

# Thermo-Balanced Writing



Thermo Balanced Writing  
for optimal recording



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*A new, patented, system addressing the problem of writing reliably to the very many brands of recordable CD media now on the market, not all of which are in conformance with the agreed international standards established for use in Philips CD-RW drives.*

## Introduction

The explosion in demand for CD Recordable (CD-R) discs and the relentless pursuit of ever lower costs and higher speeds has led to the production and sale of a great many makes and types of discs, both branded and unbranded. Numerous manufacturers all over the world are now producing what has become a commodity item. Unfortunately, in some cases, the quality of these discs are not in accordance with global standards set out in the Orange Book for CD-R media.

The original intent underlying the development and marketing of the expanding family of Compact Disc audio and data drives and their various media types and applications was to have the maximum degree of compatibility, including backwards compatibility, wherever possible. For this reason, the series of agreed global or international standards comprised in the Orange Book have been developed in co-operation and agreement of all major firms involved in the development and exploitation of this technology.

It is this common standard and the insistence on compatibility, which has largely been responsible for the rapid acceptance and intensive development and growth of this versatile storage medium.

Unfortunately, some CD-R discs available in the market do not match up in the basic technical parameters of the standards established in the Orange Book. Production facilities and quality control may be inadequate, and infrequently, sub-standard materials are used or dye layers are insufficiently and uniformly deposited on the substrate. There can be patches of the disc surface almost without recording medium (in addition to scratches, dirty marks or other surface defects), or gross mechanical damage which results in imbalance.

## The CD-R process

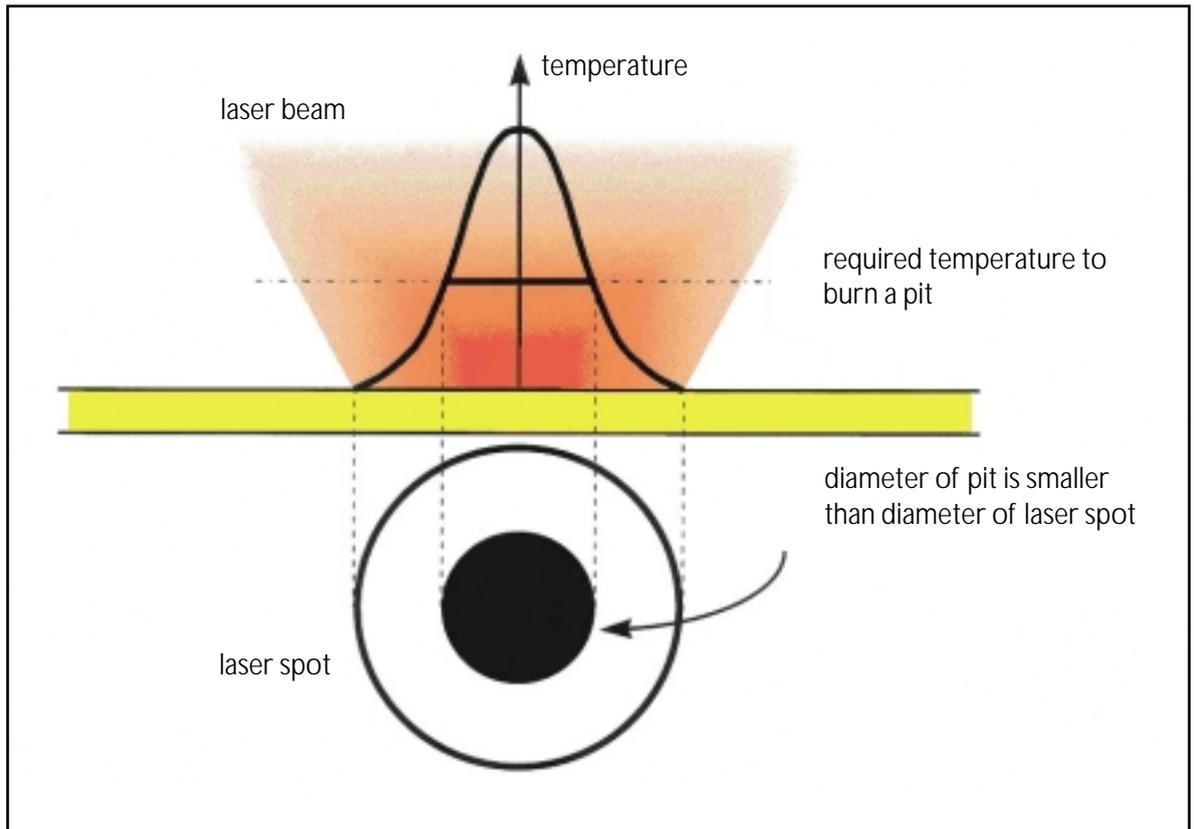
The recording process used for CD-R discs relies on the heating effect of a laser pulse focussed on the dye layer of the disc. Where the laser pulse is applied, a "pit" is created and the reflectivity of the surface is reduced. The signal representing the (digital) data is recorded in the succession of these pits, separated by reflective "lands" of unburned material. The current recording system (drive + disc) is very sensitive to variations outside the Orange Book specifications, particularly when writing at high speeds (12x and higher).

