Tutorial on ISO 10110 Optical Drawing Standard
OPTI 521 – Intro to Opto-Mechanical Engineering

Jason Lane

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1. Introduction.

Specifying optical components is a vital method for the optical designer to relay to the optician exactly what is expected to be produced. Without a standard method for describing the details of the part, there is no guarantee that the designer will end up with a part which matches his/her specifications.

For this reason, Geometrical Dimensioning & Tolerancing (GD&T) was devised as a method to explicitly describe nominal geometry and allowed variation for use in engineering drawings. In the United States, the most commonly encountered standard for GD&T (2D) is ANSI Y14.5 – 2009, although most machine shops will still be using Y14.5M-1994 as the current version is still very new. In the ISO system, GD&T is governed by the standards ISO 286-1 and -2:1988, ISO 1101:2005, ISO 5458:1998, and ISO 5459:1981. GD&T standards for data exchange and integration is governed by ISO 10303.

This tutorial assumes that the reader is familiar with basic GD&T practices, such that the focus of the tutorial may rest on the unique practices associated with describing optical components. As a mechanical part, an optical component can be described to some extent under the standards listed above. However, the unique aspects of optical components require additional standards to accurately describe the part to be made.

2. Optical Drawing Standards

ASME/ANSI Y14.18M is the American standard reference for specifying optical components. ANSI Y14.18M has its roots in the now-obsolete MIL-STD-34, and was written about the time that camera manufacturing ceased in the US. It is unclear what impact ASME Y14.18M has had on optical drawing standards in the US, except perhaps in its original form as MIL-STD-34. The ISO standards are much more commonly used in industry. ISO Technical Committee 172, Optics and Optical Instruments, writes the majority of standards for specifying optical components. The standards of most importance are: ISO 10110, *Optics and optical Instruments – Preparation of optical drawings for optical elements and systems*, is the primary reference for preparation of drawings for optical elements and systems. ISO 9211, *Optical Coatings*, is also very important. There is no American standard equivalent to ISO 9211. In addition to these, there are many ancillary standards which contribute to the specification and testing of optical components. A complete list is provided in Appendix A.

3. ISO 10110

ISO 10110 is a 13-part standard describing the preparation of drawings for optical elements and systems. Each part covers a different aspect of the optical drawing.

Part	Title	Indication
1	General	N/A
2	Material imperfections – Stress birefringence	0/
3	Material imperfections – Bubbles and Inclusions	1/
4	Material Imperfections – Inhomogeneity and Striae	2/
5	Surface form tolerances	3/
6	Centering Tolerances	4/
7	Surface Imperfection tolerances	5/
8	Surface Texture	$\sqrt{}$
9	Surface Treatment and coating	Ⓛ
10	Table representing data of a lens element	N/A
11	Non tolerance data	N/A
12	Aspheric surfaces	N/A
13	Laser irradiation damage threshold	6/

Table 1: Structure of ISO 10110-1 standard.

Part 1 covers the mechanical aspects of optical drawings that are specific to optics and not already covered in one of the ISO mechanical drawing standards. Important points to note are

- The use of the metric system for linear dimensions is established, although the standard does allow use of the English system (and must be stated on the drawing). The use of the metric system per ASME Y14.5M will satisfy the ISO standards, except that a comma is used in the ISO standard instead a period to signify decimal point.
- GD&T as described in the ISO system is used for presentation and dimensioning of optical components and assemblies. The ISO standards are very similar to ASME Y14.5M, but there are several important differences which should be reviewed and understood.
- First angle projection is used (as opposed to prevalent third-angle projection used in the US) for illustration of parts

Part 2 covers stress birefringence of the part. The indication in the drawing is 0/X, where X is the maximum birefringence in nm/cm. OPD due to stress birefringence is $a*\sigma*K$, where a is path length in cm, σ is residual stress in N/mm, and K is difference in photoelastic constants in 10^{-7} mm / N. A retardation > 20 nm / cm corresponds to a coarse anneal, and a retardation of < 10 nm/cm is a fine anneal.

Part 3 covers bubbles and inclusions. The callout is 1/NxA where N is the number of allowed bubbles or inclusions, and A is the length of the side of a square in mm. A^2 is the area that the bubble or inclusion obscures. The obscured area may be sub-divided into smaller bubbles, provided that the obscured area is no larger than designated. A typical designation would be 1/3x.1 (3 bubbles allowed, each covering an

area no larger than $0.1^2 = 0.01\ mm^2$). This system is also used for designation of surface defects as covered in Part 7.

