Chapter 16

Tape and Other Mass-Storage Drives

The data backup needs on a personal computer can be overwhelming. People with large hard drives with numerous application programs installed, and those who generate a large amount of data, may find it necessary to back up their computers on a weekly or even a daily basis.

In addition, a critical need on today's PCs is data storage space. Sometimes it seems the storage requirements of a PC can never be satisfied. On nearly any PC used for business, study, or even for fun, the amount of software you need to install and the amount of data you need to store can overwhelm what just a short time before was considered a power user's jumbo hard drive.

This chapter focuses on tape backup drives and removable media disk drives, which increasingly are used to solve the problems of the growing need for data storage space and the need for a fast and efficient way to back up many megabytes of data.

Tape Backup Drives

Any computer book worth reading warns repeatedly that you should back up your system regularly. Backups are necessary because at any time a major problem, or even some minor ones, can corrupt the important information and the programs stored on your computer's hard drive, rendering this information useless. A wide range of problems can damage the data on your hard drive. Here is a list of some of these data-damaging problems:

1. Sudden fluctuations in the electricity that powers your computer (power spikes) resulting in data damage or corruption.
2. Overwriting a file by mistake.
3. Mistakenly formatting your hard disk when you meant to format a floppy.

4. Hard drive failure resulting in loss of data that has not been backed up. Not only do you have to install a new drive but, because you have no backup, you also must reinstall your software programs, disk by disk.
5. Catastrophic damage to your computer (storm, flood, lightning strike, fire, theft). A single lightning strike near your office or home can destroy the circuitry of your computer, including your hard drive. Theft of your computer, of course, is equally devastating. A recent, complete, backup greatly simplifies the process of setting up a replacement computer.

Backups are also the cure for such common headaches as a full hard drive and the need to transfer data between computers. By backing up data you rarely use, then deleting the original data from your hard drive, you free up the space once occupied by that data. If you later need a particular data file, you can retrieve that file from your backup. Sharing large amounts of data between computers—as when you send data from one city to another, for example—is more easily accomplished by backing up the data to a tape and sending the tape.

Regardless of how important regular backups are, many people avoid making them. A major reason for this lapse is that for many people, backing up their system is tedious work when they have to use their floppy disk drive. When you use your floppy drive, you may have to insert and remove as many as 150 high-density disks to back up 150M of programs and data, depending on whether your backup software includes *data compression*, the capability to specially encode backed up data in less space than it takes to store the same data on your hard drive.

Tape backup drives are the most simple and efficient device for backing up your system. With a tape backup drive installed in your system, you simply insert a tape into the drive, start your backup software, and select the drive and files you want to back up. The backup software copies your selected files onto the tape while you attend to other business. Later, when you need to retrieve some or all of the files on the backup tape, you insert the tape in the drive, start your backup program, and select the files you want to restore. The tape backup drive takes care of the rest of the job.

This section examines the various types of tape backup drives on the market, describing the capacities of different drives as well as the system requirements for installation and use of a tape drive. The following topics are covered in this section:

- Common standards for tape backup drives, including QIC-40 and QIC-80 drives
- Common backup tape capacities
- Newer higher-capacity tape drives
- Common tape drive interfaces
- The QIC standards for tape backup drives
- Portable tape drives
- Tape backup software

The Origins of Tape Backup Standards

The evolution of tape backup standards is similar to that of standards for many computer components. Using tape to back up computer data became a common practice long before accepted tape backup standards existed. At first, reel-to-reel systems (somewhat similar to old reel-to-reel audio tape recorders) were used to store data. The most commonly used tape—quarter-inch—eventually developed into a de facto standard. But each tape system manufacturer used its own data-encoding specifications for backup tapes. Variations included not only the number of tracks and data density on the tape, but also the interface used to connect the drive to the computer.

In 1972, more than a decade before the introduction of the first IBM PC the 3M company introduced the first quarter-inch tape cartridge designed for data storage. The cartridge measured 6 by 4 by 5/8 inches. Inside this cartridge, the tape was threaded onto two reels. The tape was moved from one reel to another during the recording or read-back process by a drive belt. Because of the reliability of this tape cartridge, the demand for tape backup systems began to grow, despite the lack of established standards for storing data on these cartridges.

The result of this lack of standardization was that quarter-inch tapes written on one manufacturer's tape backup drive generally could not be read on another manufacturer's quarter-inch tape drive. One problem created by this situation was that the way particular manufacturers encoded data on a tape continued to change. If a particular model of tape drive became disabled and the manufacturer had discontinued that particular drive and no longer used its encoding format, the data stored on tapes written on the disabled drive could be unavailable until the drive had been sent for repairs. In the event the manufacturer could not repair the drive, the data was lost forever.

As with other computer components, such as hard drive interface cards, consumers were the force behind standardization. Consumers clamored for standardized tape drives that could read tapes created on different tape drives manufactured by different companies.

The QIC Standards

In response to this demand for standardization, the tape drive industry formed the Quarter-Inch Cartridge Drive Standards Inc., sometimes simply referred to as the Quarter-Inch Committee (QIC). In 1983–84, the first tape drive based on a QIC standard was shipped: the QIC-02, which stored 60M of data encoded in 9 data tracks on roughly 300 feet of tape.

As the technology improved, and because the 4-by-6-by-5/8-inch size of the first tape cartridges was difficult to adapt to the 5 1/2-inch drive bays in most IBM-compatible personal computers, QIC adopted a second standard for tape cartridges roughly the size of an audio cassette. These minicartridges measure roughly 3 1/4 by 2 1/2-by 3/5 inches.

These two cartridge sizes are currently used in various QIC-standard tape drives. A two-letter code at the end of the QIC standard number designates whether the tape standard is based on the full-sized cartridge or the minicartridge. These two-letter codes are shown in the following:

- **DC** in a QIC standard number stands for data cartridge, the 4-by-6-by-5/8-inch cassette.
- **MC** in a QIC standard number stands for minicartridge, the 3 1/4-by-2 1/2-by-3/5-inch cassette.

Table 16.1 Specifications of QIC-Standard Quarter-Inch Tape Cassettes and Minicartridges

QIC Minicartridge Tape Standards

DC-2000 QIC Tape Standards (Approximate Dimensions 3 1/4 by 2 1/2 by 3/5)

QIC Standard Number	Capacity (w/o Compression) (1)	Tracks	Data Transfer Rate (Approximate)
QIC-40	40M/60M	20	2M-to-8M/minute
QIC-80	80M/120M	28	3M-to-9M/minute
QIC-100 (obsolete)	20M/40M	12 or 24	—
QIC-128	86M/128M	32	—
QIC-3010	255M	40	9M/minute
QIC-3020	500M	40	9M/minute
QIC-3030	555M	40	—
QIC-3040	840M (3)	42 or 52	—
QIC-3050	750M	40	—
QIC-3060 (inactive)	875M	38	—
QIC-3070	4G	144	—
QIC-3080	1.6G	50	—
QIC-3110	2G	48	—
QIC-5010	13G	144	—

(1) Tape capacity may vary according to tape length.
(2) Tape lengths may vary by manufacturer.
(3) 1G with drives based on 0.315-inch tape cartridge
(4) SCSI: Small Computer Systems Interface

The new QIC-5GB-DC, for example, is a 5G-capacity tape based on the QIC standard for the full-sized cartridge. The new QIC-5010-MC, which has 13G capacity, is based on the minicartridge standard.

