

# Ophthalmic optics — Information interchange for ophthalmic optical equipment

The European Standard EN ISO 16284:2006 has the status of a  
British Standard

ICS 11.040.70

# National foreword

This British Standard is the official English language version of EN ISO 16284:2006. It is identical with ISO 16284:2006. It supersedes BS EN ISO 16284:2001 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee CH/172, Ophthalmic optics, to Subcommittee CH/172/3, Spectacles, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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## Summary of pages

This document comprises a front cover, an inside front cover, the EN ISO title page, the EN ISO foreword page, the ISO title page, pages ii to v, a blank page, pages 1 to 70, an inside back cover and a back cover.

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English Version

## Ophthalmic optics - Information interchange for ophthalmic optical equipment (ISO 16284:2006)

Optique ophtalmique - Echange d'informations pour l'équipement d'optique ophtalmique (ISO 16284:2006)

Augenoptik - Datenaustausch zwischen augenoptischen Maschinensystemen (ISO 16284:2006)

This European Standard was approved by CEN on 3 February 2006.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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## Foreword

This document (EN ISO 16284:2006) has been prepared by Technical Committee ISO/TC 172 "Optics and optical instruments" in collaboration with Technical Committee CEN/TC 170 "Ophthalmic optics", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2006, and conflicting national standards shall be withdrawn at the latest by September 2006.

This document supersedes EN ISO 16284:2001.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

## Endorsement notice

The text of ISO 16284:2006 has been approved by CEN as EN ISO 16284:2006 without any modifications.

# INTERNATIONAL STANDARD

**ISO  
16284**

Second edition  
2006-03-01

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## **Ophthalmic optics — Information interchange for ophthalmic optical equipment**

*Optique ophtalmique — Échange d'informations pour l'équipement  
d'optique ophtalmique*



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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 16284 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 7, *Ophthalmic optics and instruments* and by Technical Committee CEN/TC 170, *Ophthalmic optics* in collaboration.

This second edition cancels and replaces the first edition (ISO 16284:2001), which has been technically revised. Since the publication of the first edition in the year 2001, there have been a number of industry developments. Specifically, surface coater, front surface generator, lens measuring, inspection and lap feeder devices have all been developed. In order to communicate with these devices and to support new features on existing device types, the maintenance committee has proposed a number of new labels and device types. This revised International Standard also proposes a way of dealing with file-based data transfers between devices and hosts. In addition, a number of clarifications has been made to further explain certain requirements of the standard and deprecating several requirements because they have proved difficult to manage in practice.

## Introduction

This International Standard is the result of a desire shared by manufacturers of optical laboratory equipment and producers of software used in optical laboratories to simplify the interconnection of their products.

The International Standard defined herein provides:

- a method by which machines and computer systems conduct their exchanges of data;
- a method by which computer systems can initialize such parameters on machines as the manufacturers thereof allow;
- a method by which machines can initialize computer systems with information that the systems can use for various purposes;
- a method by which a machine can inform a computer system as to what information it wants to receive, thus allowing machines to define new interfaces dynamically;
- a standard set of records and device types that are used to communicate agreed upon sets of information.

The last feature listed above requires that this International Standard be amended on a regular basis, as the need for new data elements is inevitable.



# Ophthalmic optics — Information interchange for ophthalmic optical equipment

## 1 Scope

This International Standard establishes a method by which machines and computer software systems used in the fabrication of ophthalmic lenses can exchange information.

## 2 Normative reference

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13666:1998, *Ophthalmic optics — Spectacle lenses — Vocabulary*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13666 and the following apply.

### 3.1 General terms

#### 3.1.1

##### **device**

machine or instrument used in the fabrication of ophthalmic lenses that communicates with a computer system to send or receive job information

#### 3.1.2

##### **host**

computer system providing information to or receiving information from a device

#### 3.1.3

##### **job**

order for prescription ophthalmic lenses or spectacles

#### 3.1.4

##### **download**

communication session in which the host system transmits data to the device

#### 3.1.5

##### **upload**

communication session in which the device transmits data to the host

## 3.2 Special characters

### 3.2.1

#### **code separator**

reserved character used to delimit codes in a device record

### 3.2.2

#### **CRC position character**

reserved character marking the location of the end of the data records and the start of the optional CRC record within a packet

### 3.2.3

#### **end character**

reserved character marking the end of a packet

### 3.2.4

#### **field separator**

reserved character delimiting the fields in a record

### 3.2.5

#### **label separator**

reserved character separating the record label from the field(s) within a record

### 3.2.6

#### **mandatory record flag**

reserved character marking certain records as mandatory

### 3.2.7

#### **start character**

reserved character marking the beginning of a packet

### 3.2.8

#### **record separator**

reserved character which delimits records

### 3.2.9

#### **unknown data indicator**

reserved character indicating that data required for a particular field is unknown to the host