Part 4 covers imperfections due to inhomogeneity (variations in index of refraction from nominal) and striae (variations in index of refraction inside the glass part). The callout is 2/A;B, where A is the class number for inhomogeneity and B is the class for striae. See the tables below.

Class	Maximum permissible variation of refractive index within a part [10^{-6}]
0	± 50
1	± 20
2	± 5
3	± 2
4	± 1
5	± 0,5

Table 2: Inhomogeneity Classes

Striae class	Density of striae causing an optical path difference of at least 30 nm in %
1	≤ 10
2	≤ 5
3	≤ 2
4	≤ 1
5	Extremely free of striae The restriction to striae exceeding 30 nm does not apply Further information to be specified in a note

Table 3: Classes of striae

Part 5 describes the surface form tolerances for the optical surfaces. This is indicated on the drawing by 3/A(B/C). A is the maximum spherical sag error from test plate. A dash can be substituted for A where the radius tolerance is a dimension. B is the p-v maximum irregularity, and C is the maximum rotationally symmetric p-v figure error (best fit aspheric surface). The units are fringes (one half wavelength of 546.07 nm) and RMS specification for fringes can be used. For example, 3/4(1) implies the sag tolerance is 4 fringes and the p-v irregularity is no greater than 1 fringe. A callout of 3/-(2) implies a p-v irregularity of 2 fringes, and the radius of curvature is tolerance by the radius specification if the surface is spherical (untoleranced if plano).

Part 6 covers centering tolerances (centring). The callout is 4/α, where α is the angle between the datum and the surface. The indication is always the same for each surface, but the method of indicating the datum follows mechanical drawing practice. A polished surface can be a datum, and is often the best choice. See figures below for examples.

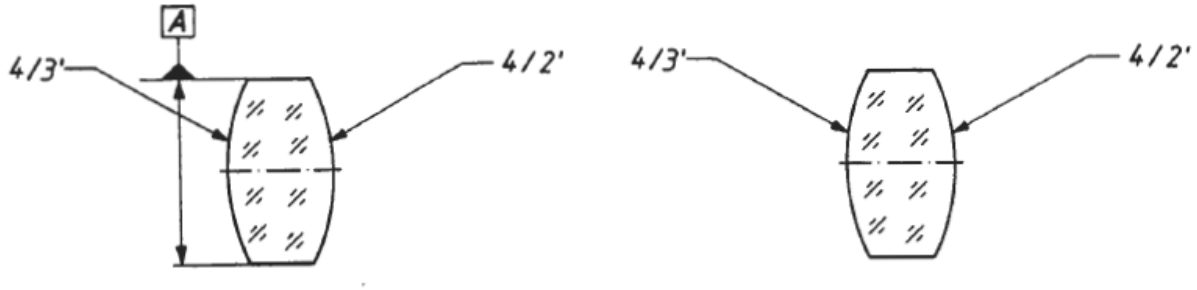

Figure 1: Centring tolerances example, ISO 10110-7

Part 7 covers surface imperfection tolerances. The callout is 5/NxA, and is similar to that of Part 3. Coating imperfections are preceded by a C, long scratches preceded by an L, and edge chips by an E. Examples are: 5/NxA; CN'xA'; LN"xA", EA'". A'" is the chip protrusion from the edge.

Part 8 covers the surface texture, and uses a texture symbol as the designator. This designates the quality of polish applied to the optical surfaces, and indicates ground surfaces (typically applied to edges). The following figure shows surface texture callouts.

