4. How Long Can You Store CDs and DVDs and Use Them Again?

The life expectancy (LE) of optical discs depends on many factors, some controllable by the user, others not.

Factors that affect disc life expectancy include the following:

- type
- manufacturing quality
- condition of the disc before recording
- quality of the disc recording
- handling and maintenance
- environmental conditions

As noted previously, the three basic types of CD and DVD discs—ROM, R, and RW and RAM—each use a different data layer material (molded aluminum, organic dye, or phase-changing film, respectively). Deterioration of this material is the primary cause for disc degradation and, ultimately, "end of life" for the disc, assuming proper physical handling.

Environmental factors can affect the rate of disc degradation. In each of the three basic disc types, environmental forces will degrade the data layer much faster than the polycarbonate substrate layer (the clear plastic that makes up most of the disc). Because degradation of the data layer will render the disc useless well before the polycarbonate begins to deteriorate, the relative degradation rate for the polycarbonate layer is not used for life expectancy considerations. Physical mishandling of the disc is usually the cause of polycarbonate layer damage. The polycarbonate may also flex or bend if stored for a long period of time in a nonvertical position.

So what is the life expectancy of a disc? First, we must define life expectancy. For most users, it means the length of time for which the disc remains usable. But that implies some acceptable amount of degradation. How much and what type of degradation is acceptable?

With CDs and DVDs, the user does not notice early degradation because the error detection and correction capability built into the system corrects a certain number of errors. The user notices a problem only when the error correction coding is unable to fully correct the errors.

One method for determining end of life for a disc is based on the number of errors on a disc before the error correction occurs. The chance of disc failure increases with the number of errors, but it is impossible to define the number of errors in a disc that will absolutely cause a performance problem (minor or catastrophic) because it depends on the number of errors left, after error correction, and their distribution within the data. When the number of errors (before error correction) on a disc increases to a certain level, the chance of disc failure, even if small, can be deemed unacceptable and thus signal the disc's end of life.

Manufacturers tend to use this premise to estimate media longevity. They test discs by using accelerated aging methodologies with controlled extreme temperature and humidity influences over a relatively short period of time. However, it is not always clear how a manufacturer interprets its measurements for determining a disc's end of life. Among the manufacturers that have done testing, there is consensus that, under recommended storage conditions, CD-R, DVD-R, and DVD+R discs should have a life expectancy of 100 to 200 years or more; CD-RW, DVD-RW, DVD+RW, and DVD-RAM discs should have a life expectancy of 25 years or more. Little information is available for CD-ROM and DVD-ROM discs (including audio and video), resulting in an increased level of uncertainty for their life expectancy. Expectations vary from 20 to 100 years for these discs.

Few, if any, life expectancy reports for these discs have been published by independent laboratories. An accelerated aging study at NIST estimated the life expectancy of one type of DVD-R for authoring disc to be 30 years if stored at 25°C (77°F) and 50% relative humidity. This testing for R discs is in the preliminary stages, and much more needs to be done.

4.1 CD-ROM, DVD-ROM Discs (audio, video, inter-active games, +graphics, computer applications)

CD-ROMs and DVD-ROMs are similar in that they are replicated discs—that is, the data are physically pressed into the disc when it is manufactured. ROMs are generally mass-produced and contain music, video, computer applications, or interactive games.

ROM disc longevity is determined by the extent to which its aluminum layer is exposed to oxygen. Oxygen, including pollutants, can migrate through the polycarbonate layer or the hard lacquer layer (CD label side and edge), carried in by moisture. Oxygen or moisture can more easily penetrate through scratches, cracks, or delaminated areas in the label. Oxygen can also be trapped inside the disc during manufacturing, although manufacturing improvements have reduced the likelihood of this.

If left in a very humid environment, moisture—and oxygen—will eventually reach the aluminum, causing it to lose its reflectivity. The normally shiny aluminum, which resembles silver, becomes oxide-dull and much less reflective, like the color of a typical aluminum ladder. The combination of high humidity and increased temperatures will accelerate the oxidation rate.