### 3.2.10

#### **ACK character**

reserved character indicating successful transmission of a packet

### 3.2.11

#### **NAK character**

reserved character indicating failed transmission of a packet

### 3.2.12

#### **control character**

character having an ASCII value of less than 32

## 3.3 Data types

### 3.3.1

#### **limited data**

text data limited to a maximum length

**3.3.2****literal data**

text data limited to a maximum length and specified in this International Standard

**3.3.3****numeric data**

floating-point and integer numbers

**3.3.4****text data**

strings of characters that have no pre-defined meaning

**3.3.5****integer data**

data represented in whole number form

**3.3.6****binary data**

data presented in a form usable by computer software with little or no translation

NOTE It requires special handling to avoid introduction of control characters.

**3.4 Messages****3.4.1****message**

structured stream of data transmitted from a host to a device or from a device to a host

**3.4.2****confirmation message**

message sent by the receiver of a packet and comprised of a single character indicating that the transmission was successful

**3.4.3****positive acknowledgement**

single character message indicating successful reception of a sender's message

**3.4.4****negative acknowledgement**

single character message indicating unsuccessful reception of a sender's message

**3.4.5****packet**

structured message consisting of a start character and a series of records and terminated by an end character

**3.4.5.1****data packet**

packet sent from a device to a host or a host to a device, and containing requested information

**3.4.5.2****request packet**

packet sent from a device to a host to initiate a session

**3.4.5.3****response packet**

packet containing status information

## 3.5 Records

### 3.5.1

#### **record**

structured stream of characters including a record label, a label separator, zero or more data fields separated by field separators and a terminating record separator

### 3.5.2

#### **data field**

single data element within a record

### 3.5.3

#### **record label**

means of identifying data contained in a record, limited in length to 8 characters and not including spaces or reserved characters defined in this International Standard

NOTE A list of device record labels is in Annex A.

### 3.5.4

#### **ASCII record**

record comprised of ASCII characters and conforming to the structures defined herein

### 3.5.5

#### **binary record**

record comprised of bytes encoded using the binary number system

### 3.5.6

#### **chiral record**

record with two fields, one for a data element for a right lens or eye, and one for a left, arranged in the order right then left

### 3.5.7

#### **CRC record**

record at the end of any packet containing a CCITT<sup>1</sup> CRC-16 cyclical redundancy check value calculated on the characters transmitted

### 3.5.8

#### **device record**

record containing job specific data elements conveyed between devices and hosts

### 3.5.9

#### **interface record**

record supporting the operation of the host-device interface and not containing job-specific data

## 3.6 Sessions

### 3.6.1

#### **session**

sequence of messages passed between a device and a host that serves to exchange information related to a single order or task

### 3.6.2

#### **initialization session**

specialized session allowing devices to provide hosts with information that would otherwise be included with each request, such as machine model, software version and operator ID

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1) Comité Consultatif International Téléphonique et Télégraphique

**3.6.2.1****auto-format initialization**

initialization session allowing devices to define sets of device records to be requested from hosts

**3.6.2.2****preset initialization**

initialization session allowing devices to transmit sets of identifying data to hosts

**3.6.3****download session**

session in which information is passed from a host to a device

**3.6.4****upload session**

session in which information is passed from a device to a host

**3.6.5****INFO session**

upload request packet containing job status information used to indicate the completion of a job by a device

**3.6.6****MNT session**

upload request packet containing vendor specific device information

**3.7 Timeout****3.7.1****timeout**

numeric value representing that period of time that a host or device shall wait for the arrival of data, after which it assumes that such data will not be forthcoming

**3.7.1.1****confirmation timeout**

timeout which applies to the reception of the confirmation message

**3.7.1.2****intercharacter timeout**

timeout which applies to the interval between successive characters in a stream of data

**3.7.1.3****packet timeout**

timeout which applies to the reception of a packet

**4 Overview**

The strategy used in this International Standard for the exchange of data between devices and hosts can be expressed as follows.

A machine used in the fabrication of ophthalmic lenses (a device) sends a request to a computer system (a host), indicating a need to do one of the following:

- initialize information to identify the device, software versions, model numbers, etc.;
- upload to the host, information for it to store and/or use in the processing of ophthalmic prescription orders;
- download from the host, information required by the device for it to perform its tasks.

Communication can be initialized in two ways. The device may begin an initialization session or the host can force the device to do so by refusing to accept a normal request and asking for initialization via a special error response. For upload requests, the host acknowledges the request and the device sends its data, the receipt of which the host acknowledges. For download requests, the host responds to the request with the data requested.

