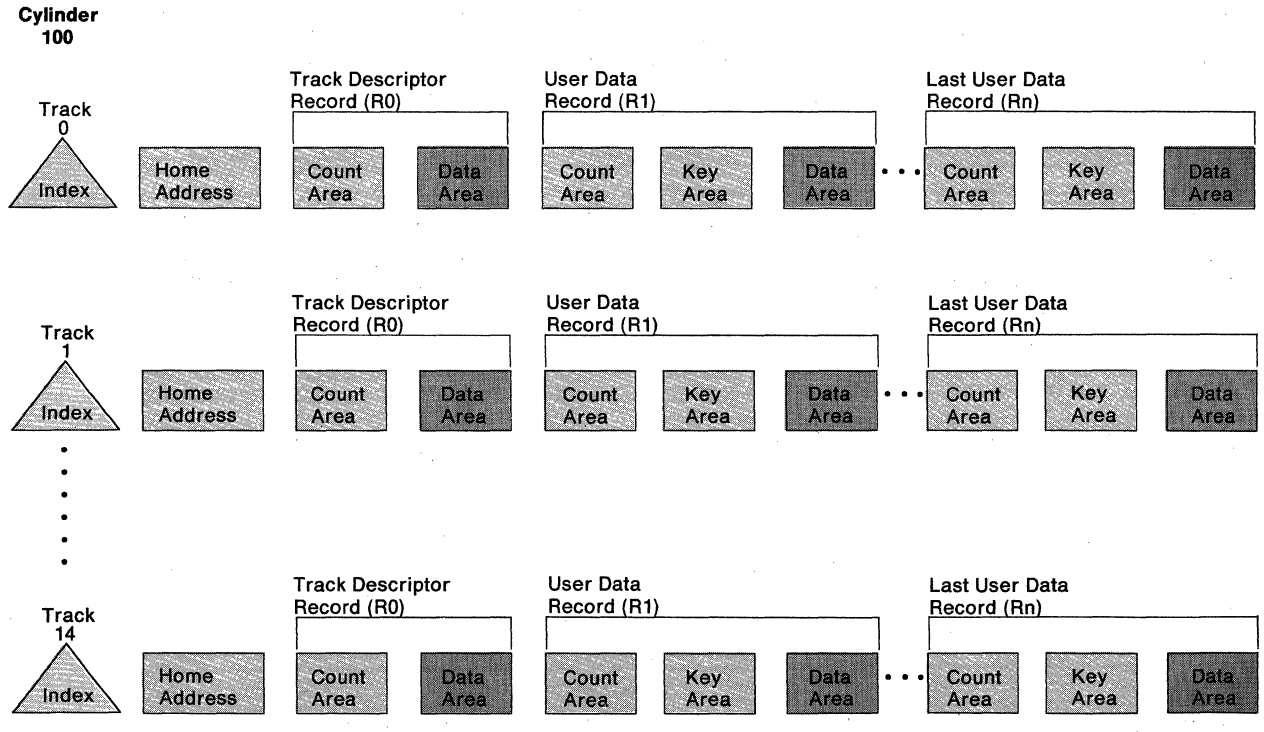


Figure 56. Track and Record Format, Simplified Representation (Standard R0)

Home Address (HA): Each track contains a home address (HA) following the index point. The HA contains the track address, as defined by the track cylinder (CC) and read/write head (HH) used to access the track data. The home address flag byte (F) contains information describing the status of the track and indicates whether the track is usable, defective, or is an alternate track. The home address in an integral part of the DASD logic that is required for correct operation.

Record Zero (R0), the Track Descriptor Record: The record zero (R0), or track descriptor record, is always the first data record on the track following the home address. A standard R0, written on every track before the DASD unit leaves the factory, has a key length of 0 and a data length of 8 bytes. A nonstandard R0 can be used as a normal data record with the key length and data length determined by the user.

If the track home address flag indicates that the track is defective, the count area of the track R0 must contain the track address of an alternate track. The alternate track R0 count area contains the track address of the defective track it replaces.

The channel command words (CCWs) used for writing and reading an R0 are:

Write Record 0
Read Record 0

Data Records (R1 through Rn): One or more data records (physical records other than the home address and record zero) may follow the R0 on a track. A data record must be contained entirely on one track; that is, the record cannot begin on one track and continue on the following track.

Data records can be formatted with or without key areas, as determined by the file organization specified by the application that uses the data.

For information on the channel command words (CCWs) used for reading and writing data records, see:

IBM 3880 Storage Control Models 1, 2, 3, and 4 Description Manual
IBM 3880 Storage Control Model 13 Description
IBM 3880 Storage Control Model 23 Description
IBM 3990 Storage Control Reference

Data Records per Track

The number of equal-length data records that can be placed on a track depends on the size of the records, the track capacity, and whether or not the records include key areas. The size of each data record is determined by the application that formats the record.

Data record size can be specified by the programmer who prepares CCW chains to write and read the records. Another way of specifying data record size is for the programmer to define data characteristics to an application or operating system and let the application or operating system determine the record size, format the data, and write and read the data records to the 3380.

On any given track, the maximum record size is determined by the track capacity, with overhead subtracted. Track overhead is the sum of the space required for element such as:

- Home address
- Record zero

- Count field
- Inter-record gaps
- Gaps between count, key and data areas
- ECC bytes

"Calculating Space Requirements" provides guidelines for making overhead allowances when calculating records per track.

Calculating Space Requirements

In selecting an appropriate physical record size (block size) for an application, it is useful to understand how efficiently a specific physical record size uses the space on a 3380 volume. More specifically, you need to consider:

- The number of equal-length physical records of a specified length that can fit on a track and a cylinder
- The amount of user data a track or cylinder can contain when it is filled with equal-length physical records of a specific length

While you are planning for the installation of new 3380 units, consider the blocking factors for the data that will be stored on the new volumes. As you migrate to your new hardware, you may want to reblock your data for more efficient use of 3380 storage space.

Further information and guidelines for determining optimum block sizes for particular operating environments can be found in:

Using the IBM 3380 Direct Access Storage in an MVS Environment
Using the IBM 3380 Direct Access Storage in a VM Environment
Using the IBM 3380 Direct Access Storage in a VSE Environment

To help you in optimum block size selection, the tables at the end of this appendix show the percentage of storage space that is utilized with physical record sizes of various data lengths (DLs). These tables also show the maximum track and cylinder capacity for the various physical record sizes. The calculations that follow are provided to help you understand how the table values are derived.

How Many Records per Track?

Each 3380 track is divided into 1499 user data cells, each of which has a length of 32 bytes. Records written on a 3380 track are always written at the beginning of a 32-byte cell and continue through one or more contiguous 32-byte cells. Gaps (areas that contain no data) occur between physical records and between the count, key, and data areas of records, but no gaps occur between 32-byte cells.

Each file is terminated with an end-of-file (EOF) record. An EOF record is a unique record; the key-length (KL) field and the data length (DL) field in the count area have a value of zero, but there will be a data area of one cell that contains 12 ECC bytes and zeros. Each EOF record requires 16 cells of track space. In the unique case of the MVS Partitioned Access Method (PAM), several files can exist on a single track; thus, there can be several EOF records on a single PAM track.

In the following formulae and sample calculations, elements or values that are variables are shown in red, and constants are shown in black.

Equal-Length Physical Records

The number of equal-length physical records that can be stored on a track can be determined by:

$$\text{Equal-length records per track} = \frac{1499}{C + K + D} \quad \text{(with fractional remainder dropped)}$$

where:

1499 is the number of 32-byte user data cells per track available for physical records (R1 through Rn).

C is the number of 32-byte cells used for the count area and for gaps (between the count area and the previous record and between the count area and the key or data area)

$C = 15$

K is the number of 32-byte cells used for the key area and for the gap between the key area and the data area.

$K = 0$ if there is no key area.

If there is a key area,

$$K = G + \frac{\text{key length} + E}{32} \quad \text{(rounded to the next higher integer)}$$

where
G = Gap before key field = 7
E = ECC bytes = 12

D the number of 32-byte cells used for the data area.

$$D = \frac{\text{data length} + E}{32} \quad \text{(rounded to the next higher integer)}$$

where
E = ECC bytes = 12
Note: Inter-record gaps for "data length" are included in C = 15

For example, an MVS partitioned data set (PDS) directory record is written as a physical record that has:

Key length = 8 bytes
Data length = 256 bytes

To determine the number of PDS directory records that can fit on a track:

$$\text{Number of PDS Records} = \frac{1499}{C + K + D}$$

$$= \frac{1499}{15 + \left(7 + \frac{(8 + 12)}{32}\right) + \frac{(256 + 12)}{32}}$$

$$= \frac{1499}{15 + \left(7 + \frac{20}{32}\right) + \frac{268}{32}}$$

$$= \frac{1499}{15 + (7.63) + (8.38)}$$

... next, round K and D to the next higher integer:

$$= \frac{1499}{15 + 8 + 9} = 46.8$$

... and, finally, remove the fraction remaining:

= 46 PDS directory records per track

Twelve bytes are added to the key length (K + 12) and data length (D + 12) values, to account for the 12 bytes of error checking and correction (ECC) code data the 3380 appends to each key and data area. The key length (KL) and data length (DL) values are then rounded up to multiples of 32 because each key area and data area is written in one or more contiguous 32-byte cells.