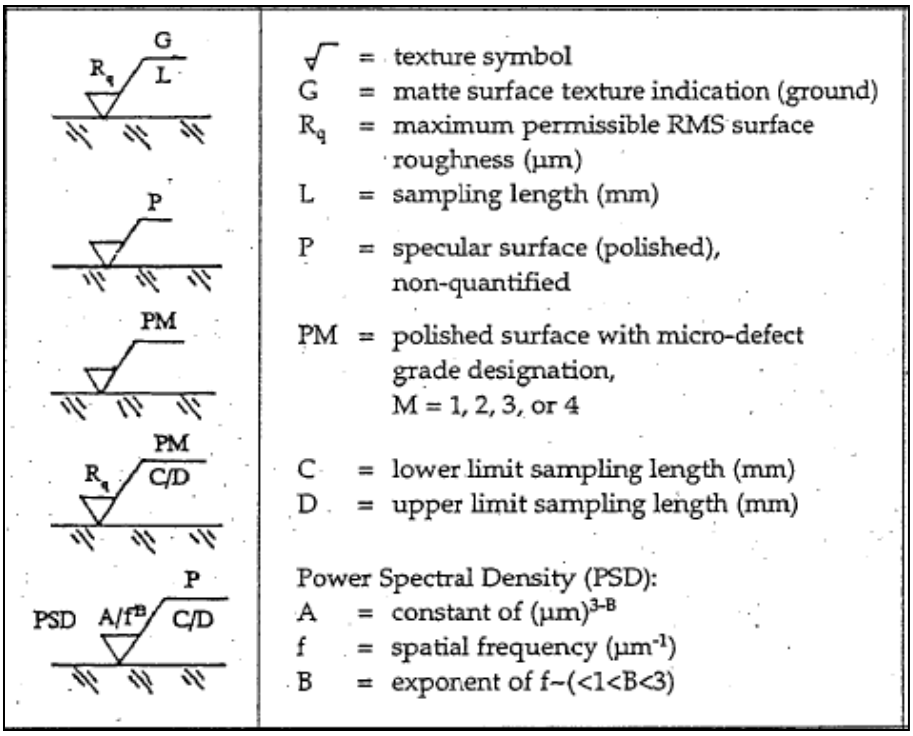

Figure 2: Surface texture callouts from ISO 10110-8

Part 9 specifies surface treatment and coatings, and can be indicated one of two ways as shown in the figure below.

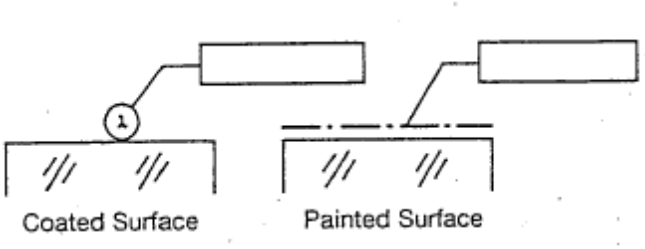

Figure 3: Indication that surface is to be coated.

The clear aperture (referenced as the optically effective surface in ISO 10110) must be specified in the drawing. The box that identifies the coating requirements specifies them according to ISO 9211. A common example for a surface with transmission requirement greater than 0.9 for a wavelength range from 450 to 750 nm would be $\rho = 0.9$ for $450 \leq \lambda \leq 750$ nm. The callout can also refer to a graph, with a callout stating "spectral reflectance as in graph xx for angle of incidence < 15°". Graph xx would then be indicated elsewhere on the drawing. The coating could also be referred to as a manufacturer's coating trade name, and would not need to be reproduced on the optical element drawing. The coating callout can also indicate a surface to be cemented.

ISO 10110-10 describes how to represent the data of the lens element in tabular form. While the ISO 10110 standard attempts to present optical components with a minimum amount of notes, the amount of information presented can become imposing. This is particularly true for simple lens elements, where a simpler method of presenting the information could be used to avoid ambiguity and errors in reading.

The tabular form of presenting data has precedent in the US. ASME Y14.18M presents optical data in tabular form as well, and MIL-STD-34 did so to some extent. The major optical design programs have adopted presenting ISO 10110 data in tabular form according to Part 10. An example of a lens drawing generated by Zemax is presented on the following page.

Note that the tabulated data is divided up into surfaces and glass material. The way in which the information is laid out is intuitive for how optical prescriptions and prescription layouts are interpreted. This layout will be the type most commonly encountered in industry.