Table 16.1 shows the common QIC-standard tape formats and their technical specifications.

Data Density	Tape Length (2)	Encoding Method	Interface Type
—	205 ft. or 307.5 ft.	MFM	Floppy or optional adapter card
—	205 ft. or 307.5 ft.	MFM	Floppy or optional adapter card
10,000bpi	—	MFM	SCSI (4) or QIC
16,000bpi	—	MFM	SCSI or QIC
22,000bpi	300 ft.	MFM	Floppy or IDE
42,000bpi	400 ft.	MFM	Floppy or IDE
51,000bpi	275 ft.	MFM	SCSI-2 or QIC
41,000bpi	400 ft.	RLL	SCSI-2 or QIC
—	295 ft.	RLL	SCSI-2 or QIC
—	295 ft.	RLL	—
68,000bpi	295 ft.	RLL	SCSI-2 or QIC
60,000bpi	—	RLL	SCSI-2 or QIC
—	—	RLL	SCSI-2 or QIC
—	—	RLL	SCSI-2 or QIC

(continues)

Table 16.1 Continued

QIC Full-Sized Data Cartridge Standards

DC-300a/DC-600/DC-6000 QIC Tape Standards (Approximate Dimensions 4 by 6 by 5/8)

QIC Standard Number	Capacity (w/o Compression)	Tracks	Max. Data Transfer Rate (Approximate)
QIC-11 (DC-300)	45M	9	—
QIC-24	45M/60M	9	—
QIC-120	125M	15	—
QIC-150	150M/250M	18	—
QIC-525	320M/525M	26	12M/minute
QIC-1000	1G	30	18M/minute
QIC-1350	1.35G	30	18M/minute
QIC-2100	2.1G	30	18M/minute
QIC-2GB	2.0G	42	18M/minute
QIC-5GB	5G	44	18M/minute
QIC-5010	13G	144	18M/minute

(1) Tape capacity may vary according to tape length.
(2) Tape lengths may vary by manufacturer.

Unlike software whose version numbers (1.0, 1.1, 2.0, 2.1) tell you which version of the software is the most recent, the QIC number designation does not serve as an accurate guide to understanding which QIC-standard tape drives are the latest technology. The designations QIC-100 and QIC-128, for example, were used for tape drives marketed long before today's QIC-40 and QIC-80 drives. Furthermore, the QIC-standard version numbers frequently have no correlation with the capacity of the tape cassettes or minicartridges used with a drive bearing a QIC designation. For example, the QIC-40 tapes have a capacity of 60M; the QIC-80 tapes, a capacity of 120M.

QIC-standard backup tapes are magnetic media, primarily ferric oxide, and are recorded in a manner similar to the way data is encoded on your hard drive, using either modified frequency modulation (MFM) or run-length limited (RLL) technologies.

Common QIC Tape Backup Types

The most common QIC-standard drives, QIC-40 and QIC-80, are based on minicartridges. Millions of drives based on the QIC-40 and QIC-80 standards are currently installed in computer systems. There are several reasons for the success of QIC-40 and QIC-80, not the least of which is that these two standards resulted in the first generation of economically attractive tape drives which stored data in a manner compatible from one manufacturer to another. In other words, QIC-40 and QIC-80 tape drives and tapes are quite affordable and backups made on one QIC-40 or QIC-80 tape drive can be read in a tape drive built by another manufacturer.

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Data Density	Tape Length (1)	Encoding Method	Interface Type
—	450 ft.	MFM	QIC-02
8,000	450 ft. or 600 ft.	MFM	SCSI or QIC-02
10,000	600 ft.	MFM	SCSI or QIC-02
10,000bpi	600 ft. or 1,000 ft.	MFM	SCSI or QIC-02
16,000bpi	1,000 ft.	MFM	SCSI or SCSI-2
36,000bpi	760 ft.	MFM	SCSI or SCSI-2
51,000bpi	760 ft.	RLL	SCSI-2
68,000bpi	875 ft.	RLL	SCSI-2
40,640bpi	900 ft.	MFM	SCSI-2
96,000bpi	1,200 ft.	RLL	SCSI-2
68,000bpi	—	RLL	SCSI-2

In addition, the compact size of the minicartridge used for QIC-40 and QIC-80 tapes has resulted in drives made by numerous manufacturers that fit easily into both 5 1/2-inch half-height drive bays and 3 1/2-by-1-inch drive bays. Portable tape drives that read and write QIC-40 and QIC-80 format tapes are quite common. Unlike a drive that is installed in a computer's drive bay, portable drives can be used to back up any number of computers.

Another reason for the success of QIC-40 and QIC-80 tape drives is that the cost of tapes themselves is considerably lower per megabyte than the cost of a stack of floppy disks that can store the same amount of backup data. For example, a name-brand QIC-80 tape that can hold 250M of data (with data compression) costs between $14 and $25. The street price of 13 boxes (of 10) name brand 1.44M 3 1/2-inch floppy disks, which hold roughly the same amount of compressed data, is about $90. The same number of generic, bulk floppy disks, which many people are hesitant to rely upon for backing up important data, costs nearly $50.

One major shortcoming of QIC-40 or QIC-80 tape drives is that the use of the floppy drive interface, especially on an 8-bit PC, makes the tape drive performance extremely slow. Data transfers occur at roughly the same slow rate as when data is written to a floppy disk. More recent drives, used on 386-, 486-, and Pentium-based systems using a 16-bit floppy drive interface and driven by backup software capable of using a Direct Memory Access channel (DMA), have improved this performance markedly.

In addition, drive manufacturers offer special interface cards that speed data transfer even more. It is not uncommon for a tape drive to achieve data transfer speeds of 2M to 4M per minute (with the floppy drive interface) or as high as 9M per minute (with a dedicated interface card).

Backup tapes, like floppy disks and hard drives, must be formatted before use. And one aspect of using a QIC-40 or QIC-80 tape drive—or any tape drive, for that matter—that has not improved is the time it takes to format a tape. Formatting a 60M-length QIC-40 tape can take quite a long time—90 minutes or more. Formatting a 125M length QIC-80 tape can take more than three hours. You can buy preformatted tapes but, as is true with many timesaving products, formatted tapes do cost slightly more than unformatted ones.

Data is stored on QIC-40 and QIC-80 tapes in Modified Frequency Modulation (MFM) format, the format used on floppy disks (and older hard drives). Another similarity in formatting a backup tape, floppy disks, or a hard drive is that the formatting process creates a record-keeping system. The record-keeping system used on QIC-40 and QIC-80 tapes is similar to that on a hard drive or floppy disk.