The variable-length packets of data that comprise this exchange consist of a series of records, each of which contains data and a label identifying the data. This International Standard defines a set of labels and characterizes the data associated with each. This set of labels shall be expanded as needed in the future.

An exchange of packets related to a single job is called a session. The structure of these sessions and the packets of records of which they are comprised is the subject of this International Standard.

Although this International Standard was conceived as being implemented on point-to-point RS-232 serial links, it could be implemented on other hardware platforms. As this is done, specifications shall be incorporated into this International Standard so as to maximize interconnectability amongst diverse hosts and devices.

In the examples given in this International Standard, in the interests of legibility, the RECORD SEPARATORS may be omitted, the START CHARACTER may be placed on a separate line and CRC RECORDS may be excluded. Remarks have been included as REM records. Comments are enclosed in square brackets ([ ... ]) and are not part of the data stream. Ellipses ("...") are used to indicate more data of the same type as precedes and follows the ellipses. SPACES have been inserted around record and field separators for readability; in practice these should not be included in packets as this needlessly decreases the efficiency of expression. In the descriptions of Clause 5, REQUEST, RESPONSE and DATA refer to packets. Since encoded data are always expressed using the point as the decimal sign, to avoid confusion the decimal sign is used throughout this document although the ISO decimal sign is the comma. Furthermore, the space representing the thousandths separator is not given in the encoded data.

## 5 Requirements

### 5.1 Records

#### 5.1.1 Interface records

This International Standard defines a set of interface records. These records contain information which the host and device use to communicate. They do not contain job-specific data. These records are enumerated in A.2.

#### 5.1.2 Device records

This International Standard defines a set of device records which identify the data elements that might be required by any of the devices that might be required for the fabrication of a job. These records are enumerated in A.1.

#### 5.1.3 Preset device types

This International Standard further identifies subsets of device records that are deemed to be appropriate for specific types of devices. These preset records are enumerated in A.3.

#### 5.1.4 Records with unknown values

If the host is requested to send any record for which it has no information or partial information, it shall send the record with a question mark "?" in all the unknown data fields in order to indicate that the information is not available. Such records shall be properly formatted according to the rules for chiral records.

### 5.1.5 Ignored records

Whenever a host or device receives a record with a label it does not recognize, it shall ignore the record.

### 5.1.6 Experimental records

When a machine vendor wishes to test new records prior to submitting them for inclusion in this International Standard, such records should use labels that begin with an underscore character (ASCII “\_”, decimal 95). Record labels are limited in length to 8 characters and may not include spaces or reserved characters defined in this International Standard.

### 5.1.7 Reserved characters

**5.1.7.1** Control characters and the additional characters specified may not appear in transmitted data streams except as specified. The set of reserved characters is specified in Table 1.

**5.1.7.2** Reserved characters shall appear in ASCII records only to provide the functionality that they are assigned, as in the case of record and field separators. Reserved characters which conform to the definition of text data may also appear in text fields.

**5.1.7.3** When a reserved character with a decimal value less than 32 appears in a binary record, it shall be “escaped” in the following manner. In place of such a character, two characters shall be sent. The first character shall be an ESC character followed by the original character with its high bit set, i.e. the character is OR'd with decimal 128, hex 0x80. The receiver, on receipt of an ESC character, shall discard the ESC character and clear the high bit of the following character. The CRC value, if present, shall be determined after such reserved characters are escaped, so that a receiver need not process packets prior to validating a received packet's CRC.

**NOTE** In other words, the transmitter encodes control characters before calculating the CRC, and the receiver calculates the CRC before decoding them.

**EXAMPLE** A stream of bytes (a short tracing record in absolute binary form) before and after having been “escaped” as described above.

Before:

```
R=175 9 23 10 45 10 223 9 90 9 205 8 89 8 252 7 183 7 143 7
130 7 147 7 197 7 24 8 136 8 18 9 167 9 39 10 85 10 19 10
213 9 146 9 75 9 14 9 199 8 120 8 38 8 222 7 166 7 131 7
117 7 122 7 149 7 191 7 241 7 41 8 92 8 152 8 229 8 67 9 <CR/LF>
```

After:

```
R=175 9 23 27 138 45 27 138 223 9 90 9 205 8 89 8 252 7 183 7 143 7
130 7 147 7 197 7 24 8 136 8 18 9 167 9 39 27 138 85 27 138 27 147 27 138
213 9 146 9 75 9 14 9 199 8 120 8 38 8 222 7 166 7 131 7
117 7 122 7 149 7 191 7 241 7 41 8 92 8 152 8 229 8 67 9 <CR/LF>
```

**5.1.7.4** Limited data are a string of ASCII characters in the range 32 to 127 decimals excluding 59 (semi-colon). The length of this string is limited to 12 characters.