For example, the heat produced by the laser pulse should be just enough to burn a pit to the right size and density. However, if the dye layer is of poor quality, or the disc manufacture is otherwise defective (as an example, unequal deposition of material), the right amount of cooling may not occur in the medium between successive pulses. This results in dimensions of individual pits which can be too large and the possibility of errors may occur in reading ("cross-talk" between tracks).



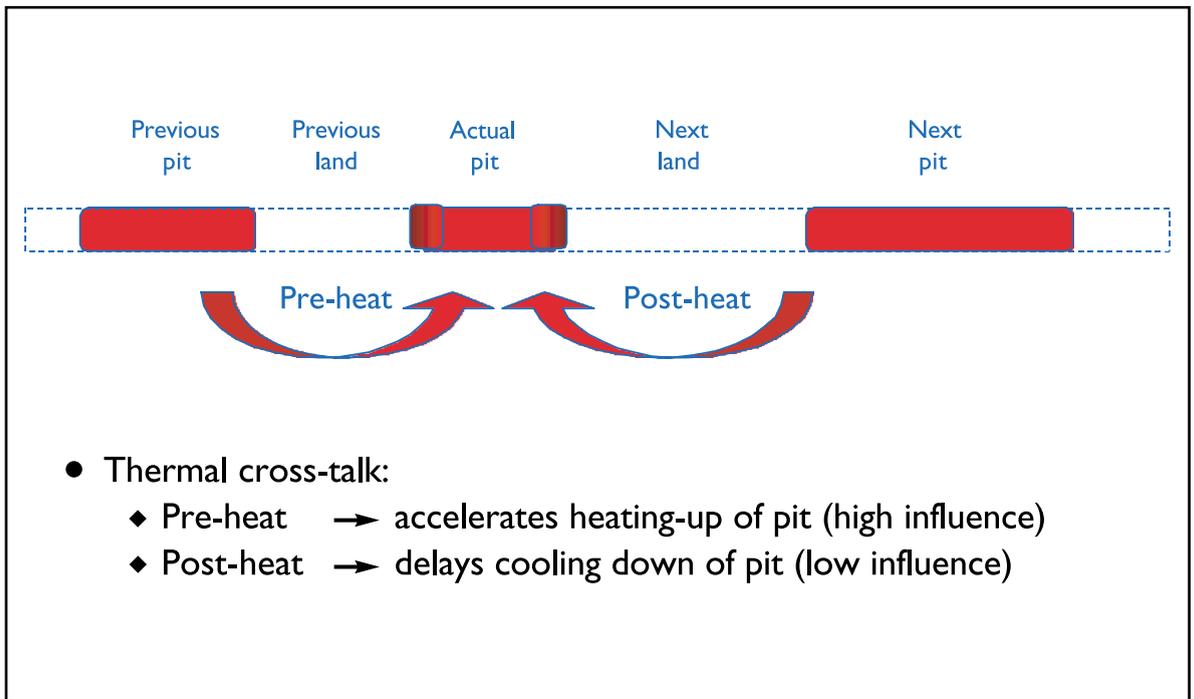
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Fig. 1, Thermo-Balanced Writing: Typical Heat Profile during CD-R write phase. Goal of TBW is to ensure a correctly balanced heat profile during this phase.



Equally of course, if the pits come out too small or too light, then other reading errors can occur. If a CD-R drive has no way of controlling the burn process, to adapt itself to the nature of the media, then the use of such sub-standard discs is far more likely to result in defective recordings and, more importantly, severe End-user disappointment.