The QIC standard calls for a file allocation table (FAT) that keeps track of where data is stored on the tape and keeps bad sectors from being used for data storage. A QIC-40 tape is divided into 20 tracks, with each track divided into 68 segments of 29 sectors each. Each sector stores one kilobyte (1,024 bytes). This record-keeping system and the error-correcting system that ensures reliably stored backup data use a total of 30 percent or more of each QIC-40 tape.

Despite the slow backup speeds of tape backup drives on some computers and the time it takes to format tapes, the ease of using a backup tape drive makes it easy to understand the popularity of QIC-40 and QIC-80 tape drives. And that popularity has its benefits. Prices of QIC-80 tape drives—the smallest-capacity tape drives anyone should consider—have plunged in recent years. Name-brand QIC-80 tape backup drives often cost less than $150; sometimes you can buy them for as little as $100 by mail order, through a publication like *Computer Shopper* magazine.

QIC-40 Drives. The first tape backup drives to gain wide acceptance were based on the QIC-40 standard, adopted in 1986. Most early QIC-40 tape drives were built to fit a 5 1/2-inch drive bay, although models designed for 3 1/2-by-1-inch bays became available. The QIC-40-standard drives use an internal power connector and send and receive data through a cable linked to the floppy controller. The first QIC-40 tapes, which had a *native capacity* of 40M (they could hold 40M of data without data compression), were soon followed by QIC-40 tapes capable of holding 60M without data compression.

One disadvantage of the first QIC-40 tape drives was that, because a spare connector had to be used on the floppy drive cable, only one floppy drive could be used on a system in which a tape drive was installed. But with the use of a special cable, more recent QIC-40 drives are easily installed on systems with two floppy drives.

Although a major goal of the QIC organization was to achieve compatibility between tape backup systems, a tape created on one brand of tape drive could not necessarily be read in another brand. Manufacturers still clung to their individual arrangements for the physical placement of data on the tape. The goal of compatibility between tape backup systems became more of a reality with the introduction of QIC-80 drives.

QIC-80 Drives. The QIC-80 tape backup drive is the most popular tape backup drive on the market and the minimum any buyer should consider. QIC-80 tape drives generally are built to fit 3 1/2-by-1-inch bays, although they usually include a frame and faceplate that enable them to be used in a larger 5 1/2-inch bay. Like the QIC-40 drives, QIC-80 tape systems use an internal power connector. The data connection for a QIC-80 tape backup can be the same type of floppy disk controller connection used for QIC-40 drives, or a special high-speed interface installed in an available expansion slot on the motherboard. The use of a high-speed interface card can greatly increase the data transfer rate and decrease the amount of time needed for a backup.

Generally, a tape created on one brand of QIC-80 tape drive can be read and written to by another manufacturer's drive. This improved compatibility is due in large measure to the QIC-80 standard itself, which specifies not only the type of record-keeping system for each tape, but also the logical data structure of the tape. QIC-80-standard drives can read, but not write, QIC-40 tapes.

Portable Tape Drives. The portable tape drive is one of the most popular tape drive configurations because portables can be moved easily from system to system—desktops, laptops, a single system, or multisystem installations. Portable tape drives are particularly useful to people who use laptops (in which an internal tape backup drive will not fit) and those who want to back up a number of systems on a single tape backup drive. Portable tape drives are good also for people who want to use a tape backup drive for their desktop system but whose system has no available drive bay, as is often the case with small profile, or slimline, desktop systems.

Portable tape drives can meet so many needs because these drives are self-contained. The drive itself is contained in a rectangular box. The unit connects to the computer's parallel port and is powered by a transformer that plugs into a common AC socket.

To set up a portable tape drive, you simply plug the transformer cord into the system unit and an AC socket, connect the data cable to the computer's parallel port, and run the backup software. One limitation of portable units is availability of compatible backup software. Although portable tape drive manufacturers include software that operates the drive, some popular third-party backup software cannot be used with portable drives.

The most popular portable tape drives are available in QIC-40 and QIC-80 standards. The QIC-40 models ordinarily can achieve a data transfer rate of 1M to 3M per minute; the QIC-80 models, a rate of 3M to 6M per minute.

Newer High-Capacity QIC-Standard Drives

Using a QIC-40 or QIC-80 tape drive to back up a network server's 2G drive or other large hard drive packed with data can be as frustrating as swapping floppies during a backup

on a system with a more common 200M–500M drive. To back up a 2G network server hard drive with a QIC-40 tape drive without using data compression, for example, you need about 32 tapes. With data compression, the number of tapes drops to 16—but making the backup takes longer.

The solution to this tape-swapping problem is to use a larger-capacity tape drive system. QIC has established a number of standards for higher-capacity tape drive systems ranging from 86M to 13G. Generally, these larger-capacity systems pack data more densely on the tape, using as many as 144 tracks to pack 60,000 bits per inch (bpi) or more onto the tape (compared to the QIC-40's 20 tracks and 10,000 bpi). To achieve these higher capacities, QIC-standards call for tape media with a higher coercivity level of 1,300 oersted or more (compared to QIC-40 and QIC-80 tape media, which has a coercivity level of 550 oersted). High-capacity tapes are also longer. QIC-5010 tapes, for example, are 1,200 feet long (compared to QIC-40 and QIC-80 tapes, both of which are roughly 300 feet long).

Note

Just as the higher coercivity level of 1.44M floppy disks enables a high-density drive to use lower levels of power to write narrower tracks of data more closely together than is possible with 720K floppy disks, higher coercivity tape enables more precise tape drive head-positioning mechanisms to write narrower tracks of data to the tape.

Although tape systems based on the minicartridge dominate the market for lower capacity tape drives (the QIC-40 60M and QIC-80 120M systems), high-capacity tape backup systems are based on both minicartridge-sized tapes and full-sized data cartridge tapes. For example, the QIC-525 standard, which has a capacity of 525M (without data compression), is based on the full-sized (4-by-6-by-5/8) cartridge. The QIC-5010 standard is based on a minicartridge (3 1/4 by 2 1/2 by 3/5).

QIC-Tape Compatibility

Although QIC-standard drives are based on the standard minicartridge and the full-sized data cartridge, it would be a mistake to assume that tapes based on the same cartridge standard are always compatible. For example, QIC-5010-standard tapes are incompatible with QIC-40 and QIC-80 tape backup systems, although both standards are based on the minicartridge. Similarly, QIC-525-standard tapes are incompatible with earlier standards based on the full-sized data cartridge. The lack of compatibility between tapes based on the same sized cartridge is due to differences in tape drive mechanisms, as well as the coercivity differences between tape standards. Table 16.2 shows the compatibility of common QIC-standard backup tapes.