Unequal-Length Physical Records

To determine the number of physical records that can be stored on a track, first calculate the length of each physical record to be stored on the track. Next, subtract the length of each record from the amount of available space that remains, until the track capacity is reached.

To determine the number of 32-byte cells that comprise a physical record, use the following formula:

Record length = C + K + D

where:

C is the number of 32-byte cells used for the count area and for gaps (between the count area and the previous record and between the count area and the key or data area)

C = 15

K is the number of 32-byte cells used for the key area and for the gap between the key and data area

K equals = 0 if there is no key area.

If there is a key area,

$$K = G + \frac{\text{key length} + E}{32} \quad \text{(rounded to the next higher integer)}$$

where
G = Gap before key field = 7
E = ECC bytes = 12

D is the number of 32-byte cells used for the data area

$$D = \frac{\text{data length} + E}{32} \quad \text{(rounded to the next higher integer)}$$

where
E = ECC bytes = 12
Note: Inter-record gaps for "data length" are included in C = 15

If the track descriptor record is an IBM standard R0 (an R0 with no key and an 8-byte data area), track capacity (the amount of space available for physical records that contain user data) is 1499 32-byte cells. If there is no R0, the track capacity contains 16 additional cells.

If the first record on the track is not an IBM standard R0, the track might begin with a track descriptor record designed by the user, or might not include a track descriptor record at all. Without the IBM standard R0 record, track capacity (for records R0 or R1 through Rn) is 1515 32-byte cells.

Tables for Space Calculation: Without and With Keys

The number of records that can be placed on a track depends on the data length of each record and whether or not the record includes a key area. Because partial records cannot be written on a track, the number of equal-length records that can fit on a track is the same over a range of data lengths.

The percentage of track space used for data assumes the track contains the maximum number of records, each of which is the largest possible for the given data-length range. The track and cylinder capacity values in the tables specify the number of bytes available for user data.

Figure 57 on page 104 shows the number of equal-length records that can be written on a track when the records do not include keys. Figure 58 on page 106 through Figure 66 on page 114 show the number of equal-length records that can be written on a track for records with keys in different size ranges.

Equal-Length Physical Records Without Keys

Use Figure 57 on page 104 to find out how track (or cylinder) space is utilized for fixed-length physical records of a specific data length (DL):

1. Use the Data Length Range column on the left side of the table to select the range that includes the length of the record.
2. Use the Percent Space Used column to determine what percentage of the track would be occupied with user data if the track contains the maximum number of records, each of which has the maximum data length for the data length range.
3. Read the number of records that can fit on a track or a cylinder from the Maximum Track Capacity and Maximum Cylinder Capacity columns, located at the right-hand side of the table.

For example, consider a data record of 4096 bytes. The data length of the record is between 3861 and 4276. This means that 10 records can be written per track and 150 records can be written per cylinder.

Now, observe that with a 4096-byte record, the percentage of track space actually used for data is 86.2, whereas with the maximum data length in the range (4276), 90 percent of the track space is used.

```
4096 x 10      ((data bytes per record) * records)
--------- =
   47476       (maximum data per track)

 40960
-------- =  .862  =  86.2 percent
 47476
```

Finally, note the maximum track and cylinder data capacity. If a track is filled with 4276-byte data records (10 records have been written), the maximum capacity of the track is 42760 bytes of user data. The data capacity of a cylinder, 641400 bytes of user data, is approximately 626K bytes of user data (1K byte = 1024 bytes). Smaller records in the 3861 to 4276 range would yield a user data capacity for a track and a cylinder somewhat less than the value listed in the table. The track or cylinder would continue to contain the same number (10 or 150) equal-length physical records.

Data Length Range		Percent Space	Maximum Track Capacity *		Maximum Cylinder Capacity *	
Min	Max	Used *	Records	Bytes	Records	Bytes
23 477	47 476	100.0	1	47 476	15	712 140
15 477	23 476	98.9	2	46 952	30	704 280
11 477	15 476	97.7	3	46 428	45	696 420
9 077	11 476	96.6	4	45 904	60	688 560
7 477	9 076	95.5	5	45 380	75	680 700
6 357	7 476	94.4	6	44 856	90	672 840
5 493	6 356	93.7	7	44 492	105	667 380
4 821	5 492	92.5	8	43 936	120	659 040
4 277	4 820	91.3	9	43 380	135	650 700
3 861	4 276	90.0	10	42 760	150	641 400
3 477	3 860	89.4	11	42 460	165	636 900
3 189	3 476	87.8	12	41 712	180	625 680
2 933	3 188	87.2	13	41 444	195	621 660
2 677	2 932	86.4	14	41 048	210	615 720
2 485	2 676	84.5	15	40 140	225	602 100
2 325	2 484	83.7	16	39 744	240	596 160
2 165	2 324	83.2	17	39 508	255	592 620
2 005	2 164	82.0	18	38 952	270	584 280
1 877	2 004	80.2	19	38 076	285	571 140
1 781	1 876	79.0	20	37 520	300	562 800
1 685	1 780	78.7	21	37 380	315	560 700
1 589	1 684	78.0	22	37 048	330	555 720
1 493	1 588	76.9	23	36 524	345	547 860
1 397	1 492	75.4	24	35 808	360	537 120
1 333	1 396	73.5	25	34 900	375	523 500
1 269	1 332	72.9	26	34 632	390	519 480
1 205	1 268	72.1	27	34 236	405	513 540
1 141	1 204	71.0	28	33 712	420	505 680
1 077	1 140	69.6	29	33 060	435	495 900
1 045	1 076	67.9	30	32 280	450	484 200
981	1 044	68.1	31	32 364	465	485 460
949	980	66.0	32	31 360	480	470 400
917	948	65.8	33	31 284	495	469 260
853	916	65.6	34	31 144	510	467 160
821	852	62.8	35	29 820	525	447 300
789	820	62.1	36	29 520	540	442 800
757	788	61.4	37	29 156	555	437 340
725	756	60.5	38	28 728	570	430 920
693	724	59.4	39	28 236	585	423 540
661	692	58.3	40	27 680	600	415 200
629	660	57.0	41	27 060	615	405 900
597	628	55.5	42	26 376	630	395 640
565	596	55.2	44	26 224	660	393 360
533	564	53.4	45	25 380	675	380 700
501	532	51.5	46	24 472	690	367 080
469	500	50.5	48	24 000	720	360 000
437	468	48.3	49	22 932	735	343 980
405	436	46.8	51	22 236	765	333 540
373	404	45.1	53	21 412	795	321 180
341	372	43.1	55	20 460	825	306 900
309	340	40.8	57	19 380	855	290 700
277	308	38.2	59	18 172	885	272 580
245	276	36.0	62	17 112	930	256 680
213	244	33.4	65	15 860	975	237 900
181	212	30.3	68	14 416	1 020	216 240
149	180	26.9	71	12 780	1 065	191 700
117	148	23.0	74	10 952	1 110	164 280
85	116	19.0	78	9 048	1 170	135 720
53	84	14.6	83	6 972	1 245	104 580
21	52	9.6	88	4 576	1 320	68 640
1	20	3.9	93	1 860	1 395	27 900

* Calculations are made using maximum size record in range.

Figure 57. Equal-Length Physical Records Without Keys

Equal-Length Physical Records With Keys

To find out how track (or cylinder) space is utilized for keyed fixed-length physical records of a specific data length (DL):

1. First, turn to the appropriate table for the key length (KL) in use:

   Figure 58 on page 106 for KL = 1 to 20
   Figure 59 on page 107 for KL = 21 to 52
   Figure 60 on page 108 for KL = 53 to 84
   Figure 61 on page 109 for KL = 85 to 116
   Figure 62 on page 110 for KL = 117 to 148
   Figure 63 on page 111 for KL = 149 to 180
   Figure 64 on page 112 for KL = 181 to 212
   Figure 65 on page 113 for KL = 213 to 244
   Figure 66 on page 114 for KL = 245 to 255

2. Use the Data Length Range column to select the range that includes the data length of the record.
3. Use the Percent Space Used column to determine the percentage of the track that would be occupied with user data if the track contains the maximum number of records, each of which has the maximum data length for the data length range.
4. Read the number of records that can fit on a track or a cylinder from the Maximum Track Capacity and the Maximum Cylinder Capacity columns, located at the right-hand side of the table.