**5.1.7.5** Text data are a string of ASCII characters in the range 32 to 127 decimals excluding 59 (semi-colon) and having no predefined meaning. The length is limited to 80 characters.

**5.1.7.6** Literal data is a string of ASCII characters in the range 32 to 127 whose meaning is implied by the record type and specified in this International Standard. Length is limited to 12 characters unless otherwise noted in the record definition. Literal data shall not contain reserved characters defined by the interface (see Table 1). Literal data is case sensitive.

### 5.1.8 Record length

Non-binary records should not exceed 80 characters in length. Binary data may be longer than 80 characters.

**Table 1 — Reserved characters**

| Character | Hexadecimal value | Decimal value | Control key | Use                      |
|-----------|-------------------|---------------|-------------|--------------------------|
| FS        | 0×1C              | 28            | ^\<br>      | Start of message         |
| GS        | 0×1D              | 29            | ^]<br>      | End of message           |
| DC1       | 0×11              | 17            | ^Q<br>      | Reserved (XOFF)          |
| DC3       | 0×13              | 19            | ^S<br>      | Reserved (XON)           |
| ACK       | 0×06              | 06            | ^F<br>      | Positive acknowledgement |
| NAK       | 0×15              | 21            | ^U<br>      | Negative acknowledgement |
| ESC       | 0×1B              | 27            | ^[<br>      | Escape                   |
| RS        | 0×1E              | 30            | ^^<br>      | CRC separator            |
| SUB       | 0×1A              | 26            | ^Z<br>      | DOS end-of-file marker   |
| CR        | 0×0D              | 13            | ^M<br>      | Record separator         |
| LF        | 0×0A              | 10            | ^J<br>      | Record separator         |
| ;         | 0×3B              | 59            | ;<br>       | Field separator          |
| =         | 0×3D              | 61            | =<br>       | Label separator          |
| ,         | 0×2C              | 44            | ,<br>       | Code separator           |
| *         | 0×2A              | 42            | *<br>       | Mandatory record flag    |
| ?         | 0×3F              | 63            | ?<br>       | Unknown data indicator   |

## 5.2 Reference point records

**5.2.1** Records are defined to indicate the horizontal and vertical distances between two reference points or to indicate an action that a machine should take relative to a reference point. The following naming scheme will clarify all such reference records included in this International Standard and can easily be extended for future ones.

**5.2.2** The first two letters of the record label describe the first reference point (see Table 2), the second two letters of the record label describe the second reference point and the last two letters indicate “IN” (horizontal) or “UP” (vertical) directions (see Table 3). The values indicate the position of the second reference point with respect to the first reference point.

**5.2.3** A positive IN value indicates that the second reference point is towards the nasal relative to the first.

**5.2.4** A negative IN value indicates that the second reference point is towards the temporal relative to the first.

**5.2.5** A positive UP value indicates that the second reference point is above the first.

**5.2.6** A negative UP value indicates that the second reference point is below the first.

**Table 2 — Reference point identifiers**

| Identifier | Reference point                                            |
|------------|------------------------------------------------------------|
| BC         | Blank centre                                               |
| FB         | Finish block                                               |
| FC         | Frame centre                                               |
| OC         | Optical centre/prism reference point                       |
| SB         | Surface block                                              |
| SG         | Segment/progressive fitting cross (layout reference point) |

**Table 3 — Reference point records**

| Label           | Meaning                                                     |
|-----------------|-------------------------------------------------------------|
| FBFCIN, FBFCUP  | Finish block to frame centre (see Table A.1 for use)        |
| FBSGIN, FB SGUP | Finish block to segment                                     |
| FBOCIN, FBOCUP  | Finish block to prism reference point (O.C.)                |
| SBBCIN, SBBCUP  | Surface block to blank centre                               |
| BCSGIN, BCSGUP  | Blank centre to segment                                     |
| BCOCIN, BCOCUP  | Blank centre to prism reference point (O.C.)                |
| SBSGIN, SBSGUP  | Surface block to layout reference point (segment)           |
| SBOCIN, SBOCUP  | Surface block to prism reference point (see 5.3.11 for use) |
| SBFCIN, SBFCUP  | Surface block to frame centre                               |
| SGOCIN/SGOCUP   | Segment to O.C.                                             |
| FCSGIN/FCSGUP   | Frame centre to segment (similar to segment height or drop) |
| FCOCIN/FCOCUP   | Frame centre to O.C. (similar to O.C. height or drop)       |

### 5.3 Generator records

**5.3.1** The surface generator interface includes a number of records used to indicate adjustments that should be applied to the generator machine settings. Because this International Standard provides for a complete data set ("preset packet") to be sent to an "unknown" generator, it is necessary to clarify some of the relationships amongst these records, especially as relates to the "compensation" fields.