Table 16.2 QIC-Tape-Standard Compatibility

QIC Minicartridge Standard	Compatibility
QIC-40	—
QIC-80	QIC-40 (read-only)
QIC-100	—
QIC-128	QIC-100 (read-only)
QIC-3010	QIC-40 and QIC-80 (read only)
QIC-3030	QIC-3010 (read-only)
QIC-3070	QIC-3030 (read-only)
QIC Full-Sized Cartridge Standard	**Compatibility**
QIC-24	—
QIC-120	QIC-24 (read-only)
QIC-150	QIC-24 and QIC-120 (read-only)
QIC-525	QIC-24, QIC-120, and QIC-150 (read-only)
QIC-1000	QIC-120, QIC-150, and QIC-525 (read-only)
QIC-1350	QIC-525 and QIC-1000 (read-only)
QIC-2GB	QIC-120, QIC-150, QIC-525, and QIC-1000 (read-only)
QIC-2100	QIC-525 and QIC-1000 (read-only)
QIC-5GB	QIC-24, QIC-120, QIC-150, QIC-525, and QIC-1000 (read-only)
QIC-5010	QIC-150, QIC-525, and QIC-1000 (read-only)

Tape compatibility is an important issue to consider when you choose a tape backup system. For example, as you can see from table 16.2, the 4G QIC-3070-standard drive can read only its own tapes and those that conform to the QIC-3030 standard. If you have many QIC-80 tapes containing data you must be able to continue to access, a better choice might be a drive based on the 2G QIC-3010 standard. The QIC-3010 can read QIC-40 and QIC-80 tapes. This chapter's "Choosing a Tape Backup Drive" section covers similar issues to be considered when you purchase a new tape backup drive.

Other High-Capacity Tape Drive Standards

Although ferric oxide QIC-standard tapes continue to be popular, two other types of tape backup systems are becoming increasingly popular for backing up networks and other systems with large amounts of data: 4mm digital audio tape (DAT) and 8mm video tape.

Sony, which introduced both DAT tape and 8mm videotape, licenses DAT tape technologies to other manufacturers, in effect setting the standard for drives and tapes manufactured by those companies. Because the 8mm tape backup drive technologies have been developed by a variety of manufacturers, there is no recognized 8mm standard. For that reason, a QIC-standard or DAT tape drive might be a better choice for most potential buyers of backup tape systems. Table 16.3 shows the basic specifications of the DAT and 8mm technology tapes.

Table 16.3 DAT and 8mm Tape Specifications

Tape Standard	Capacity (w/o Compression)	Data Density	Tracks (Approximate)
DAT tape (4mm metal particle)	1.3G/2G/ square in.	114 megabits	1,869
8mm video tape (Sony-standard)	10G	NA	NA

(1) DDS: digital data storage

Helical scan recording is similar in many ways to the way video images are recorded to videotape. As with QIC-standard tape drives, DAT and 8mm tapes move past the recording heads, which are mounted on a drum. These read/write heads rotate at a slight angle to the tape, writing a section of a *helix*, or spiral. The tape drive mechanism wraps the tape about half way around the read/write heads, causing the heads to touch the tape at an angle. With helical scan technology, the entire surface of the tape is used to record data, unlike other technologies in which data tracks are separated by areas of unrecorded tape. This use of the entire tape surface enables helical scan backup drives to pack a much greater amount of data on a particular length of tape.

The DAT Tape Drive Standard. The technology behind the digital audio tape is similar in many ways to the techniques used to record music and encode it on musical compact discs (CDs). Data is not recorded on the tape in the MFM or RLL format used by QIC-standard drives; rather, bits of data received by the tape drive are assigned numerical values, or digits. Then these digits are translated into a stream of electronic pulses that are placed in the tape. Later, when information is being restored to a computer system from the tape, the DAT tape drive translates these digits back into binary bits that can be stored on the computer.

The most common capacity for DAT tapes is 1.3G, although increased tape length is making higher-capacity DAT backup drives and tapes more common. Two types of data formats—digital data storage (DDS) and DataDAT—are used for DAT tapes.

Thanks to the digital audio tape technology, the DAT tape backup drives are able to pack an incredible amount of information on the tiny cassettes (roughly 1/2 by 3 by 2 inches). DAT technology uses an extremely sensitive tape (1,450 oersted metal particle) that packs 114 megabits of data per square inch, the densest data storage of any backup tape technology.

The 8mm Tape Drive. A single manufacturer, Exabyte, offers tape backup drives that take advantage of 8mm videotape cartridges. These drives are offered in two capacities: 1.5G (3G, with hardware data compression), for the least expensive drives, and 5G (10G, with hardware compression) for the more expensive models. Although these drives use 8mm videotapes, video technology is not used in the process of recording computer data to these drives. Rather, Exabyte developed its own technology for encoding data on the tapes. The helical scan method is used to record data to the tape.

Tape Length	Recording Technology	Encoding Format	Interface
195 ft./300 ft.	Helical Scan DataDAT	DDS (1)	SCSI
2-hour video	Helical Scan/ proprietary	NTSC	Proprietary

The highest capacity 8mm tape backup drives are somewhat expensive. For example, one hardware vendor specializing in network hardware recently offered the 5G to 10G capacity Exabyte 8505i half-height internal drive for $2,265. That might seem expensive when the Exabyte drive is compared, gigabyte for gigabyte, with the 2G (4G, with software data compression) Colorado Memory Systems PowerDAT 6000 tape drive, offered by the same vendor for $1,295.

But the 30M per minute data throughput rate of the Exabyte 8mm tape backup drive, compared with the 10M per minute throughput of the DAT drive, makes the 8mm tape drive a more attractive choice. The extraordinary speed and huge capacity of these 8mm tape drives makes them extremely attractive for backing up network servers and for backing up workstations from the server. You can reach Colorado Memory Systems and Exabyte by writing or calling:

Colorado Memory Systems Inc.
800 S. Taft Avenue
Loveland, CO 80537
(800)845-7905
(800)451-4523

Exabyte Corporation
11100 West 82nd Street
Lexena, KS 66214
(913)492-6002
(800)825-4727

Choosing a Tape Backup Drive

Choosing a tape backup drive can be a simple job if you need to back up a single standalone system with a 500M (or smaller) hard drive. The decision becomes more complex if the system has a larger hard drive or if you must back up not only a desktop system, but also a laptop. Choosing a backup tape drive type can be an even more complex problem if you must back up a network server's 3G hard drive and perhaps even back up the workstations from the server. As you ponder which backup tape drive type you should choose, consider the following factors:

- The amount of data you must back up
- The data throughput you need

- The tape standard that is best for your needs
- The cost of the drive and tapes

By balancing the considerations of price, capacity, throughput, and tape standard, you can find a tape drive that best meets your needs.

Note

When purchasing a tape backup drive, take the time to look through a magazine like the *Computer Shopper*. Published monthly, the *Computer Shopper* is more a catalog than a magazine. It caters to people willing to spend money in the *direct channel* (often called *mail order)*. Many of the vendors who advertise in direct channel magazines have cut their prices to the bone. By reading such publications, you can get an excellent idea of the drives available and the price you can expect to pay.

Capacity. The first rule for choosing a tape backup drive is to buy a drive whose capacity is large enough for your needs, now and for the forseeable future. The ideal is to buy a drive with enough capacity that you can start your backup software, insert a blank tape in the drive, walk away from the system (or go about other work), and find the backup completed when you return. You can safely store the tape and resume working.