Fig. 2, Thermo-Balanced Writing: Pit & Land Cross section. A build up of Thermal "cross-talk" during successive "burns" creates pits with variable dimensions, and the possibility of errors when data is read back.



Unfortunately, there is no reliable way a consumer can judge what he or she is buying (as example, an authoritative quality logo on the disc packaging or verification of media conformance), and so when an End user buys and "burns" what are, in effect, sub-standard discs, any resulting problems are liable to be attributed more often to the CD drive unit than to the disc. It is a question of compatibility, something the End user implicitly desires, and unfortunately, is not able to recognise whether it is there or not.

## The solution

Philips, anticipating End user concerns about disc compatibility and data integrity, has applied considerable effort to developing and testing a system of self-calibration for recording CD-R discs. This solution is "on board" in the drive itself, and provides an excellent solution. It is part of a continuous Philips programme devoted to the perfection of CD technology, and particularly, to anticipating and solving End user problems, thus enabling greater Ease of Use.

The Philips solution lies in a technique designated TBW [Thermo-Balanced Writing], a feature which is to be introduced in all new Philips CD-RW drives. TBW, partnering with a Self-Learning process, adds intelligence to the drive and enables it to automatically make decisions about how to process and write a new disc.

CD-RW drives also write CD-RW discs of course, however, TBW technology is not applicable to the RW function as CD-RW discs utilise a completely different recording methodology.

TBW allows many discs of lower quality to be used without anxiety, and with the assurance that the drive will automatically determine the integrity of the recording layer, then automatically select the correct burn conditions and associate these always with the optimal appropriate recording speed to ensure compatibility. The process is similar to the way in which modern fax machines communicate to detect what kind of partner machine is at the other end of a connection so that the two can transfer data properly without the user having to guess what might be there and press buttons to set up the link.

The heart of the Philips solution is a new hardware and firmware built into the drive with the TBW algorithm which evaluates the disc and determines the burn parameters.

## The intelligent algorithm

When a disc is inserted in the drive with intention to write, the start logic immediately triggers the partner to TBW, the self learning algorithm. In a brief interval of time, unnoticed by the End user, a sequence of physical tests are performed on the disc to determine its' characteristics.

On insertion, a test is automatically made in which a series of test pits are burned into the disc at the appropriate speed and with the burn laser pulsed as necessary to achieve the optimal relationship between pits and lands, in particular, to provide the correct reflectivity differential, the correct position, length and spacing of each element and an acceptable block error rate. The test burn is then read and if the result corresponds, within the tolerances allowed, then the disc is passed for recording under those conditions.



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If this initial test shows some discrepancies, then the algorithm goes to its main sequence. In one or more test burn/read iterations the required burn pulse data is recalculated, and if necessary, the disc is reassigned to the next lowest drive speed available. The calibration stops when the results show a correct performance within defined tolerances. The disc is then recorded with the revised conditions.

What happens is a fast sequence of tests that determine precisely the power dosage of the laser burn pulses that need to be applied to the particular disc that the TBW intelligent CD-RW drive itself discovers to have been inserted in the disc tray.

After final testing, recording can begin and the burn process tailors the laser pulses to give exactly the right amount of heat so as to create a sequence of signal pits all having the right size and density. The result is an optimal ratio of reflectivity between pits and lands, with the correct size and spacing defined. Thus the drive maintains a high degree of accuracy in writing, readability and above all, compatibility.

Note, as well as intelligently calculating the optimal burn parameters, the choice of disc speed is made automatically without any intervention by the user. The user is always assured of a disc being recorded under optimal conditions.

End-users may notice that recording takes place slower (or faster!) than expected (e.g. compared to the information on the disc packaging) but they should almost never see a wasted disc resulting from a recording failure due to this type of problem. As expected, end-users are informed via the application of the new selected recording speed.

In other words, the TBW intelligent drive can calibrate itself and so automatically compensates for variables in the recording media; and every disc is treated individually. This feedback system offers other advantages over one with fixed parameters: if the laser characteristics vary over time or if it suffers from a build-up of dirt, the effect on its output will automatically be compensated for by the TBW feature. This makes for greater reliability, and longer useful life of the drive itself.