For example, consider a keyed data record that has a key length of 10 bytes and a data length of 1024 bytes. The appropriate table is Figure 58 on page 106, covering key lengths from 1 to 20 bytes. The data length of the record is between 1013 and 1076; this means that 26 records can be written per track and 390 records can be written per cylinder.

Next, observe that (at best) 58.9% of the track can be occupied by user data. In our example, the percentage of track space actually used for data is 56.1%:

```
1024 x 26      ((data bytes per record) * records)
--------- =
  47476        (maximum data per track)

 26264
-------- =  0.5607  =  56.1 percent
 47476
```

Finally, note the maximum track and cylinder data capacity. If a track is filled with 1076-byte data records (26 records have been written) the maximum capacity of the track is 27976 bytes of user data. The data capacity of a cylinder, 419640 bytes of user data, is approximately 410K bytes of user data (1K byte = 1024 bytes). Smaller records in the 1013 to 1076 range would yield a user data capacity for a track and a cylinder somewhat less than the value listed in the table. The track or cylinder would continue to contain the same number (26 or 390) of equal-length physical records.

Data Length Range		Percent Space	Maximum Track Capacity *		Maximum Cylinder Capacity *	
Min	Max	Used *	Records	Bytes	Records	Bytes
23 221	47 220	99.5	1	47 220	15	708 300
15 221	23 220	97.8	2	46 440	30	696 600
11 221	15 220	96.2	3	45 660	45	684 900
8 821	11 220	94.5	4	44 880	60	673 200
7 221	8 820	92.9	5	44 100	75	661 500
6 101	7 220	91.3	6	43 320	90	649 800
5 237	6 100	89.9	7	42 700	105	640 500
4 565	5 236	88.2	8	41 888	120	628 320
4 021	4 564	86.5	9	41 076	135	616 140
3 605	4 020	84.7	10	40 200	150	603 000
3 221	3 604	83.5	11	39 644	165	594 660
2 933	3 220	81.4	12	38 640	180	579 600
2 677	2 932	80.3	13	38 116	195	571 740
2 421	2 676	78.9	14	37 464	210	561 960
2 229	2 420	76.5	15	36 300	225	544 500
2 069	2 228	75.1	16	35 648	240	534 720
1 909	2 068	74.1	17	35 156	255	527 340
1 749	1 908	72.3	18	34 344	270	515 160
1 621	1 748	70.0	19	33 212	285	498 180
1 525	1 620	68.3	20	32 400	300	486 000
1 429	1 524	67.4	21	32 004	315	480 060
1 333	1 428	66.2	22	31 416	330	471 240
1 237	1 332	64.5	23	30 636	345	459 540
1 141	1 236	62.5	24	29 664	360	444 960
1 077	1 140	60.0	25	28 500	375	427 500
1 013	1 076	58.9	26	27 976	390	419 640
949	1 012	57.6	27	27 324	405	409 860
885	948	55.9	28	26 544	420	398 160
821	884	54.0	29	25 636	435	384 540
789	820	51.8	30	24 600	450	369 000
725	788	51.5	31	24 428	465	366 420
693	724	48.8	32	23 168	480	347 520
661	692	48.1	33	22 836	495	342 540
597	660	47.3	34	22 440	510	336 600
565	596	43.9	35	20 860	525	312 900
533	564	42.8	36	20 304	540	304 560
501	532	41.5	37	19 684	555	295 260
469	500	40.0	38	19 000	570	285 000
437	468	38.4	39	18 252	585	273 780
405	436	36.7	40	17 440	600	261 600
373	404	34.9	41	16 564	615	248 460
341	372	32.9	42	15 624	630	234 360
309	340	31.5	44	14 960	660	224 400
277	308	29.2	45	13 860	675	207 900
245	276	26.7	46	12 696	690	190 440
213	244	24.7	48	11 712	720	175 680
181	212	21.9	49	10 388	735	155 820
149	180	19.3	51	9 180	765	137 700
117	148	16.5	53	7 844	795	117 660
85	116	13.4	55	6 380	825	95 700
53	84	10.1	57	4 788	855	71 820
21	52	6.5	59	3 068	885	46 020
1	20	2.6	62	1 240	930	18 600

* Calculations are made using maximum size record in range.

Figure 58. Equal-Length Physical Records with Key Length 1 to 20 Bytes

Data Length Range		Percent Space Used *	Maximum Track Capacity *		Maximum Cylinder Capacity *	
Min	Max		Records	Bytes	Records	Bytes
23 189	47 188	99.4	1	47 188	15	707 820
15 189	23 188	97.7	2	46 376	30	695 640
11 189	15 188	96.0	3	45 564	45	683 460
8 789	11 188	94.3	4	44 752	60	671 280
7 189	8 788	92.6	5	43 940	75	659 100
6 069	7 188	90.8	6	43 128	90	646 920
5 205	6 068	89.5	7	42 476	105	637 140
4 533	5 204	87.7	8	41 632	120	624 480
3 989	4 532	85.9	9	40 788	135	611 820
3 573	3 988	84.0	10	39 880	150	598 200
3 189	3 572	82.8	11	39 292	165	589 380
2 901	3 188	80.6	12	38 256	180	573 840
2 645	2 900	79.4	13	37 700	195	565 500
2 389	2 644	78.0	14	37 016	210	555 240
2 197	2 388	75.4	15	35 820	225	537 300
2 037	2 196	74.0	16	35 136	240	527 040
1 877	2 036	72.9	17	34 612	255	519 180
1 717	1 876	71.1	18	33 768	270	506 520
1 589	1 716	68.7	19	32 604	285	489 060
1 493	1 588	66.9	20	31 760	300	476 400
1 397	1 492	66.0	21	31 332	315	469 980
1 301	1 396	64.7	22	30 712	330	460 680
1 205	1 300	63.0	23	29 900	345	448 500
1 109	1 204	60.9	24	28 896	360	433 440
1 045	1 108	58.4	25	27 700	375	415 500
981	1 044	57.2	26	27 144	390	407 160
917	980	55.7	27	26 460	405	396 900
853	916	54.0	28	25 648	420	384 720
789	852	52.0	29	24 708	435	370 620
757	788	49.8	30	23 640	450	354 600
693	756	49.4	31	23 436	465	351 540
661	692	46.6	32	22 144	480	332 160
629	660	45.9	33	21 780	495	326 700
565	628	45.0	34	21 352	510	320 280
533	564	41.6	35	19 740	525	296 100
501	532	40.3	36	19 152	540	287 280
469	500	39.0	37	18 500	555	277 500
437	468	37.5	38	17 784	570	266 760
405	436	35.8	39	17 004	585	255 060
373	404	34.0	40	16 160	600	242 400
341	372	32.1	41	15 252	615	228 780
309	340	30.1	42	14 280	630	214 200
277	308	28.5	44	13 552	660	203 280
245	276	26.2	45	12 420	675	186 300
213	244	23.6	46	11 224	690	168 360
181	212	21.4	48	10 176	720	152 640
149	180	18.6	49	8 820	735	132 300
117	148	15.9	51	7 548	765	113 220
85	116	13.0	53	6 148	795	92 220
53	84	9.7	55	4 620	825	69 300
21	52	6.2	57	2 964	855	44 460
1	20	2.5	59	1 180	885	17 700

* Calculations are made using maximum size record in range.

Figure 59. Equal-Length Physical Records with Key Length 21 to 52 Bytes

Data Length Range		Percent Space	Maximum Track Capacity *		Maximum Cylinder Capacity *	
Min	Max	Used *	Records	Bytes	Records	Bytes
23 157	47 156	99.3	1	47 156	15	707 340
15 157	23 156	97.6	2	46 312	30	694 680
11 157	15 156	95.8	3	45 468	45	682 020
8 757	11 156	94.0	4	44 624	60	669 360
7 157	8 756	92.2	5	43 780	75	656 700
6 037	7 156	90.4	6	42 936	90	644 040
5 173	6 036	89.0	7	42 252	105	633 780
4 501	5 172	87.2	8	41 376	120	620 640
3 957	4 500	85.3	9	40 500	135	607 500
3 541	3 956	83.3	10	39 560	150	593 400
3 157	3 540	82.0	11	38 940	165	584 100
2 869	3 156	79.8	12	37 872	180	568 080
2 613	2 868	78.5	13	37 284	195	559 260
2 357	2 612	77.0	14	36 568	210	548 520
2 165	2 356	74.4	15	35 340	225	530 100
2 005	2 164	72.9	16	34 624	240	519 360
1 845	2 004	71.8	17	34 068	255	511 020
1 685	1 844	69.9	18	33 192	270	497 880
1 557	1 684	67.4	19	31 996	285	479 940
1 461	1 556	65.6	20	31 120	300	466 800
1 365	1 460	64.6	21	30 660	315	459 900
1 269	1 364	63.2	22	30 008	330	450 120
1 173	1 268	61.4	23	29 164	345	437 460
1 077	1 172	59.3	24	28 128	360	421 920
1 013	1 076	65.7	25	26 900	375	403 500
949	1 012	55.4	26	26 312	390	394 680
885	948	53.9	27	25 596	405	383 940
821	884	52.1	28	24 752	420	371 280
757	820	50.1	29	23 780	435	356 700
725	756	47.8	30	22 680	450	340 200
661	724	47.3	31	22 444	465	336 660
629	660	44.5	32	21 120	480	316 800
597	628	43.7	33	20 724	495	310 860
533	596	42.7	34	20 264	510	303 960
501	532	39.2	35	18 620	525	279 300
469	500	37.9	36	18 000	540	270 000
437	468	36.5	37	17 316	555	259 740
405	436	35.0	38	16 568	570	248 520
373	404	33.2	39	15 756	585	236 340
341	372	31.3	40	14 880	600	223 200
309	340	29.4	41	13 940	615	209 100
277	308	27.3	42	12 936	630	194 040
245	276	25.6	44	12 144	660	182 160
213	244	23.1	45	10 980	675	164 700
181	212	20.5	46	9 752	690	146 280
149	180	18.2	48	8 640	720	129 600
117	148	15.3	49	7 252	735	108 780
85	116	12.5	51	5 916	765	88 740
53	84	9.4	53	4 452	795	66 780
21	52	6.0	55	2 860	825	42 900
1	20	2.4	57	1 140	855	17 100