The position of a lens in a generator can be determined by the RNGH, RNGD, SAGR and SAGBD fields (ring height, ring diameter, lens sag at ring diameter and lens sag at blank diameter, respectively). Some generators, especially those with exclusively mechanical components, may presume certain values for some of the above records and may be unable to effect the adjustments required by the mismatch in assumptions. The following compensation fields provide the data required to make these adjustments.

**5.3.2** BLKCOMP represents the change that is required to be made to the generator thickness setting that arises from a mismatch between the curvature of a block that has a curved contact surface with the lens and the curvature of the lens blocked thereon. The BLKB field contains the curvature of that surface of the block that contacts the lens; the BLKD field contains the diameter of the block.

**5.3.3** When the blocks used for a job do not have a curved contact surface, the BLKB field is not necessary. If it is sent in such a case, its value should be equivalent to IFRNT.

**5.3.4** RNGCMP represents the change that is required to be made to the generator thickness setting that arises from a mismatch between the blocking ring height and/or diameter, known to the host, and that which is presumed by the generator.

**5.3.5** FINCMP indicates the amount of thickness that should be added to the generator setting to allow for material removed during fining (smoothing) and polishing.

**5.3.6** THKCMP shall be used for such compensations to thickness as may be required, which are not otherwise handled by the records defined in this International Standard (the thickness compensation fields apply equally to GTHK and OTHK).

**5.3.7** EECMP indicates a dioptre amount that shall be added to the GCROS and GCROX values when elliptical error compensation is required.

**5.3.8** A host can maintain complete control over the settings on a generator by including all of the compensation values that it believes to be required by a particular machine in the basic setting records and sending zero values in the compensation records; e.g. sum GCROS with EECMP, send the result as GCROS and send EECMP with values equal to zero.

**5.3.9** In compensation records, zero values indicate that the host does not want the machine to apply any compensation that it may be capable of being set to do.

**5.3.10** The ABSENCE of compensation fields indicates that the generator should apply such compensations as it may be set to do.

**5.3.11** For prism versus decentration, the fields GPRVM and GPRVA represent prism magnitude and direction to be generated. These values shall include all possible contributions to prism, including Rx (prescription) prism, thinning prism, and prism for decentration. The fields SBOCIN and SBOCUP express vector distances to which the grinding centre is to be offset from the surface block centre, laterally and vertically. In order that both be expressed in a single packet, as would be desirable in the case of a "generic" GEN request, a set of prism records is defined, RPRVM and RPRVA, which represents prism to be ground exclusive of the decentration expressed in SBOCIN/SBOCUP. In addition, when decentration is expressed directly (via SBOCIN/SBOCUP), the OTHK value should be present. The following rules describe how these fields should be aggregated.

**5.3.11.1** When expressing decentration to be generated as prism, the following fields are used together: GPRVM, GPRVA and GTHK.

**5.3.11.2** When expressing decentration to be generated directly, the following fields are used together: RPRVM, RPRVA, SBOCIN, SBOCUP and OTHK.

**5.3.11.3** Because the method described in 5.3.11.1, in which decentration is expressed in the form of prism, is the more universal one for expressing decentration to be ground, the set of records described therein should be supported by all generators and hosts. The set of records described in 5.3.11.2, in which decentration is expressed as vectors, should be included in addition to the 5.3.11.1 set. Generators not supporting the vector method can safely ignore the vector fields.

**5.3.12** For pad thickness, the inclusion of the PADTHK record indicates that LAP curves cut by a generator should be compensated for the thickness of the pad. No compensation should be made to the lens curves expressed in GBASE/GCROS or GBASEX/GCROX. It is the responsibility of the host to determine such compensations as shall be applied to generator curves, the need for which may result from the use of laps not compensated for pad thickness, or the desire to fine lenses from edge to centre.

**5.3.13** For curve signs, concave curves shall be expressed as negative numbers and convex curves as positive numbers. One implication of this is that for generators that cut laps, the lens curves and lap curves shall have opposite signs.

## 5.4 Tracing records

### 5.4.1 Expression of trace data

Trace data begins with a TRCFMT record that specifies the format in which the tracing is to be expressed, the number of points to be transmitted, whether the radii are equiangular, the orientation of the tracing and an indication of what was traced.

A device indicates its desire to upload or download trace data by including one or more TRCFMT records in either its initialization packet, or, if no initialization is done, its request packet. All supported formats and numbers of points are listed in the order of the device's preference. It is not necessary to include every combination of side specifiers (B, R, and L); because of the requirement specified in 5.4.13, only the device's preferred mode need be specified. Devices that neither upload nor download trace data do not include any TRCFMT records in their initialization or request packets. The same rules apply to sag data and ZFMT.