## The advantage is real

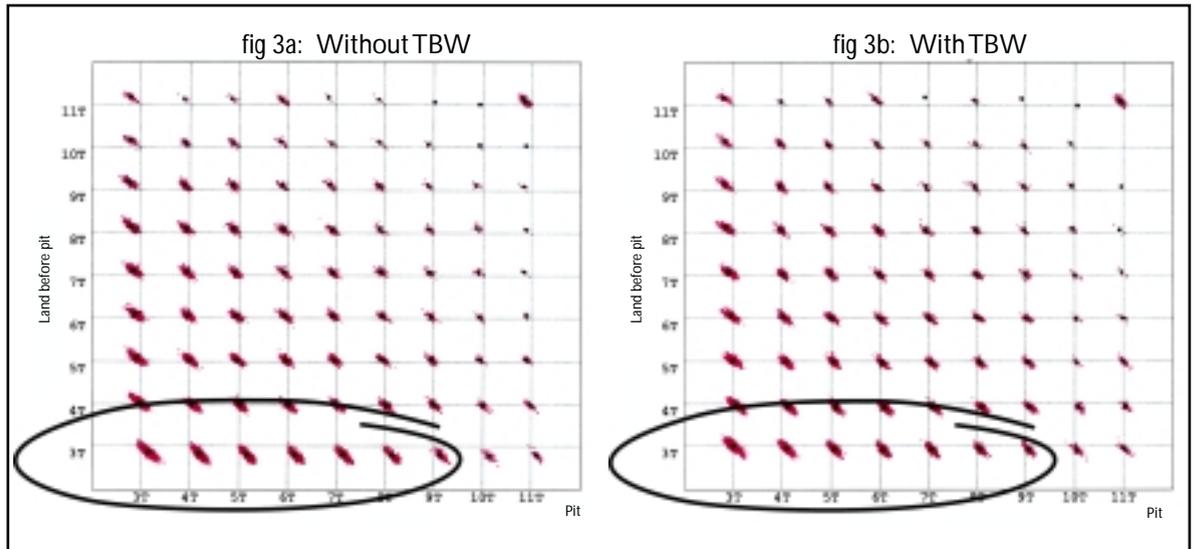
Extensive development and testing of the TBW and Self Learning features was done in the Philips Research Laboratory in the Netherlands, and Philips Development Centre in Belgium. The testing is ongoing, and covers most CD-R media currently available on the market, and has demonstrated the real advantage of Philips solution. Most sub-specification CD-R media can now be satisfactorily written and read with a very limited chance of rejection.

In addition to satisfactory practical tests, objective evidence of the reality of the quality obtained by TBW can be demonstrated (see Fig.3). TWB also forms the basis of a new proposed effort aimed at high speed recordable media standards.



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Fig.3 (Fig. 3a & 3b),  
Thermo- Balanced Writing:  
Thermal "cross-talk" is  
reduced by TBW.



The standard for Pit and Land length is represented by an intersection of the horizontal and vertical lines. The plots, representing the individual measurements of each Pit and Land, in ideal circumstances (no "cross-talk" as example), should be located on the intersections themselves.

The black "dots" in the illustrations represent the average of the measurements of Pit and Land length, and optimal writing would place the black dot on or very near each intersection.

The two charts, one without TBW writing, and one with, clearly demonstrate an improvement in writing accuracy with TBW technology especially at the 3T up to 5T pit combinations. (The 3T up to 5T pit combinations are used for approx. 70% of instances of writing data to disc).

The new Philips 12x8x32x CD-RW is the first product to have been introduced utilising TBW technology and from now, all Philips 8x4x32x CD-RW drives have this feature.

## To summarise

TBW intelligent drive technology, developed and patented by Philips, is a powerful new feature that adds significant End user benefit. End user confidence in recording CD-R discs is assured by a state-of-the-art drive that can create recordings on previously questionable discs. Data integrity is assured by physically testing each disc and then tuning the output of the recording laser and choosing the recording speed to suit each individual disc. Even if the drive determines to use a recording speed lower than the maximum possible, it will always choose the maximum speed which can safely be used for the disc inserted. New discs are likewise characterised and then written to in accordance with their measured characteristics.

These methods result in an "intelligent" drive, which adapts its behaviour to suit the precise requirements of each individual disc, ensuring the best possible recording quality on all media. It provides a very high success rate even when recording on discs of a quality below the internationally recognised standards.

The TBW technology is developed, qualified and already in production.



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**Philips Optical Storage**

Building SFH3

P.O.Box 80002

5600 JB Eindhoven

The Netherlands

[www.components.philips.com](http://www.components.philips.com)

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