* Calculations are made using maximum size record in range.

Figure 60. Equal-Length Physical Records with Key Length 53 to 84 Bytes

Data Length Range		Percent Space Used *	Maximum Track Capacity *		Maximum Cylinder Capacity *	
Min	Max		Records	Bytes	Records	Bytes
23 125	47 124	99.3	1	47 124	15	706 860
15 125	23 124	97.4	2	46 248	30	693 720
11 125	15 124	95.6	3	45 372	45	680 580
8 725	11 124	93.7	4	44 496	60	667 440
7 125	8 724	91.9	5	43 620	75	654 300
6 005	7 124	90.0	6	42 744	90	641 160
5 141	6 004	88.5	7	42 028	105	630 420
4 469	5 140	86.6	8	41 120	120	616 800
3 925	4 468	84.7	9	40 212	135	603 180
3 509	3 924	82.7	10	39 240	150	588 600
3 125	3 508	81.3	11	38 588	165	578 820
2 837	3 124	79.0	12	37 488	180	562 320
2 581	2 836	77.7	13	36 868	195	553 020
2 325	2 580	76.1	14	36 120	210	541 800
2 133	2 324	73.4	15	34 860	225	522 900
1 973	2 132	71.9	16	34 112	240	511 680
1 813	1 972	70.1	17	33 524	255	502 860
1 653	1 812	68.7	18	32 616	270	489 240
1 525	1 652	66.1	19	31 388	285	470 820
1 429	1 524	64.2	20	30 480	300	457 200
1 333	1 428	63.2	21	29 988	315	449 820
1 237	1 332	61.7	22	29 304	330	439 560
1 141	1 236	59.9	23	28 428	345	426 420
1 045	1 140	57.6	24	27 360	360	410 400
981	1 044	55.0	25	26 100	375	391 500
917	980	53.7	26	25 480	390	382 200
853	916	52.1	27	24 732	405	370 980
789	852	50.3	28	23 856	420	357 840
725	788	48.1	29	22 852	435	342 780
693	724	45.8	30	21 720	450	325 800
629	692	45.2	31	21 452	465	321 780
597	628	42.3	32	20 096	480	301 440
565	596	41.4	33	19 668	495	295 020
501	564	40.4	34	19 176	510	287 640
469	500	36.9	35	17 500	525	262 500
437	468	35.5	36	16 848	540	252 720
405	436	34.0	37	16 132	555	241 980
373	404	32.3	38	15 352	570	230 280
341	372	30.6	39	14 508	585	217 620
309	340	28.7	40	13 600	600	204 000
277	308	26.6	41	12 628	615	189 420
245	276	24.4	42	11 592	630	173 880
213	244	22.6	44	10 736	660	161 040
181	212	20.1	45	9 540	675	143 100
149	180	17.4	46	8 280	690	124 200
117	148	15.0	48	7 104	720	106 560
85	116	12.0	49	5 684	735	85 260
53	84	9.0	51	4 284	765	64 260
21	52	5.8	53	2 756	795	41 340
1	20	2.3	55	1 100	825	16 500

* Calculations are made using maximum size record in range.

Figure 61. Equal-Length Physical Records with Key Length 85 to 116 Bytes

Data Length Range		Percent Space	Maximum Track Capacity *		Maximum Cylinder Capacity *	
Min	Max	Used *	Records	Bytes	Records	Bytes
23 093	47 092	99.2	1	47 092	15	706 380
15 093	23 092	97.3	2	46 184	30	692 760
11 093	15 092	95.4	3	45 276	45	679 140
8 693	11 092	93.5	4	44 368	60	665 520
7 093	8 692	91.5	5	43 460	75	651 900
5 973	7 092	89.6	6	42 552	90	638 280
5 109	5 972	88.1	7	41 804	105	627 060
4 437	5 108	86.1	8	40 864	120	612 960
3 893	4 436	84.1	9	39 924	135	598 860
3 477	3 892	82.0	10	38 920	150	583 800
3 093	3 476	80.5	11	38 236	165	573 540
2 805	3 092	78.2	12	37 104	180	556 560
2 549	2 804	76.8	13	36 452	195	546 780
2 293	2 548	75.1	14	35 672	210	535 080
2 101	2 292	72.4	15	34 380	225	515 700
1 941	2 100	70.8	16	33 600	240	504 000
1 781	1 940	69.5	17	32 980	255	494 700
1 621	1 780	67.5	18	32 040	270	480 600
1 493	1 620	64.8	19	30 780	285	461 700
1 397	1 492	62.9	20	29 840	300	447 600
1 301	1 396	61.8	21	29 316	315	439 740
1 205	1 300	60.2	22	28 600	330	429 000
1 109	1 204	58.3	23	27 692	345	415 380
1 013	1 108	56.0	24	26 592	360	398 880
949	1 012	53.3	25	25 300	375	379 500
885	948	51.9	26	24 648	390	369 720
821	884	50.3	27	23 868	405	358 020
757	820	48.4	28	22 960	420	344 400
693	756	46.2	29	21 924	435	328 860
661	692	43.7	30	20 760	450	311 400
597	660	43.1	31	20 460	465	306 900
565	596	40.2	32	19 072	480	286 080
533	564	39.2	33	18 612	495	279 180
469	532	38.1	34	18 088	510	271 320
437	468	34.5	35	16 380	525	245 700
405	436	33.1	36	15 696	540	235 440
373	404	31.5	37	14 948	555	224 220
341	372	29.8	38	14 136	570	212 040
309	340	27.9	39	13 260	585	198 900
277	308	26.0	40	12 320	600	184 800
245	276	23.8	41	11 316	615	169 740
213	244	21.6	42	10 248	630	153 720
181	212	19.7	44	9 328	660	139 920
149	180	17.1	45	8 100	675	121 500
117	148	14.3	46	6 808	690	102 120
85	116	11.7	48	5 568	720	83 520
53	84	8.7	49	4 116	735	61 740
21	52	5.6	51	2 652	765	39 780
1	20	2.2	53	1 060	795	15 900

* Calculations are made using maximum size record in range.