The life expectancy of a ROM disc therefore depends on the environmental conditions to which it is exposed over time. Generally, it is best to keep ROM discs in a dry, cool environment. If the disc is removed from a humid, hot environment to an ideal condition before damage has been done, it will "dry out" and should be as playable as if it had been kept in ideal conditions all along. Other contaminates, however, such as inks, solvents, and pollutants, have the potential to irreversibly penetrate and to deform, discolor, or corrode the disc, causing permanent reading problems for the laser.

4.2 CD-R, DVD-R, DVD+R Discs

Most tests of optical disc life expectancy are performed with recordable discs (CD-R, DVD-R, DVD+R). The tests are generally performed by manufacturers, and the discs are usually categorized by the metal and dye types used in the disc. These discs use gold, silver, or a silver alloy for the reflective layer instead of aluminum as in ROM discs. Gold will not corrode but is expensive. Silver is more reflective and cheaper than gold but is susceptible to corrosion if exposed to sulfur dioxide, an air pollutant that can penetrate the disc in the same way oxygen can—with moisture. Manufacturers use various silver alloys to help inhibit silver corrosion, and most R discs available today use a silver alloy reflective layer. The chance of silver corrosion from exposure to sulfur dioxide is less than the chance of aluminum oxidation caused by high humidity. Nonetheless, keeping the disc in a filtered "clean air" environment can minimize or eliminate its exposure to sulfur dioxide. With proper storage, these discs will outlast the technology.

R discs use a dye-based layer (organic dye) for recording data. These are "write-once" discs and cannot be erased by CD or DVD drives. The organic dye used in the data layer of R discs degrades naturally but slowly over time. High temperatures and humidity will accelerate the process. Prolonged exposure to UV light can degrade the dye properties and eventually make the data unreadable. Heat buildup within the disc, caused by sunlight or close proximity to heated light sources, will also accelerate dye degradation.

Manufacturers claim that CD-R and DVD-R discs have a shelf life of 5 to 10 years *before* recording, but no expiration dates are indicated on CD-R, DVD-R, or DVD+R packaging, nor are there published reports of tests to verify these claims. Still, it would be prudent, in light of these claims, to purchase new discs as they are needed rather than to order large quantities and stockpile them for future use.

4.3 CD-RW, DVD-RW, DVD+RW, DVD-RAM Discs

RW and RAM discs are generally not considered for long-term or archival use, and life expectancy tests are seldom done for this medium. Rewritable discs use a phase-changing metal alloy film for recording data and aluminum for the reflective layer. The alloy film is not as stable as the dye used in R discs because the material normally degrades at a faster rate; however, these discs should still be stable enough to outlast the current CD or DVD technology.

The phase-changing film is affected primarily by heat, but ultraviolet (UV) light may also be a factor in the aging process. The combination of high temperature and UV light may further accelerate the aging process. The combination of high temperatures and high relative humidity will also most likely accelerate the aging process, just as it does with the organic dye used in R discs. No lab test results are yet available on the effects of these environmental conditions on RW or RAM discs.

The data on the phase-changing metal alloy film layer can be erased and rewritten to a limited number of times (about 1,000 times for RW discs and about 100,000 times for RAM discs). This rewriting does, however, affect disc life expectancy; RW or RAM discs archived after the first recording should have a longer life expectancy than those that have undergone several erase-recording cycles. Given the normal degradation rate alone, the life expectancy for RW and RAM discs will be less than that of R discs. Add to that multiple rewrites, and the life expectancy can be even less.

Just as the life expectancy of the disc varies with rewriting, so, too, does the security of the information itself. Information on RW and RAM discs is susceptible to loss or alteration as a result of the rewriting. Information on R discs is more secure precisely because it cannot be changed or rewritten.

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