Given that ideal, an internal QIC-80 drive might be just the ticket if you need to back up a single system with a hard drive of 250M or less. If you need to back up several systems, including laptops, with hard drives of 250M or less, a portable QIC-80 drive might be the solution.

But if you must back up a large network server hard drive, relying on a QIC-80 tape drive with its 125M capacity (250, with software data compression) is a bad idea. A better choice would be one of the larger-capacity tape backup drive systems detailed earlier in this chapter.

Tape Standards. The next most important consideration, after adequate capacity, is choosing a drive whose tapes meet a standard that is useful to you. For example, if you must be able to restore backup data using any of a number of different tape backup drives, you should ensure that all these drives can at least read the tapes. For this reason, if you have several systems to work with, you should choose a tape standard that will work in them all.

There is no quick, simple answer as to which standard is the best. Many people stick with QIC-standard drives because QIC created the first standards and continues to develop new standards for large-capacity tape backups. But if you need a large-capacity backup tape system, DAT or 8mm may be the correct choice.

If you need backward compatibility with tapes or tape drives you already have, you will need to buy drives that are the same standard or a higher compatible standard. For example, if you need a large-capacity tape drive that is backwardly compatible with your

QIC-80 tapes, you should consider the 2G-capacity QIC-3010, which reads QIC-40 and QIC-80 tapes. If, on the other hand, you don't have to worry about data already stored on old tapes, the important considerations may be capacity and performance. Therefore DAT or 8mm drives may be the best choice.

It is important that you make a choice you can live with. If you manage a large installation of computers, mixing QIC, DAT, and 8mm drives among systems is seldom a good idea.

Data Throughput. Without question, you should consider the 8mm drives if performance is more important to you than price or compatibility. These drives offer huge capacity and tremendous data throughput—as high as 30M per minute. Large-capacity drives based on newer QIC-standards are capable of 18M per minute throughput. DAT tape drives offer throughput of 10M per minute.

The low end of the tape backup drive performance spectrum is older QIC-80 standard drives. When linked to a floppy controller, these drives achieve 3M to 4M per minute throughput. Even with a dedicated interface card purchased at added cost, QIC-80 drives are lucky to achieve their advertised throughput of 9M per minute. Portable QIC-80 drives are advertised at 3M to 8M per minute, but 2M or 3M a minute is a more realistic figure.

The Cost of the Drive and Tapes. It pays to shop enthusiastically for price after you have settled on the type of drive you want to buy. The cost of tape drives and their tapes quite literally depends on where you buy. For example, the internal Colorado Memory Systems PowerDAT Series 6000 tape drive, purchased directly from Colorado, costs $1,695, a price close to that charged by many retail stores. The same DAT drive, advertised by several vendors in *Computer Shopper*, can be purchased for roughly $1,130, a savings of nearly $600. Regardless of where you buy the drive, the Colorado warranty remains in effect.

The cost of backup tapes also varies widely, depending on where you buy. The same name-brand DAT tape that costs as much as $14 from one vendor can cost $12 from another. The cost of a formatted name-brand QIC-80 (120M) tape can range from $15 to $26, depending on where you buy it. Because many computer retailers and direct channel vendors offer lower prices when you buy three or more tapes at a time, it pays to shop for price and buy the largest quantity of tapes you expect to need.

One point worth remembering when you evaluate whether to buy a tape drive is that the cost of the tapes and drive, taken as a whole, is nowhere near as high as the costs (in terms of frustration and lost productivity) of a single data-damaging hard drive problem. Considering that most people are more likely to back up their system if they have a tape drive installed than if they must use floppy disks for the backup, the cost of a drive and tapes is quite small, even on a stand-alone PC used mostly for fun.

Tape Drive Installation Issues

Each of the tape drive standards covered in this chapter provides a range of options for installation. These options include both internal and external installation. Whether to

choose an internal or external drive, and which external drive to choose, if that appears to be the best choice for you, is not always a cut-and-dried issue. If you must back up a single computer with a relatively small hard drive (500M or less), an internal QIC-80 drive might be your best choice. If you have to back up several computers with 500M hard drives, or if you must be able to share data between several computers, you might be able to make do with a QIC-80 portable. If your backup needs are not that simple, however, here are some additional considerations:

- If your computer has a large hard drive and you back up often, or if you administer a large number of systems and want to minimize the amount of work you must do and the number of tapes you have to store for each computer, installing large-capacity QIC, DAT, or 8mm tape drives in each computer might be what you need to do.
- If your best choice is a large capacity QIC, DAT, or 8mm tape drive and almost all the computers you administer have an available drive bay, you might choose a portable DAT or 8mm tape system, which can be moved from system to system.

Caution

Steer away from nonstandard tape backup drives. For example, some drives may not conform to QIC, DAT, or Exabyte standards. Since Exabyte is the only manufacturer of 8mm tape backup drives, you can be confident that tapes made on this manufacturer's drives can be read on their drives. Also avoid drives based on VHS videotape. Many people consider these drives extremely unreliable.

Although some of the larger-capacity drives are available in external models, few models, except for QIC-80 portables like the Colorado Memory Systems Inc. Jumbo Trakker, can be considered truly portable. The reason is that most external tape drives require an interface card installed in a motherboard slot, whereas the QIC-40 and QIC-80 portables require only that the computer have a parallel port. The following sections cover some important installation issues for internally and externally mounted drives.

Internal Installation. Virtually all internal tape backup drives available today are designed to be installed in a half-height drive bay. Many are designed to be installed in either half-height drive bays or the smaller drive bays generally used for 3 1/2-inch floppy drives. Drives that can be installed in 3 1/2-inch floppy drive bays generally are shipped in a cage, or frame, that enables them to be installed in a 5 1/4-inch bay. To install the drive in a 3 1/2-inch bay, you remove the cage and the 5 1/4-inch bay faceplate. Most tape drives are between about 5 and 9 inches deep; they require approximately 5–9 inches of clearance inside the system case. To mount tape drives inside the system, use the same rails or cage apparatus used for floppy drives, hard drives, and devices such as CD-ROM drives.

Note

Half-height drive bays measure roughly 1.7 inches high by 5.9 inches wide. The smaller drive bays measure 1 by 4 inches.

Internal tape drives require a spare power connector, usually the larger connector used for hard drives, although some may require the smaller power connector common to 3 1/2-inch floppy drives. If a power connector is not available inside your system, you can buy a *power splitter* from a computer store or cable supply vendor. A power splitter looks like the letter Y and acts like an extension cord. You unplug the power connector from a device (such as a floppy drive) that's already installed. Then plug the bottom point of the Y into that power connector. The two arms of the Y then provide you with two power connectors.

Internal tape drives also require an interface to the system. QIC-40 and QIC-80 drives most often connect to the system through the floppy controller. On a system with only one floppy drive you connect the tape drive to an unused connector on the floppy disk data cable. On systems with two floppy disk drives you use a special cable linked to the floppy disk data cable which is in effect a splitter cable.