Figure 62. Equal-Length Physical Records with Key Length 117 to 148 Bytes

Data Length Range		Percent Space Used *	Maximum Track Capacity *		Maximum Cylinder Capacity *	
Min	Max		Records	Bytes	Records	Bytes
23 061	47 060	99.1	1	47 060	15	705 900
15 061	23 060	97.1	2	46 120	30	691 800
11 061	15 060	95.2	3	45 180	45	677 700
8 661	11 060	93.2	4	44 240	60	663 600
7 061	8 660	91.2	5	43 300	75	649 500
5 941	7 060	89.2	6	42 360	90	635 400
5 077	5 940	87.6	7	41 580	105	623 700
4 405	5 076	85.5	8	40 608	120	609 120
3 861	4 404	83.5	9	39 636	135	594 540
3 445	3 860	81.3	10	38 600	150	579 000
3 061	3 444	79.8	11	37 884	165	568 260
2 773	3 060	77.3	12	36 720	180	550 800
2 517	2 772	75.9	13	36 036	195	540 540
2 261	2 516	74.2	14	35 224	210	528 360
2 069	2 260	71.4	15	33 900	225	508 500
1 909	2 068	69.7	16	33 088	240	496 320
1 749	1 908	68.3	17	32 436	255	486 540
1 589	1 748	66.3	18	31 464	270	471 960
1 461	1 588	63.6	19	30 172	285	452 580
1 365	1 460	61.5	20	29 200	300	438 000
1 269	1 364	60.3	21	28 644	315	429 660
1 173	1 268	58.8	22	27 896	330	418 440
1 077	1 172	56.8	23	26 956	345	404 340
981	1 076	54.4	24	25 824	360	387 360
917	980	51.6	25	24 500	375	367 500
853	916	50.2	26	23 816	390	357 240
789	852	48.5	27	23 004	405	345 060
725	788	46.5	28	22 064	420	330 960
661	724	44.2	29	20 996	435	314 940
629	660	41.7	30	19 800	450	297 000
565	628	41.0	31	19 468	465	292 020
533	564	38.0	32	18 048	480	270 720
501	532	37.0	33	17 556	495	263 340
437	500	35.8	34	17 000	510	255 000
405	436	32.1	35	15 260	525	228 900
373	404	30.6	36	14 544	540	218 160
341	372	29.0	37	13 764	555	206 460
309	340	27.2	38	12 920	570	193 800
277	308	25.3	39	12 012	585	180 180
245	276	23.3	40	11 040	600	165 600
213	244	21.1	41	10 004	615	150 060
181	212	18.8	42	8 904	630	133 560
149	180	16.7	44	7 920	660	118 800
117	148	14.0	45	6 660	675	99 900
85	116	11.2	46	5 336	690	80 040
53	84	8.5	48	4 032	720	60 480
21	52	5.4	49	2 548	735	38 220
1	20	2.6	51	1 020	765	15 300

* Calculations are made using maximum size record in range.

Figure 63. Equal-Length Physical Records with Key Length 149 to 180 Bytes

Data Length Range		Percent Space	Maximum Track Capacity *		Maximum Cylinder Capacity *	
Min	Max	Used *	Records	Bytes	Records	Bytes
23 029	47 028	99.1	1	47 028	15	705 420
15 029	23 028	97.0	2	46 056	30	690 840
11 029	15 028	95.0	3	45 084	45	676 260
8 629	11 028	92.9	4	44 112	60	661 680
7 029	8 628	90.9	5	43 140	75	647 100
5 909	7 028	88.8	6	42 168	90	632 520
5 045	5 908	87.1	7	41 356	105	620 340
4 373	5 044	85.0	8	40 352	120	605 280
3 829	4 372	82.9	9	39 348	135	590 220
3 413	3 828	80.6	10	38 280	150	574 200
3 029	3 412	79.1	11	37 532	165	562 980
2 741	3 028	76.5	12	36 336	180	545 040
2 485	2 740	75.0	13	35 620	195	534 300
2 229	2 484	73.3	14	34 776	210	521 640
2 037	2 228	70.4	15	33 420	225	501 300
1 877	2 036	68.6	16	32 576	240	488 640
1 717	1 876	76.2	17	31 892	255	478 380
1 557	1 716	65.1	18	30 888	270	463 320
1 429	1 556	62.3	19	29 564	285	443 460
1 333	1 428	60.2	20	28 560	300	428 400
1 237	1 332	58.9	21	27 972	315	419 580
1 141	1 236	57.3	22	27 192	330	407 880
1 045	1 140	55.2	23	26 220	345	393 300
949	1 044	52.8	24	25 056	360	375 840
885	948	49.2	25	23 700	375	355 500
821	884	48.4	26	22 984	390	344 760
757	820	46.6	27	22 140	405	332 100
693	756	44.6	28	21 168	420	317 520
629	692	42.3	29	20 068	435	301 020
597	628	39.7	30	18 840	450	282 600
533	596	38.9	31	18 476	465	277 140
501	532	35.9	32	17 024	480	255 360
469	500	34.8	33	16 500	495	247 500
405	468	33.5	34	15 912	510	238 680
373	404	29.8	35	14 140	525	212 100
341	372	28.2	36	13 392	540	200 880
309	340	26.5	37	12 580	555	188 700
277	308	24.7	38	11 704	570	175 560
245	276	22.7	39	10 764	585	161 460
213	244	20.6	40	9 760	600	146 400
181	212	18.3	41	8 692	615	130 380
149	180	15.9	42	7 560	630	113 400
117	148	13.7	44	6 512	660	97 680
85	116	11.0	45	5 220	675	78 300
53	84	8.1	46	3 846	690	57 960
21	52	5.3	48	2 496	720	37 440
1	20	2.1	49	980	735	14 700

* Calculations are made using maximum size record in range.

Figure 64. Equal-Length Physical Records with Key Length 181 to 212 Bytes

Data Length Range		Percent Space	Maximum Track Capacity *		Maximum Cylinder Capacity *	
Min	Max	Used *	Records	Bytes	Records	Bytes
22 997	46 996	99.0	1	46 996	15	704 940
14 997	22 996	96.9	2	45 992	30	689 880
10 997	14 996	94.8	3	44 988	45	674 820
8 597	10 996	92.6	4	43 984	60	659 760
6 997	8 596	90.5	5	42 980	75	644 700
5 877	6 996	88.4	6	41 976	90	629 640
5 013	5 876	86.6	7	41 132	105	616 980
4 341	5 012	84.5	8	40 096	120	601 440
3 797	4 340	82.3	9	39 060	135	585 900
3 381	3 796	80.0	10	37 960	150	569 400
2 997	3 380	78.3	11	37 180	165	557 700
2 709	2 996	75.7	12	35 952	180	539 280
2 453	2 708	74.2	13	35 204	195	528 060
2 197	2 452	72.3	14	34 328	210	514 920
2 005	2 196	69.4	15	32 940	225	494 100
1 845	2 004	67.5	16	32 064	240	480 960
1 685	1 844	66.0	17	31 348	255	470 220
1 525	1 684	63.9	18	30 312	270	454 680
1 397	1 524	61.0	19	28 956	285	434 340
1 301	1 396	58.8	20	27 920	300	418 800
1 205	1 300	57.5	21	27 300	315	409 500
1 109	1 204	55.8	22	26 488	330	397 320
1 013	1 108	53.7	23	25 484	345	382 260
917	1 012	51.2	24	24 288	360	364 320
853	916	48.2	25	22 900	375	343 500
789	852	46.7	26	22 152	390	332 280
725	788	44.8	27	21 276	405	319 140
661	724	42.7	28	20 272	420	304 080
597	660	40.3	29	19 140	435	287 100
565	596	37.7	30	17 880	450	268 200
501	564	36.8	31	17 484	465	262 260
469	500	33.7	32	16 000	480	240 000
437	468	32.5	33	15 444	495	231 660
373	436	31.2	34	14 824	510	222 360
341	372	27.4	35	13 020	525	195 300
309	340	25.8	36	12 240	540	183 600
277	308	24.0	37	11 396	555	170 940
245	276	22.1	38	10 488	570	157 320
213	244	20.0	39	9 516	585	142 740
181	212	17.9	40	8 480	600	127 200
149	180	15.5	41	7 380	615	110 700
117	148	13.1	42	6 216	630	93 240
85	116	10.8	44	5 104	660	76 560
53	84	8.0	45	3 780	675	56 700
21	52	5.0	46	2 392	690	35 880
1	20	2.0	48	960	720	14 400

* Calculations are made using maximum size record in range.

Figure 65. Equal-Length Physical Records with Key Length 213 to 244 Bytes

Data Length Range		Percent Space	Maximum Track Capacity *		Maximum Cylinder Capacity *	
Min	Max	Used *	Records	Bytes	Records	Bytes
22 965	46 964	98.9	1	46 964	15	704 460
14 965	22 964	96.7	2	45 928	30	688 920
10 965	14 964	94.6	3	44 892	45	673 380
8 565	10 964	92.4	4	43 856	60	657 840
6 965	8 564	90.2	5	42 820	75	642 300
5 845	6 964	88.0	6	41 784	90	626 760
4 981	5 844	86.2	7	40 908	105	613 620
4 309	4 980	83.9	8	39 840	120	597 600
3 765	4 308	81.7	9	38 772	135	581 580
3 349	3 764	79.3	10	37 640	150	564 600
2 965	3 348	77.6	11	36 828	165	552 420
2 677	2 964	74.9	12	35 568	180	533 520
2 421	2 676	73.3	13	34 788	195	521 820
2 165	2 420	71.4	14	33 880	210	508 200
1 973	2 164	68.4	15	32 460	225	486 900
1 813	1 972	66.5	16	31 552	240	473 280
1 653	1 812	64.9	17	30 804	255	462 060
1 493	1 652	62.6	18	29 736	270	446 040
1 365	1 492	59.7	19	28 348	285	425 220
1 269	1 364	57.5	20	27 280	300	409 200
1 173	1 268	56.1	21	26 628	315	399 420
1 077	1 172	54.3	22	25 784	330	386 760
981	1 076	52.1	23	24 748	345	371 220
885	980	49.5	24	23 520	360	352 800
821	884	46.6	25	22 100	375	331 500
757	820	44.9	26	21 320	390	319 800
693	756	43.0	27	20 412	405	306 180
629	692	40.8	28	19 376	420	290 640
565	628	38.4	29	18 212	435	273 180
533	564	35.6	30	16 920	450	253 800
469	532	34.7	31	16 492	465	247 380
437	468	31.5	32	14 976	480	224 640
405	436	30.3	33	14 388	495	215 820
341	404	28.9	34	13 736	510	206 040
309	340	25.1	35	11 900	525	178 500
277	308	23.4	36	11 088	540	166 320
245	276	21.5	37	10 212	555	153 180
213	244	19.5	38	9 272	570	139 080
181	212	17.4	39	8 268	585	124 020
149	180	15.2	40	7 200	600	108 000
117	148	12.8	41	6 068	615	91 020
85	116	10.3	42	4 872	630	73 080
53	84	7.8	44	3 696	660	55 440
21	52	4.9	45	2 340	675	35 100
1	20	1.9	46	920	690	13 800

* Calculations are made using maximum size record in range.