When trace data is expected by a device, but unavailable from the host, a special form of the TRCFMT record is sent, composed of a single field with the integer value 0. When trace data is available, but sag data is not, a similarly-formed ZFMT record is sent by the host. When TRCFMT=0 is sent, ZFMT=0 is implied and not required. When two sides of radius data are sent, for which sag data are unavailable, a ZFMT=0 record should follow each set of radius data. In the case that two-side data has been negotiated, and only a single side is sent, TRCFMT=0 is not sent for the missing side.

**EXAMPLE 1** Trace data requested by device, but unavailable from host:

```
TRCFMT=0
```

**EXAMPLE 2** Trace data requested by device and available from host, Z data requested, but unavailable:

```
TRCFMT=1;400;E;R;F<CR/LF>
R=2479;2583;2605;2527;2394;2253;2137;2044;1975;1935<CR/LF>
R=1922;1939;1989;2072;2184;2322;2471;2599;2645;2579<CR/LF>
<etc.>
R=1922;1939;1989;2072;2184;2322;2471;2599;2645;2579<CR/LF>
ZFMT=0
```

### 5.4.2 Radius data

These are contained in "R" records. Sag data is contained in "Z" records. Angle data for radius data is contained in "A" records and for sag data in ZA records. For the ASCII format, all of the records follow the 80-character line limit rule, therefore there may (in fact, will likely) be multiple R, A, Z and ZA records for each tracing. For BINARY data, the line limit rule will not apply and there will be only one R, A, Z and ZA record as needed. Radius and sag data is expressed in hundredths of a degree with an implied decimal point.

**EXAMPLE** Radius data:

#### a) ASCII format

```
TRCFMT=1;400;E;R;F<CR/LF>
R=2479;2583;2605;2527;2394;2253;2137;2044;1975;1935<CR/LF>
R=1922;1939;1989;2072;2184;2322;2471;2599;2645;2579<CR/LF>
etc...
```

#### b) Binary formats

```
TRCFMT=2;400;E;R;F<CR/LF>
R=<binary data stream><CR/LF>
```

### 5.4.3 Uneven angles

When these are specified in the TRCFMT record, angle data is required. It shall appear immediately after its corresponding radius data. Angle data is contained in one or more “A” records, and shall be expressed in the same format as the radius data to which it corresponds. Angle data is expressed hundredths of a degree with an implied decimal point and shall be in the range 0 to 35999.

NOTE Angle data can also follow the sag data if uneven angles are specified for the sag data.

### 5.4.4 ZFMT

The sag data format record, ZFMT, has exactly the same definition as the TRCFMT record. The same rules apply to angle data for sag data as to angle data for radius data.

### 5.4.5 “R” records

These shall appear immediately after the TRCFMT record. All of the “R” records for a tracing (i.e. a single side, when two are provided) appear together. Each side has its own TRCFMT record.

### 5.4.6 “Z” records

These shall appear immediately after the ZFMT record. All of the “Z” records for a tracing (i.e. a single side, when two are provided) appear together. Each side has its own ZFMT record.

### 5.4.7 “A” or ZA records

These, when present, shall appear immediately after their corresponding set of “R” or “Z” records. ZFMT and “Z” records shall appear immediately after their corresponding TRCFMT and “R” records.

EXAMPLE A two-eye tracing data set (abbreviated) showing the required sequence of records:

```
TRCFMT=1;400;U;R;F<CR/LF>
R=2479;2583;2605;2527;2394;2253;2137;2044;1975;1935<CR/LF>
R=1922;1939;1989;2072;2184;2322;2471;2599;2645;2579<CR/LF>
...
R=1909;1914;1941;1983;2033;2089;2140;2200;2277;2371<CR/LF>
A=0;90;180;270;360;450;540;630;720;810<CR/LF>
A=900;990;1080;1170;1260;1350;1440;1530;1620;1710<CR/LF>
...
A=35100;35190;35280;35370;35460;35550;35640;35730;35820;35910<CR/LF>
ZFMT=1;100;U;R;F<CR/LF>
Z=322;331;342;328;314;308;300;295;288;280<CR/LF>
...
Z=316;318;324;328;333;343;349;352;357;362<CR/LF>
ZA=0;360;720;1080;1440;1800;2160;2520;2880;3240<CR/LF>
...
ZA=32400;32760;33120;33480;33840;34200;34560;34920;35280;35640<CR/LF>
TRCFMT=1;400;U;L;F<CR/LF>
R=2517;2450;2379;2318;2247;2168;2086;2014;1958;1923<CR/LF>
R=1909;1914;1941;1983;2033;2089;2140;2200;2277;2371<CR/LF>
...
R=1922;1939;1989;2072;2184;2322;2471;2599;2645;2579<CR/LF>
A=0;90;180;270;360;450;540;630;720;810<CR/LF>
A=900;990;1080;1170;1260;1350;1440;1530;1620;1710<CR/LF>
...
A=35100;35190;35280;35370;35460;35550;35640;35730;35820;35910<CR/LF>
ZFMT=1;100;U;R;F<CR/LF>
Z=322;331;342;328;314;308;300;295;288;280<CR/LF>
```

```

...
Z=316;318;324;328;333;343;349;352;357;362<CR/LF>
ZA=0;360;720;1080;1440;1800;2160;2520;2880;3240<CR/LF>
...
ZA=32400;32760;33120;33480;33840;34200;34560;34920;35280;35640<CR/LF>