Internal drives other than QIC-40s and QIC-80s usually require a special adapter card, or they may link to a card already installed in your system. This card is usually one of the following: a QIC-standard adapter card, a Small Computer Systems Interface (SCSI) adapter, a SCSI-2 adapter card, or an Integrated Drive Electronics (IDE) card. When purchasing a drive, you must determine which interface you need; make sure that the drive kit includes the adapter card you need or that you purchase the correct card.

External Installation. If you want to move an external tape drive (except the portable QIC-40 and QIC-80 tape backup drives) from computer to computer, you must install an adapter card in each system on which you want to use the tape drive. Portable QIC-40 and QIC-80 tape backup drives like the Jumbo Trakker use the computer's parallel port connector. Adapter cards designed for use with external tape drives have a connector, somewhat similar to a parallel port connector, that is accessible from the back panel of the system unit. These cards generally are QIC-standard, SCSI, SCSI-2, or IDE.

When you buy an external tape backup drive that requires an adapter, you must ensure either that the drive includes the necessary adapter card or that you purchase the card at the same time you purchase the drive. In addition, if you plan to use the external tape drive to back up a number of systems, you must buy a card for each system on which you plan to use the drive.

Power is supplied to external units by a transformer that plugs into an ordinary 120v AC wall socket. Generally, the transformer connects to the external tape drive with a small connector. When you choose an external tape drive, be sure you have enough AC power sockets available for your computer, its peripherals, and the tape drive.

Tape Drive Backup Software

The most important decision you can make after you choose the tape standard and capacity of your backup tape drive is the backup software you will use with it. Most tape drives are shipped with backup software that generally is adequate for your basic backup needs.

Often, however, third-party software compatible with the drive you have chosen gives you greater flexibility and functionality. For example, some tape drives may be shipped with only DOS-based software. If you want to use one of these drives from within Windows, or on a system running OS/2 or UNIX, you may need to purchase third-party backup software. And if you will be backing up network workstations from a server, you must make sure that the drive is shipped with software capable of performing this function; otherwise, you will need to acquire third-party software.

One important issue with backup software is data compression. Most backup software offers data compression, special programming that stores data on the backup tape in less space than is needed on the original source disk. Some companies produce backup software that is well known for especially efficient data compression. In other words, backup software produced by these companies does a better job of compressing large data files into a small amount of space.

Note

Microsoft Backup (MSBACKUP.EXE) and Windows Backup (MWBACKUP.EXE), which are included with DOS 6.0 and later versions, do not work with tape drives. You must use either the software bundled with the drive or purchase third-party software. A similar problem is that some well-known third-party software does not work with the Colorado Jumbo Trakker portables. With these drives, you may need to use the excellent software for Windows and DOS provided by Colorado or purchase software that will work with remote tape drives.

You may want to take the time to read some articles on backup software in one of the many monthly computer magazines, such as *Byte* or *PCWorld*. These and other magazines frequently determine which backup software does the best job of compressing data; they also provide information on how quickly backup software programs perform a typical backup. The speed of the backup software and its data-compression capabilities are important considerations. Also of great importance is whether the software is easy to use. If your backup software makes backing up more difficult than it has to be, chances are you won't back up as often as you should.

Bundled Software. Before you buy a backup tape drive you should always check whether the drive includes software that will meet your needs. If it doesn't, be sure to buy third-party software that does the job. Generally, the software bundled with most tape backup drives will do the job for you—provided that you don't plan to place great demands on the tape drive.

The software included with a QIC-80 drive, for example, generally cannot be used to back up network workstations from the server. If you want to use a QIC-80 drive for this

task, you may need to buy special software compatible with your network and the tape backup drive. If you use Windows, Windows NT, OS/2, or UNIX, your backup software must be compatible with your operating system as well as the drive, and you must determine whether the software shipped with the drive will do the job for you.

Third-Party Software. A large number of companies manufacture backup software designed for different types of tape drives and different uses. For example, many manufacturers design their backup software to be compatible with most networks. Others specialize in DOS and Windows backup software. Some specialize in OS/2 software. Others are well known among those whose computers run in UNIX. You may need to ask a trusted retailer or call the software company itself to determine whether a particular type of software is compatible not only with the tape drive you have chosen, but also with your network and operating environment.

Often, third-party software is easier to use than the software designed by a tape manufacturer. The tape manufacturer's software may have an unfamiliar interface or its commands may seem cryptic to you, even if you have used backup software for years. It is not uncommon for tape manufacturers to include inadequate or even incomplete documentation for the backup software included with the drive, although this generally is the case only with lower cost models. In such a case, you may be able to solve the problem by purchasing third-party software.

Third-party software often does a better job of data compression than the software designed by a tape manufacturer. In addition, third-party software often includes capabilities not included with the software bundled with many drives. Some of the capabilities you might want to look for include the following:

- *Unattended backup scheduling*. Enabling you to schedule a backup for a time when you won't need to use your computer
- *Macro capability*. For selecting options and the files to back up
- *A quick tape-erase capability*. For erasing the entire contents of a tape
- *Partial tape-erase capability*. For erasing only part of a tape
- *Tape unerase capability*. For recovering erased data
- *Password protect capability*. To protect backup data from access by unauthorized persons

The following is a short list of backup software manufacturers with a good reputation for programs that are easy to use, reliable, and do a good job with data compression.

Norton Backup
10201 Torre Avenue
Cupertino, CA 95014
(408)253-9600
(800)441-7234

Central Point Backup
15220 NW Greenbrier Parkway
Suite 150
Beaverton, OR 97006
(800)445-4208
(503)690-8088

FastBack Backup
Fifth Generation Systems
10049 N. Reiger Rd.
Baton Rouge, LA
(800)873-4384
(504)291-7221

You can find additional backup software manufacturers by reading some of the many monthly computer magazines, paying particular attention to their usability reviews. Generally, if a backup software product gets good reviews, works on a system configuration like yours, and has the features you need, it is worth the price you pay.

Removable Storage Drives

The reason for the shortage of storage space on today's PCs is easy enough to understand. Just take a look at the sheer number and size of the files stored in the two main directories used by Windows (usually C:\WINDOWS and C:\WINDOWS\SYSTEM). The amount of disk space used by the files in those two directories alone can quickly balloon to 40M or more after you also install a few Windows applications. The reason is simple: Nearly all Windows applications place files in one of the Windows directories that the application will use later. These files include those with extensions like DLL, 386, VBX, DRV, TTF, and many others. Similarly, Windows NT, OS/2, and UNIX, as well as the software applications that run in these operating systems, can require enormous amounts of storage space.

The remainder of this chapter focuses on some of the more advanced data storage options on the market: removable media large-capacity storage drives. Some removable media drives use media as small as a 1.44M floppy disk, others use media about the size of a 5 1/4-inch floppy.

These drives, whose capacities range from 35M to 270M, offer fairly speedy performance, the ability to store data or less frequently used programs on a removable disk, and the ability to easily transport huge data files—Computer Aided Drawing (CAD) files and graphics files, for example—from one computer to another. Or you can use a removable media disk to remove sensitive data from your office so that you can lock it safely away from prying eyes.