Figure 66. Equal-Length Physical Records with Key Length 245 to 255 Bytes

Appendix C. 3380 Support in Transaction Processing Facility

The Transaction Processing Facility (TPF), is a specialized, standalone operating system. TPF runs in real time and is designed for transaction-driven applications that require high performance and high availability. See *Transaction Processing Facility General Information Manual* for further information.

TPF supports 3380 direct access storage devices as described below for uni-processor and shared DASD environments. Note that TPF does not support the following storage controls:

- 3880 Model 3 with Speed Matching Buffer feature
- 3880 Models 11, 13, 21, or Model 23 without RPQ 8B0035
- 3990 Model 3

Contact your IBM marketing representative for further information on your specific environment.

Single, Uni-Processor Environments

TPF supports all 3380 models that attach to 3880 Model 3 or 3990 Model 1 or 2 Storage Controls. In uni-processor mode, the RPQs that are required for operation in loosely-coupled shared DASD environments can be used optionally.

Loosely-Coupled, Shared DASD Environments

The supported hardware configurations require the following RPQs:

3380 Model A04 or AA4 Attached to a 3880 Model 3 Storage Control

- The 3880 Model 3 requires:
  - RPQ 8S0026 Limited Lock Facility, or
  - RPQ MM2741 Airline Buffer and Limited Lock Facility
- The 3380 Model AA4 requires:
  - RPQ MR0352 Static Switch, Field Installed

3380 AD4 or AE4 Models Attached to a 3880 Model 3

- The 3880 Model 3 requires:
  - RPQ 8B0050 Limited Lock Facility

3380 A04, AA4, or AD4 Models Attached to a 3880 Model 23

- The 3880 Model 23 requires:
  - RPQ 8B0035 Record Cache and Limited Lock Facility
- The 3380 Model AA4 requires:
  - RPQ MR0352 Static Switch, Field Installed
- The 3380 Model AD4 requires:
  - RPQ 8S0140 Static Switch, Factory Installed
  - RPQ 8S0141 Static Switch, Field Installed

Acronyms and Abbreviations

This list contains definitions for acronyms and abbreviations used in this book. Some terms are more specifically defined in the glossary.

CCW Channel command word

CKD Count-key-data

CTL-I Control interface

DASD Direct access storage device

DL Data length

DLS Device level selection

DLSE Device level selection enhanced

DPS Dynamic path selection

EOF End-of-file

EREP Environmental Record Editing and Printing program

GB Gigabyte

HA Home address

HDA Head-disk assembly

ID Identifier

IOCP I/O configuration program

I/O Input/output

IPL Initial program load

KL key length

KVA kilovolt ampere

MB Megabyte

MPSD Multipath storage director

OS Operating system

PAM Partitioned access method

R0 Record zero

RPS Rotational position sensing

SF Support facility

SML MVS Storage Management Library

SSID Subsystem identifier

TPF Transaction Processing Facility

VTOC Volume table of contents

Glossary

This glossary contains disk storage subsystem terms used in this book. If you do not find the term you are looking for, refer to the index or to the *Dictionary of Computing*, SC20-1699.

A

A-unit. The direct access storage unit that contains the controller functions to attach to the storage control. An A-unit controls the B-units that are attached to it and is often referred to as a head of string.

actuator. A set of access arms and their attached read/write heads, which move as an independent component within a head-disk assembly (HDA). See also device and volume.

alternate track. On a direct access storage device, a track designated to contain data in place of a defective primary track.

B

B-unit. A direct access storage unit that attaches to the subsystem through an A-unit.

C

C-unit. A direct channel attach 3380 direct access storage unit that contains both the storage control functions and the DASD controller functions. A 3380 C-unit (3380 Model CJ2) functions as a head of string and controls the B-units that are attached to it.

cache. A random access electronic storage in selected storage controls used to retain frequently used data for faster access by the channel. For example, 3990 Model 3 contains cache.

cache fast write. A form of fast write where the data is written directly to cache without using nonvolatile storage and is available for later destaging. This 3990 Model 3 Storage Control function should be used for data of a temporary nature, or data which is readily recreated, such as the sort work files created by the appropriate release of DFSORT.

cluster. See storage cluster.

control interface (CTL-I). The hardware connection between the storage control function and the DASD controller function.

control unit. A hardware unit that controls the reading, writing, or displaying of data at one or more input/output devices. See also storage control.

controller. The hardware component of a DASD head of string unit that provides the path control and data transfer functions. For example, 3390 A-units have four controllers, and there are two controllers in a 3380 Model AE4, AK4, or CJ2.

controller ID. An 8-bit identifier that uniquely identifies the physical string regardless of the selection address. It identifies to the service representative, by means of EREP, a failing subsystem component (controller or device) without having to translate a selection address (which may have little relation to a physical address) to a physical component. The controller ID is the number shown on the operator panel. Controller ID applies to the 3380 Models AA4, AD4, and AE4. See also string ID.

count-key-data (CKD). A DASD data recording format employing self-defining record formats in which each record is represented by a count area that identifies the record and specifies its format, an optional key area that may be used to identify the data area contents, and a data area that contains the user data for the record. CKD is also used to refer to a set of channel commands that are accepted by a device that employs the CKD recording format. See extended count-key-data.

D

DASD. Direct access storage device.

DASD fast write. A form of fast write to cache where the data is written concurrently to cache and nonvolatile storage and automatically scheduled for destaging to the DASD. Both copies are retained in the storage control until the data is completely written to the DASD, providing data integrity equivalent to writing directly to the DASD. DASD fast write is available with a 3990 Model 3 Storage Control.

DASD subsystem. A storage control and its attached direct access storage devices.

destage. The asynchronous write of new or updated data from cache or nonvolatile storage to DASD. This is used only for the fast write and dual copy functions of the 3990 Model 3. See also fast write and write hit.

device. A uniquely addressable part of a DASD unit that consists of a set of access arms, the associated disk surfaces, and the electronic circuitry required to locate, read, and write data. See also volume.

device address. Three or four hexadecimal digits that uniquely define a physical I/O device on a channel path in System/370 mode. The one or two leftmost digits are the address of the channel to which the device is attached. The two rightmost digits represent the unit address.

device ID. An 8-bit identifier that uniquely identifies a physical I/O device.

device level selection (DLS). A DASD function available with 3380 Models AD4, BD4, AE4, BE4, AJ4, BJ4, AK4, BK4, and CJ2. With DLS, each of the two controllers in the DASD string has a path to all devices in the string, and any two devices in the 2-path DASD string can read or write data simultaneously. See DLS mode.

device level selection enhanced (DLSE). A DASD function providing four data transfer paths to each device in a 4-path DASD string. With DLSE, any four devices in a 4-path DASD string can read or write data simultaneously. See DLSE mode.

device number. Four hexadecimal digits that logically identify an I/O device in a System/370 Extended Architecture or Enterprise Systems Architecture/370* Systems.*

device release. A command that terminates the reservation of the device from the channel issuing the command or from all channels on the interface path group.

device reserve. A command that reserves the device for the channel issuing the command, or for all channels in the same interface path group.

Device Support Facilities program (ICKDSF). A program used to initialize DASD at installation and provide media maintenance.

director. See storage director.

DLS mode. A mode of operation in a 3990 Storage Control that supports 3380 2-path strings. DLS mode must be specified by the IBM service representative at installation for the 3990. See single-path storage director.