```

#### 5.4.8 Frame tracings

These shall be centred geometrically when presented to the host. The host may decentre the shape in order to produce a certain effect on a device.

#### 5.4.9 Frame sizing

**5.4.9.1** BSIZ and CSIZ records indicate that devices shall modify the dimensions of the received trace by the amount specified.

**5.4.9.2** Non-zero values shall not be supplied for both BSIZ and CSIZ.

**5.4.9.3** HBOX, VBOX and CIRC records shall reflect the dimensions of the shape sent in R records.

**5.4.9.4** In the particular case where BSIZ and CSIZ are absent or unknown and a single side tracing and two CIRC values which differ are received, the CIRC for the eye sent should reflect the shape. CSIZ is implied to be the difference between the two circumferences and the shape for the eye not sent shall be modified according to the implied CSIZ.

#### 5.4.10 Tracing data

These shall be expressed so that the first radius is at zero degrees (3 o'clock on standard polar scale) and shall proceed anti-clockwise. When angle data are provided, the starting radius shall be the one at the first available meridian greater than or equal to zero.

#### 5.4.11 Eye orientation

**5.4.11.1** Eye orientation, right or left, shall be viewed as a refractionist views a spectacle wearer; right-eye oriented data therefore start at the nasal side while left-eye data start at the temporal.

**5.4.11.2** Eye orientation may be established during initialization. If it is not, it is specified in the devices' request packet.

**5.4.11.3** When eye R (right) is specified, the device wants to send or receive a single set of trace data with right-eye orientation.

**5.4.11.4** When eye L (left) is specified, the device wants to send or receive a single set of trace data with left-eye orientation.

**5.4.11.5** When eye B (both) is specified, the device wants to send or receive both right and left sets of tracing data, each in the appropriate orientation.

#### 5.4.12 Eye orientation during tracing transmission

**5.4.12.1** When eye R (right) is specified in the TRCFMT or ZFMT records, the tracing will have RIGHT eye orientation.

**5.4.12.2** When eye L (left) is specified in the TRCFMT or ZFMT records, the tracing will have LEFT eye orientation.

**5.4.12.3** Eye B shall not be specified in data packets, only in request or initialization packets. In data packets in which both sides are included, there shall be two TRCFMT records, one for each side, labelled appropriately.

### 5.4.13 Trace orientation acceptance

Hosts and devices shall handle the reception of either orientation of tracing data without generating an error condition. Hosts should make an effort to provide data in the quantity and orientation requested by the device when possible.

### 5.4.14 Sag data

In the expression of sag data, the smallest number in the data set shall be positive and shall represent the point located furthest toward the front of the frame or lens. The distances from this point to other points in the data set shall have positive values in increments of 0.01 mm.

## 5.5 Tracing formats

### 5.5.1 Example data

It is strongly recommended that devices be consistent in the representations of data. While it is not expressly forbidden, representing radius data in one orientation and sag data in another, might violate host systems' programmers unwarranted assumptions and fail.

The following small sample tracing, comprised of 40 radii, is used for the examples below. The sample is not formatted in any particular way; it is just a list of the radius values used in the examples given in 5.5.2 to 5.5.6.

24.79, 25.83, 26.05, 25.27, 23.94, 22.53, 21.37, 20.44, 19.75, 19.35,  
19.22, 19.39, 19.89, 20.72, 21.84, 23.22, 24.71, 25.99, 26.45, 25.79,  
25.17, 24.50, 23.79, 23.18, 22.47, 21.68, 20.86, 20.14, 19.58, 19.23,  
19.09, 19.14, 19.41, 19.83, 20.33, 20.89, 21.40, 22.00, 22.77, 23.71

### 5.5.2 ASCII absolute format

In this format, each radius is presented as a 4-digit decimal number in hundredths of a millimetre with an implied decimal point. Each value is separated by a field separator (semi-colon). Data shall follow the 80-character line limit rule, therefore multiple "R" records are required for a single radius data set.