There are two commonly used types of removable media drives: magnetic media and optical media, also called *magneto-optical* media. Magnetic media drives use much the

same technology used on a floppy disk or hard drive to encode data for storage. Magneto-optical media drives encode information on disk by using newer technology, a combination of traditional magnetic and laser technologies.

Magnetic media drives are considerably faster than magneto-optical drives and offer similar capacities. The SyQuest magnetic media drives, for example, offer 14ms average access times, compared to the 30ms (or slower) access times of magneto-optical drives. Magneto-optical drives can be more than twice as expensive as magnetic media drives. If you have a great deal of data to store, however, the comparative cost of using a magneto-optical drive drops because magneto-optical media cartridges are considerably less expensive than magnetic media. For example, when you buy 10, 270M SyQuest cartridges can cost roughly $80 each, and 150M Bernoulli cartridges can cost about $90 apiece. The 128M magneto-optical cartridges can cost as little as $25 apiece when you buy 10.

The following section provides information on magnetic media and magneto-optical drive types.

Magnetic Media Drives

A small group of companies dominate the market for magnetic removable media drives. One company, Iomega Bernoulli, always tops the list because it developed the first popular large-capacity removable magnetic media drives, and because its disk cartridges are known as the most rugged in the industry. Two other leading names in removable magnetic media drives are SyQuest and SyDOS (owned by SyQuest).

Both the Bernoulli and SyQuest designs are their own de facto standard. Other manufacturers market drives based on the Bernoulli and SyQuest designs (and some actually manufactured by Bernoulli or SyQuest). Generally these manufacturers' drives are somewhat less expensive than the Bernoulli and SyQuest models. If you are considering one of these compatible drives, however, make sure that the drive you are buying has the same performance characteristics (average access speed, and so on) as the original and that the drive manufacturer offers the same warranty as the original (Bernoulli, three years; SyQuest/SyDOS, two years).

Bernoulli Removable Media Drives. The disk used in the Bernoulli Drive is roughly the same size as a 5 1/4-inch floppy disk, although a large shutter, similar to the shutter on a 3 1/2-inch floppy disk, easily differentiates Bernoulli disks from floppy disks. Modern Bernoulli cartridges are available in 35M, 65M, 105M, and 150M capacities. The Iomega Bernoulli MultiDisk 150 drive, the company's newest model, reads and writes all of these drive capacities. In addition, the MultiDisk reads and writes to older Bernoulli 90M disks and reads older 40M disks. The MultiDisk is available in both internal and external models.

Bernoulli disks are widely known as the most durable of the removable media drive types. It is probably safer to mail a Bernoulli cartridge than another type of removable disk because the media is well protected inside the cartridge. Bernoulli encases a magnetic-media-covered flexible disk (in effect, a floppy disk) in a rigid cartridge in the same way the thin disk of a 1.44M floppy is encased in a rigid plastic shell.

When it rotates in the drive the disk floats on a cushion of air fractions of an inch from the read/write head. As the disk spins, the airflow generated by the disk movement encounters what is called a *Bernoulli plate*, a stationary plate designed to control the air flow so that the disk is pulled toward the read/write head but never touches the head itself. The disk itself spins at speeds approaching the 3,600 rpm of relatively slow hard drives. The drive has an average seek time of 18ms, not a great deal slower than today's medium-priced hard drives.

The Bernoulli MultiDisk 150 drive is available in an internal model, which requires a half-height drive bay, and an external model. The internal model connects to the IDE hard drive adapter already installed in your system. The external model requires a SCSI adapter card with an external connector. The external model is powered by a transformer that connects to a grounded AC wall plug.

SyQuest Removable Media Drives. SyQuest manufactures some drives that use 5 1/4-inch cartridges and others that use 3 1/2-inch cartridges. But the SyQuest disks, like the Bernoulli cartridges, are easily differentiated from floppy disks. The 5 1/4-inch 44M and 88M cartridges used in some SyDOS drives are encased in clear plastic, as are the SyDOS 3 1/2-inch 105M and SyQuest 270M cartridges. The disk spins inside the cartridge at several thousand rpm. SyQuest claims a 14ms average access time for the drives it manufactures.

The disks for the SyQuest and SyDOS drives are composed of a rigid platter inside a plastic cartridge but are not as well protected as the disk in a Bernoulli cartridge. Some people consider these disks fragile. If the SyQuest and SyDOS cartridges are not severely jostled or dropped, however, they can be transported safely. These cartridges must be carefully protected when they are mailed or shipped.

The SyQuest/SyDOS drives are available in internal and external models. The internal models require a connection to the existing IDE hard drive interface card. The external models require a SCSI interface card with an external connector and are powered by a transformer that connects to a grounded AC wall plug.

Floptical Drives

Floptical drives are another popular form of increased-capacity removable magnetic media drives. However, unlike Bernoulli and SyQuest drives, flopticals do not provide hard drive-sized storage capacities. Instead, flopticals pack 21M of data on the same sized disk as a 3 1/2-inch floppy. In addition, floptical drives can read and write 1.44M and 720K floppy disks (although they cannot handle 2.88M disks as of this writing). Because of their greatly increased storage capacity and ability to use common floppy disks, flopticals are considered by many to be the super floppy disk drive.

The name "floptical" might suggest the use of laser beams to burn or etch data onto the disk or to excite the media in preparation for magnetic recording—as is the case with the CD-ROM, Write-Once Read-Many (WORM), and magneto-optical disks discussed later in this chapter. But this suggestion is erroneous. The read/write heads of a floptical drive use magnetic recording technology, much like that of floppy drives. The floptical disk

itself is composed of the same ferrite materials common to floppy and hard disks. Floptical drives are capable of such increased capacity because 755 tracks are packed on each disk, compared with the 80 tracks of a 1.44M floppy. Obviously, in order to fit so many tracks on the floptical disk, the tracks must be much more narrow than those on a floppy disk.

That's where optical technology comes into play. Flopticals use a special optical mechanism to properly position the drive read/write heads over the data tracks on the disk. The way this works, servo information, which specifically defines the location of each track, is embedded in the disk during the manufacturing process. Each track of servo information is actually etched or stamped on the disk and is never disturbed during the recording process. Each time the floptical drive writes to the disk, the recording mechanism (including the read/write heads) is guided by a laser beam precisely into place by this servo information. When the floptical drive reads the encoded data, this servo information again is used by the laser to guide the read/write heads precisely into place.

Each floptical disk track is formatted to 27 sectors of 512 bytes. The disks themselves revolve at 720 rpm. Flopticals are capable of nearly 10M-per-minute data throughput. These drives require a special interface. Most use an adaptation of the standard SCSI interface, although some brands require a proprietary interface. Many flopticals can be configured as drive A, so they can be used to boot your system. Each floptical drive comes with special software drivers and utilities that enable the drive to function properly on your system.

Magneto-Optical Drives

Magneto-optical drives, which are manufactured by a large number of companies, use an ingenious combination of magnetic and laser technology to pack data on 5 1/4-inch and 3 1/2-inch disks contained in cartridges. The media itself and the construction of the platter are similar in ways to the media of a CD-ROM disc. An aluminum base is covered with clear plastic, then a layer of magnetic, optically active media particles—an alloy of cobalt, iron, and terbium. A clear plastic coating seals the disk, rendering it nearly impervious to shock, contamination, and damage.