DLSE mode. A mode of operation in a 3990 Model 2 or 3 Storage Control that supports 3380 AJ4 and AK4 4-path strings and 3390 strings. DLSE mode must be specified by the IBM service representative at installation time for the 3990. See multipath storage director.

dual copy. A high availability function made possible by nonvolatile storage in a 3990 Model 3. Dual copy maintains two functionally identical copies of designated DASD volumes in the logical 3990 Model 3 subsystem, and automatically updates both copies every time a write operation is issued to the dual copy logical volume.

dual-frame configuration. Consists of two like storage controls physically interconnected. Pairs of 3880 Model 13 or Model 23 and 3990 Model 2 or Model 3 Storage Controls can be dual-framed. In a dual-frame configuration, each storage director in a logical DASD subsystem is in a different storage control. When a 3990 Storage Control is in DLS mode, each DASD string has one path to a single-path storage director in each of the 3990 Storage Controls. When a 3990 Storage Control is in DLSE mode, each DASD string has two paths to a multipath storage director in each of the 3990 Storage Controls.

dynamic path reconnect. A function that allows disconnected DASD operations to reconnect over any available channel path rather than being limited to the one on which the I/O operation was started. It is available only on System/370 Extended Architecture and Enterprise Systems Architecture/370 Systems. For example, when a host has four channels connected to 3990 Storage Control (in DLSE mode) with a 4-path DASD string, any device can reconnect on any one of four channel paths, providing improved performance and availability.

dynamic path selection (DPS). DASD subsystem functions available with all 3380 heads of string except Model A04. These functions include:

- Two controllers providing data paths from the 3380 strings to the storage directors
- Simultaneous transfer of data over two paths to two devices, providing the two devices are on separate internal paths within the string
- Sharing DASD volumes by using System-Related Reserve and Release
- Providing dynamic path reconnect to the first available path.

E

Environmental Record Editing and Printing (EREP) program. The program that formats and prepares reports from the data contained in the Error Recording Data Set (ERDS).

extended count-key-data. A set of channel commands that use the CKD track format. Extended count-key-data uses the Define Extent and Locate

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* ENTERPRISE SYSTEMS ARCHITECTURE/370 is a trademark of the International Business Machines Corporation.

Record commands to describe the nature and scope of a data transfer operation to the storage control to optimize the data transfer operation. The 3990 Storage Control supports the extended count-key-data commands.

F

fast write. In a 3990 Model 3 Storage Control, a write operation at cache speed that does not require immediate transfer of data to a DASD. The data is written directly to cache and/or nonvolatile storage and is available for later destaging. Fast write reduces the time an application must wait for the I/O operation to complete. See also DASD fast write, cache fast write, and destage.

G

gigabyte (GB). 10^9 bytes.

H

head-disk assembly (HDA). A field replaceable unit in a direct access storage device containing the disks and actuators.

head of string. The unit in a DASD string that contains controller functions. Also called the A-unit.

home address (HA). The first field on a CKD track that identifies the track and defines its operational status. The home address is written after the index point on each track.

I

ICKDSF. See Device Support Facilities program.

identifier (ID). A sequence of bits or characters that identifies a program, device, controller or system.

index point. The reference point on a disk surface that determines the start of a track.

L

logical DASD subsystem. Two storage directors attached to the same DASD strings together with those DASD strings.

M

media. The disk surface on which data is stored.

megabyte (MB). 10^6 bytes.

multipath storage director. A storage director in a 3990 Storage Control operating in DLSE mode. Each multipath storage director in a storage control is associated with two storage paths. All storage paths in a multipath storage director respond to the same range of control unit addresses on a channel.

N

nonsynchronous operation. A type of operation in which the channel and storage control activities required to end one command and initiate the next do **not** necessarily occur within the inter-record gap between two adjacent fields. With nonsynchronous operations, the channel can be slower than the device on reads, and faster than the device on writes. The time difference in processing a channel program will be as a result of the current operating environment rather than on a property of the device or storage control. Contrast with synchronous operation.

nonvolatile storage (NVS). Additional random access electronic storage with a backup battery power source, available with a 3990 Model 3 Storage Control, used to retain data during a power failure. Nonvolatile storage, accessible from all storage directors, stores data during DASD fast write and dual copy operations.

P

physical ID. A unique designation to identify specific components in a data processing complex.

Q

quiesce. A function on a 3990 Model 2 or 3 Storage Control in DLSE mode, configured with only 4-path strings. This function makes one component of a storage subsystem temporarily unavailable to the processor while assuring that the remaining components are available for data transfer. For example, components of a storage subsystem are storage path, controller, and DASD string. This function is initiated by a service representative. Contrast with resume.

R

release. A facility that allows other host systems to communicate with the reserved device. Contrast with reserve.

reserve. A facility for devices attached to multiple channel paths. It allows only one host system to communicate with the specified device. Contrast with release.

resume. A function on a 3990 Model 2 or 3 Storage Control in DLSE mode, configured with only 4-path strings. This function enables a component that has been quiesced. This function is initiated by a service representative. Contrast with quiesce.

rotational position sensing (RPS). A function that permits a DASD to reconnect to a block multiplexer channel when a specified sector has been reached. This allows the channel to service other devices on the channel during positional delay.

S

single-path storage director. A storage director in a 3990 or 3380 Model CJ2 operating in DLS mode. Each single-path storage director in the storage cluster is associated with one storage path. A storage path on a single-path storage director responds to a unique control unit address on the channel. A single-path storage director in a 3990 is like a storage director in a 3880.

storage cluster. In the 3990 Storage Control and 3380 Model CJ2, a power and service region containing two independent transfer paths. See also storage director, single-path storage director, and multipath storage director.

storage control. The component in a DASD subsystem that connects the DASD to the host channels. It performs channel commands and controls the DASD devices. For example, the 3990 Model 2 and Model 3 are storage controls.

storage director. In a 3990 storage control, a logical entity consisting of one or more physical storage paths in the same storage cluster. In a 3880, a storage director is equivalent to a storage path. See also storage path, single-path storage director, and multipath storage director.

storage director ID. For 3880 Storage Control configurations, an 8-bit designation that uniquely identifies the storage director regardless of its selection address. It identifies to the service representative, by means of EREP, a failing subsystem component (storage director) without having to translate a selection address (which may have little relation to a physical address) to a physical component. The storage director ID is the number shown on the operator panels of 3880s and the attached DASD units. For 3990s, see subsystem identifier (SSID).

storage path. The hardware within the 3990 Storage Control that transfers data between the DASD and a channel. See also storage director.

storage subsystem. A storage control and its attached storage devices.

string. A series of connected DASD units sharing the same A-unit (or head of string).

string address. The 1-bit address used by the storage control to direct commands to the correct 3380 AJ4/AK4 or 3390 DASD string on the CTL-I. See also controller address.

string ID. An 8-bit identifier that uniquely identifies the physical string regardless of the selection address. It identifies to the service representative, by means of EREP, a failing subsystem component (controller or device) without having to translate a selection address (which may have little relation to a physical address) to a physical component. The string ID is the number shown on the operator panel of the DASD A-unit. See also controller ID.

substring. In a 4-path AJ4/AK4 DASD configuration, one of the two A-units and the physically adjacent B-units (as many as three B-units).

subsystem identifier (SSID). In a 3990 Storage Control configuration, a number that identifies the physical components of a logical DASD subsystem. This number is set by the service representative at the time of installation, and is included in the vital product data in the support facility. This number is identified on the DASD A-units and 3990 operator panels.

subsystem. See DASD subsystem or storage subsystem.

support facility (SF). A component of each 3990 and 3380 Model CJ2 storage cluster that provides initial microcode load, error logging, maintenance panel, MAPs, and microdiagnostic functions for that cluster.

synchronous operation. A type of operation in which all channel and storage control activities required to end one command and initiate the next must occur within the inter-record gap between two adjacent fields. Contrast with nonsynchronous operation.

U

unit address. The last two hexadecimal digits of a DAS device address. This identifies the storage control and DAS string, controller, and device to the channel subsystem. Often used interchangeably with control unit address and device address in System/370 mode.

V

vital product data (VPD). Nonvolatile data that includes configuration data, machine serial number, EC level, and machine features. It is maintained by the 3990 support facility. It is stored in the 3990 support facility and 3390.

volume. The DASD space accessible by a single actuator.

W

write hit. When data requested by the write operation is in the cache.

Numerics

2-path string. A series of physically connected DASD units in which the head of string unit provides two data transfer paths that can operate simultaneously.

4-path string. A series of physically connected DASD units in which the head of string provides four data transfer paths that can operate simultaneously. A 3390 4-path string requires one A-unit, while two 3380 Model AJ4/AK4 units are required for a 3380 4-path string.

Bibliography

The books listed in the table below contain more detailed information on the subjects discussed in this book. For each book referenced, the table shows the short and expanded title with the book's order number, and a short description of relevant contents. Books are listed alphabetically by short title, within the major publication categories (Hardware and Software).

For information on how to order these books, contact your local IBM branch office.