**EXAMPLE** A tracing expressed in format #1, ASCII absolute, requires 196 bytes of radius data (including the semi-colons).

```
TRCFMT = 1;40;E;R;F<CR/LF>
R=2479;2583;2605;2527;2394;2253;2137;2044;1975;1935<CR/LF>
R=1922;1939;1989;2072;2184;2322;2471;2599;2645;2579<CR/LF>
R=2517;2450;2379;2318;2247;2168;2086;2014;1958;1923<CR/LF>
R=1909;1914;1941;1983;2033;2089;2140;2200;2277;2371<CR/LF>
```

### 5.5.3 Binary absolute format

In this format, each radius is expressed as a 16-bit integer with the radius in hundredths of a millimetre. The entire data set is contained within a single radius data record.

**EXAMPLE** Each binary 8-bit byte in the following example is represented by one or more decimal digits separated from the next byte by a space. Semi-colons are used to separate the individual radii. *The semi-colons and spaces are not part of the actual binary record.*

A tracing expressed in format #2, binary absolute, requires 86 bytes including the escape characters. The first example shows the data prior to the escape process (described in 5.1.7.3) having been applied, the second, afterwards. The escape sequences are shown in **bold**.

```

TRCFMT = 2;40;E;R;F
R=175  9; 23 10; 45 10;223  9; 90  9;205  8; 89  8;
      252 7;183  7;143  7;130  7;147  7;197  7; 24  8;
      136 8; 18  9;167  9; 39 10; 85 10; 19 10;213  9;
      146 9; 75  9; 14  9;199  8;120  8; 38  8;222  7;
      166 7; 131  7;117  7;122  7;149  7;191  7;241  7;
      41  8; 92  8;152  8;229  8; 67  9<CR/LF>

TRCFMT = 2;40;E;R;F
R=175  9;23 27 138;45 27 138;223  9; 90  9;205  8 ; 89  8;
      252 7;183  7;143  7;130  7;147  7;197  7; 24  8;
      136 8; 18  9;167  9; 39 27 138; 85 27 138;27 147 27 138;213  9;
      146 9; 75  9; 14  9;199  8;120  8; 38  8;222  7;
      166 7;131  7 117  7;122  7;149  7;191  7;241  7;
      41  8; 92  8;152  8;229  8; 67  9<CR/LF>

```

#### 5.5.4 Binary differential format

In this format, the starting radius is represented as a two-byte integer, as in format 2. Each radius thereafter is represented in a single signed byte as the difference between the current radius and the previous one. The data value expressed is therefore equal to the previous radius subtracted from the current. If the differential cannot be represented by signed byte, whose value shall be between  $-127$  and  $+127$ , a special value (hexadecimal  $0 \times 80$ ,  $-128$  decimal) is used to indicate that the next radius is expressed in absolute (i.e. 16-bit) form. The radius immediately following the 16-bit value is then represented in differential form.

**EXAMPLE** A tracing expressed in format #3, binary differential, requires 54 bytes including the escape characters. As above, the first example shows the data prior to the escape process (described in 5.1.7.3) having been applied, the second, afterwards. In the first example, the absolute radii flags are shown in **bold**. In the second, the escape sequences are shown in **bold**.

```

TRCFMT = 3;40;E;R;F
R=175  9; 104; 22; -78; -128 90 9; -128 205 8; -116; -93;
      -69; -40; -13; 17; 50; 83; 112; -128 18 9; -128 167 9;
      -128 39 10; 46; -66; -62; -67; -71; -61; -71; -79; -82;
      -72; -56; -35; -14; 5; 27; 42; 50; 56; 51; 60; 77; 94<CR/LF>

TRCFMT = 3;40;E;R;F
R=175  9; 104; 22; -78 ; -128 90 9; -128 205 8; -116; -93;
      -69; -40; -13; 27 145; 50; 83; 112; -128 18 9; -128 167 9;
      -128 39 27 138; 46; -66; -62; -67; -71; -61; -71; -79; -82;
      -72; -56; -35; -14; 5; 27 155; 42; 50; 56; 51; 60; 77; 94<CR/LF>

```

#### 5.5.5 Packed binary format

This is the most efficient, and most complex, method for the expression of shape information. To facilitate implementation of this format, a complete example is included in Annex B.

Three data types are defined (the decimal sign is a point):

- absolute, in which sixteen-bit “words” are used to express values in the range  $-327.67$  mm to  $+327.67$  mm;
- differential, in which eight-bit “bytes” are used to express values in the range  $-1.26$  mm to  $+1.27$  mm;
- incremental, in which four-bits “nibbles” are used to express values in the range  $-0.07$  mm to  $+0.07$  mm.

The first radius in a tracing is always expressed using the absolute data type. Radii subsequent to the first may be expressed as any of the three forms. Special values are reserved for each of the three types, which are inserted into the data stream to indicate that subsequent radii will be expressed in a different data type. These are shown in Table 4.