Although the magneto-optical disks are similar to CD-ROM discs, there is a world of difference in the way data is stored. When manufacturers write CD-ROM discs, the laser actually burns pits into the media to represent the data. These pits are read by the laser and translated into the form of computer data. In the case of magneto-optical disks, the magnetically/optically active media is not burned or pitted. Instead, during the writing process a magneto-optical drive focuses a laser beam onto a very tight track—a much thinner track than could be used to store data on a purely magnetic media platter. The laser beam heats the track and a weak magnetic signal is applied. The result is that only the thin track of heated media receives the magnetic signal and stores the data it contains.

Unlike a CD-ROM disc, a magneto-optical disk theoretically can be rewritten an infinite number of times because the media is never burned or pitted. When the time comes to erase data from or rewrite the disk, the disk is simply reheated with the laser and the old

data removed magnetically so that new data can be recorded. When the magneto-optical drive reads the disk, the drive functions optically—that is, the laser reads the data from the disk (without heating the media).

Because of the thin tracks on which data is written to magneto-optical disks, the data is packed extremely densely: large amounts of data can be packed on a platter about the same size as common 3 1/2-inch and 5 1/4-inch floppy disks. The current maximum capacity of the 3 1/2-inch cartridges is 230M; the 5 1/2-inch cartridges can hold as much as a gigabyte of data. It is important to note, however, that capacity ratings of magneto-optical disks can be misleading. Magneto-optical disks are double sided, like floppy disks, but magneto-optical drives have only one read/write head. Therefore, to read or write to the second side you must manually flip over the cartridge. So only half the disk capacity is available at any one time.

For many applications, magneto-optical drives are tediously slow, although some drives—using refinements of the basic magneto-optical technology—offer data-access speeds that are inching more closely to those of removable magnetic media drives. One reason that magneto-optical drives are slow is that they typically spin the disk at roughly 2,000 rpm—much slower than the 3,600 rpm of a relatively slow hard drive. Another reason for the slow speeds is that the read/write head mechanism, although optically and magnetically advanced, is mechanically a kludge. The massive mechanism of a magneto-optical drive's read/write heads takes much longer to move and settle than the read/write heads of a hard drive or even a removable magnetic media drive.

Magneto-optical drives typically are rated with average access speeds of about 30ms. However, these average access speed figures do not tell the entire story. The process of rewriting a disk can take nearly twice the time it takes to read the disk. Because of the way magnetic-optical technology works, all the bias magnetic field of the area of the disk to be written must be oriented in a single direction during the write process. Because of this limitation, during the write process most magneto-optical drives must make a first pass over the disk to align the tracks of the disk that are to be rewritten. Then the drive makes a second pass over the disk to realign, or change the alignment of, the necessary areas. This alignment/realignment process is known as *two pass recording*.

New magneto-optical technologies are emerging which use single-pass recording of disks. If speed is an important factor in choosing a magneto-optical drive, you should be prepared to pay extra for a drive whose performance is not penalized by two-pass recording technology. In addition, several manufacturers are offering drives that spin the platter at speeds approaching the 3,600 rpm speeds of a hard drive. The performance boost offered by these drives is considerable, but this technology also boosts considerably the prices of these drives.

Most manufacturers adhere to the International Standards Organization specifications for magneto-optical disks and drives. The ISO standard calls for all drives to use a SCSI host adapter to interface with the computer. Under the ISO standard, 5 1/4-inch drives must be able to read two different disk formats: disks with 512-byte sectors and disks with 1,024-byte sectors. The disks with 512-byte sectors have a capacity of roughly

600M; those 1,024-byte sectors hold 650M of data. Under the ISO standard the 3 1/2-inch drives, which are quite popular among first-time purchasers, are required to read only the 128M disks. Some manufacturers, in addition to designing their drives to meet ISO standards, also design their drives to use a proprietary data format that can increase the capacity of 5 1/4-inch disks to about 1.3G. Both 5 1/4-inch and 3 1/2-inch drives are available as internal and external units.

Write-Once Read-Many (WORM) Drives

The removable media drive known as *write-once read-many* (WORM) is designed to serve as a nearly bulletproof data archival system. If you have extremely important data files that absolutely must remain in an unaltered state, perhaps accounting or database data, a WORM drive can provide the kind of security you are looking for. Data written to a WORM disk cannot be changed.

The WORM disk is encased in a high-impact cartridge with a sliding shutter similar to the shutter on a 3 1/2-inch floppy disk. The cartridge and the extremely durable nature of the disk inside make WORM disks worry free for data exchange. A WORM drive cartridge is very difficult to damage. The disk itself, with the media sandwiched in plastic, is not unlike a CD-ROM disc or a magneto-optical disk. The technology used to write a WORM disk, however, is more like the technology used for CD-ROM recording than that used for writing to magneto-optical disks. The WORM drive uses a laser to burn microscopic patches of darkness into the light-colored media.

A number of companies manufacture WORM drives but follow no single standard. Therefore, a WORM disk written on one manufacturer's drive is quite unlikely to be readable on another manufacturer's drive. Each manufacturer (sometimes small groups of manufacturers) uses its own proprietary data format and disk capacity and many use a cartridge size only their drives can handle. For example, most WORM drives are designed for 5 1/4-inch cartridges but some WORM drives handle only 12-inch disks. In addition, although most WORM drives interface the computer via a SCSI host adapter, others use different interfaces, some of them proprietary.

Certainly, at least in part because of these incompatibility problems, WORM drives are not big sellers. No more than several thousand are sold each year at prices soaring to the heights—some 5 1/4-inch drives cost several thousand dollars. The 5 1/4-inch-drive cartridges, which range in capacity from 650M to 1.3G, can cost more than $180.

The term *niche market* is used occasionally to describe a computer product or peripheral that lacks broad appeal or usefulness. Because of its cost and incompatibility problems, WORM drive technology is a niche market product. Unless you must be able to store massive amounts of data and ensure it can never be altered, you are better off buying a magneto-optical drive, or perhaps even a tape backup drive.

Summary

This chapter examined a wide range of data storage options, including backup tape drives and large-capacity removable media drives. The QIC standards for tape backup drives as well as DAT and 8mm tape drives also were covered. In addition, you were given some useful guidelines for choosing the tape backup drive that is right for your computer or the computer installation you administer.

In addition, this chapter covered magnetic media drives, such as those manufactured by Bernoulli and SyQuest, and discussed the similarities and the differences between these two de facto standards in large-capacity removable magnetic media drives. Floptical drives also were covered.

This chapter also discussed magneto-optical drives, detailing their strengths and weaknesses, explaining the technology of writing data to and reading it from magneto-optical disks, and offering some guidelines that may help you decide whether magneto-optical drive technology will meet your needs.

Finally, this chapter discussed WORM drives and their uses. It also discussed the incompatibilities between WORM drives, and different media, and explained why WORM drives are appropriate only for a small segment of computer users.