Short Title	Full Title	Order Number	Contents
Physical Planning and Installation Information			
IOCP User's Guide and Reference	*Input/Output Configuration Program User's Guide and Reference*	GC28-1027	Describes definition of I/O configuration data (MVS, VM, and standalone versions of IOCP), with information on device numbers
IBM 9370 Information System Installation Manual - Physical Planning	*IBM 9370 Information System Installation Manual - Physical Planning*	GA24-4031	Description of physical planning for I/O hardware attached to 9370 processors
IBM System/360, System 370, 4300, and 9370 Processors Input/Output Equipment Installation Manual – Physical Planning	*IBM System/360, System 370, 4300, and 9370 Processors Input/Output Equipment Installation Manual – Physical Planning*	GC22-7064	Description of physical planning for I/O hardware
Storage Subsystem Library	**Shared Publications**		
Maintaining IBM Storage Subsystem Media	*Maintaining IBM Storage Subsystem Media*	GC26-4495	Description of DASD media maintenance and error handling
Storage Subsystem Library Master Bibliography, Index, and Glossary	*Storage Subsystem Library Master Bibliography, Index, and Glossary*	GC26-4496	Index to information in 3380, 3390, and 3990 books
Related Direct Access Storage Publications			
Introduction to IBM Direct Access Storage Devices	*Introduction to IBM Direct Access Storage Devices*	SR21-3208	Textbook describing large IBM early DASD and data storage theory and methods
3380 DASD Features, Installation and Conversion	*3380 DASD Features, Installation and Conversion*	GG22-9308	Describes standard 3380 hardware features, how to prepare for installation of 3380 and migration of data
Storage Subsystem Library	**3380 DASD Manuals**		
IBM 3380 Direct Access Storage Reference Summary	*IBM 3380 Direct Access Storage Reference Summary*	GX26-1678	Summary of 3380 device characteristics
Using the IBM 3380 Direct Access Storage in an MVS Environment	*Using the IBM 3380 Direct Access Storage in an MVS Environment*	GC26-4492	Discussion of 3380 use under MVS/XA and MVS/370
Using the IBM 3380 Direct Access Storage in a VM Environment	*Using the IBM 3380 Direct Access Storage in a VM Environment*	GC26-4493	Discussion of 3380 use under VM
Using the IBM 3380 Direct Access Storage in a VSE Environment	*Using the IBM 3380 Direct Access Storage in a VSE Environment*	GC26-4494	Discussion of 3380 use under VSE
Storage Subsystem Library	**3390 DASD Manuals**		
IBM 3390 Direct Access Storage Introduction	*IBM 3390 Direct Access Storage Introduction*	GC26-4573	Overview of all 3390 models
Using IBM 3390 Direct Access Storage in an MVS Environment	*Using IBM 3390 Direct Access Storage in an MVS Environment*	GC26-4574	Discussion of 3390 use under MVS
Using IBM 3390 Direct Access Storage in a VM Environment	*Using IBM 3390 Direct Access Storage in a VM Environment*	GC26-4575	Discussion of 3390 use under VM

Short Title	Full Title	Order Number	Contents
Using IBM 3390 Direct Access Storage in a VSE Environment	*Using IBM 3390 Direct Access Storage in a VSE Environment*	GC26-4576	Discussion of 3390 use under VSE
IBM 3390 Direct Access Storage Reference Summary	*IBM 3390 Direct Access Storage Reference Summary*	GX26-4577	Summary booklet containing 3390 device characteristics
Storage Subsystem Library	**3990 Storage Control Publications**		
IBM 3990 Storage Control Introduction	*IBM 3990 Storage Control Introduction*	GA32-0098	Overview of 3990 storage control functions
IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide	*IBM 3990 Storage Control Planning, Installation, and Storage Administration Guide*	GA32-0100	Detailed information on installation and use of the 3990 storage control
IBM 3990 Storage Control Reference	*IBM 3990 Storage Control Reference*	GA32-0099	Reference information on 3990 functions
Cache Device Administration	*Cache Device Administration*	GC35-0101	Describes the AMS cache utility commands necessary to manage cache and to obtain information about cache status and performance
IBM 3990 Operations Study Guide	*IBM 3990 Operations Study Guide*	GA32-0131	Describes how to operate the 3990
IBM 3990 Operations and Recovery Reference	*IBM 3990 Operations and Recovery Reference*	GA32-0133	User's study guide for operators of 3990 Storage Controls
Introduction to Nonsynchronous Direct Access Storage Subsystems	*Introduction to Nonsynchronous Direct Access Storage Subsystems*	GC26-4519	Describes nonsynchronous operation and provides descriptions of the ECKD commands set and ECKD channel programs
IBM 3990 Transaction Processing Facility Support RPQs	*IBM 3990 Transaction Processing Facility Support RPQs*	GA32-0134	Describes the 3990 RPQs available for support of TPF
3880 Storage Control Information			
Early Experiences with 3880-21	*Early Experiences with 3880-21*	GG66-0200	Describes initial experiences with cache
IBM 3880 Storage Control Model 13 Description	*IBM 3880 Storage Control Model 13 Description*	GA32-0067	Reference book for 3880 Model 13 functions
IBM 3880 Storage Control Model 23 Description	*IBM 3880 Storage Control Model 23 Description*	GA32-0083	Reference book for 3880 Model 23 functions
IBM 3880 Storage Control Model 23 Installation and Administration Guide	*IBM 3880 Storage Control Model 23 Installation and Administration Guide*	GA32-0085	Describes how to install and use the 3880 Model 23 effectively
IBM 3880 Storage Control Model 23 Introduction	*IBM 3880 Storage Control Model 23 Introduction*	GA32-0082	Overview of 3880 Model 23 functions
IBM 3880 Storage Control Models 1, 2, 3, and 4 Description Manual	*IBM 3880 Storage Control Models 1, 2, 3, and 4 Description Manual*	GA26-1661	Overview of 3880 Models 1, 2, 3, and 4 functions
IBM 3880 Storage Control Model 23 with RPQ #8B0035 Description	*IBM 3880 Storage Control Model 23 with RPQ #8B0035 Description*	GA32-0087	Reference book for 3880 Model 23 functions with RPQ #8B0035
Introduction to IBM 3880 Storage Control Model 23 with RPQ #8B0035	*Introduction to IBM 3880 Storage Control Model 23 with RPQ #8B0035*	GA32-0086	Overview of 3880 Model 23 functions with RPQ #8B0035
Enterprise Systems Connection			
Introducing Enterprise Systems Connection	*Introducing Enterprise Systems Connection*	GA23-0383	Describes ES Connection
Software			
EREP User Guide and Reference	*Environmental Recording, Editing, and Printing (EREP) User Guide and Reference*	GC28-1378	Description of EREP functions and commands for DASD media reporting

Short Title	Full Title	Order Number	Contents
ICKDSF Primer for the User of IBM 3380 and 3390 Direct Access Storage	*Device Support Facilities: Primer for the User of IBM 3380 and 3390 Direct Access Storage*	GC26-4498	Description of specific ICKDSF usage considerations for the 3380 family of DASD, with guidelines on using ICKDSF commands
ICKDSF User's Guide and Reference	*Device Support Facilities User's Guide and Reference*	GC35-0033	Description of ICKDSF functions and commands for DASD initialization and maintenance
TPF General Information Manual	*Transaction Processing Facility Version 2 (TPF2) General Information Manual*	GH20-6200	Provides on overview of TPF with a description of supported hardware
TPF General Information Manual	*Transaction Processing Facility Version 3 (TPF3) General Information Manual*	GH20-7521	Provides an overview of TPF3 with a description of supported hardware
Storage Management Library	**Version 3 Release 1**		
MVS SML: Configuring Storage Subsystems	*MVS Storage Management Library: Configuring Storage Subsystems*	SC26-4409	Describes evaluating hardware configurations, developing capacity plans, and performance, availability and space utilization considerations
MVS SML: Managing Data Sets	*MVS Storage Management Library: Managing Data Sets*	SC26-4408	Describes managing data sets, catalogs and control data sets, establishing and enforcing data set policy, and data set security
MVS SML: Managing Storage Pools	*MVS Storage Management Library: Managing Storage Pools*	SC26-4407	Describes storage requirements for groups of data sets, designing storage pools, making transition to pooled storage, and maintaining and monitoring storage pools
Storage Management Library	**Version 3 Release 2**		
MVS/ESA SML Managing Data Sets and Objects	*MVS/ESA Storage Management Library Managing Data Sets and Objects*	SC26-4657	Describes managing data sets, catalogs and control data sets, and objects, establishing and enforcing data set policy, and data set security
MVS/ESA SML Managing Storage Pools	*MVS/ESA Storage Management Library Managing Storage Pools*	SC26-4656	Describes storage requirements for groups of data sets, designing storage pools, making transition to pooled storage, and maintaining and monitoring storage pools

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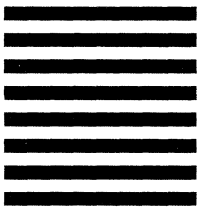

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