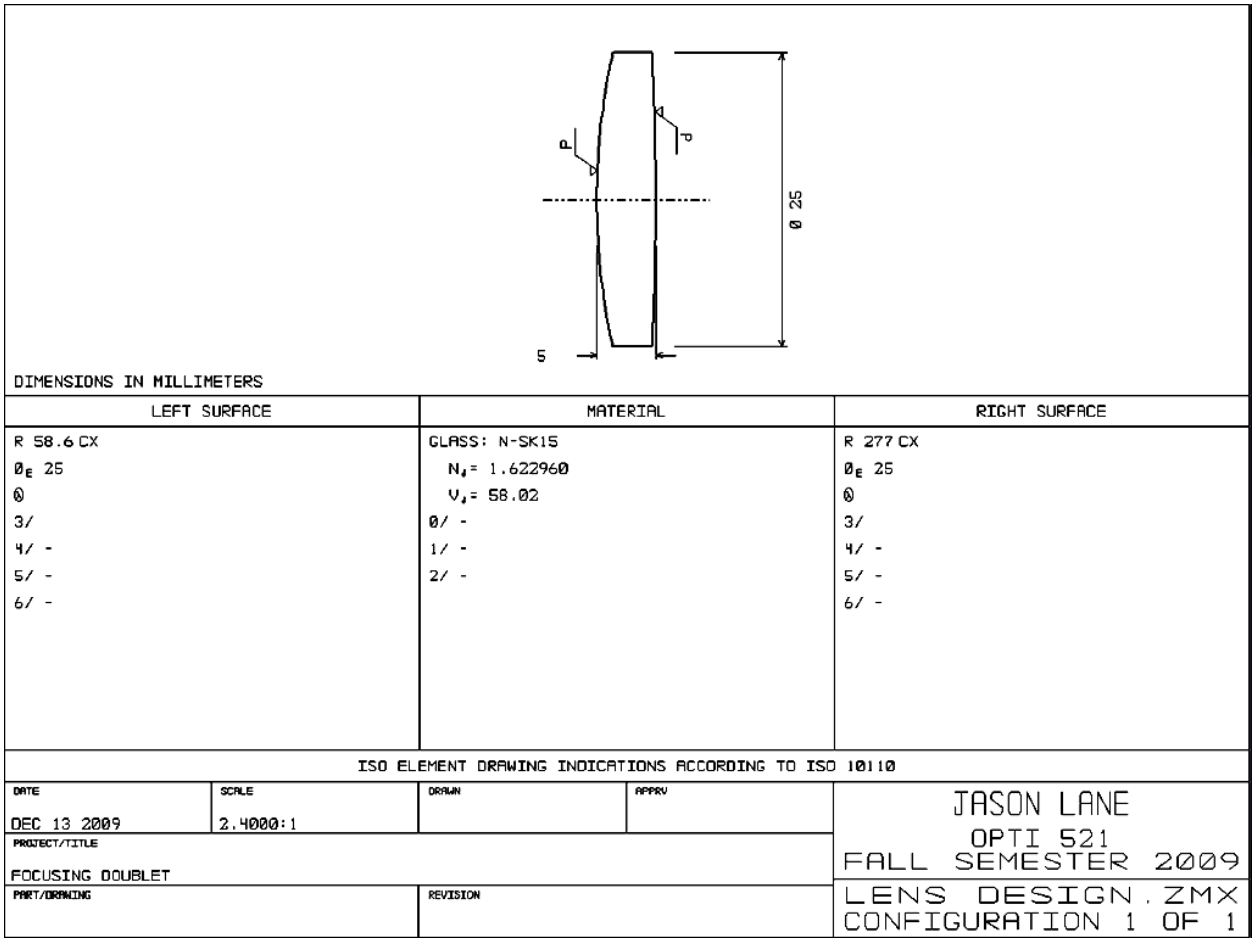

Figure 4: ISO 10110 Tabulated Data Drawing layout.

Part 11 describes maximum allowable tolerances on features of the optical elements when those tolerances are not specifically called out on the optical drawing. This is different than how tolerances are handled in the US. Typically, an ASME Y14.5M drawing will have block (or shop) tolerances called out on the part, and these are in no way standardized in Y14.5M. Part 11 of ISO 10110 is an attempt to guarantee that no optical element will be manufactured to looser tolerances than specified in the standard unless specifically called out in the drawing.

Table 4 provides the features and the corresponding "default" tolerances called out in Part 11. It should be noted that the default tolerances given in this part are very loose and may lead to undesirable consequences if not carefully considered. Note also that the tolerances scale with the size of the part, a practice common in Europe but rarely encountered in the US.

Property	Range of maximum (diagonal) dimension of the part [mm]			
	up to 10	over 10 up to 30	over 30 up to 100	over 100 up to 300
Edge length, diameter [mm]	±0,2	±0,5	±1	±1,5
Thickness [mm]	±0,1	±0,2	±0,4	±0,8
Angle deviation of prisms and plate	±30'	±30'	±30'	±30'
Width of protective chamfer [mm]	0,1 - 0,3	0,2 - 0,5	0,3 - 0,8	0,5 - 1,6
Stress birefringence acc. to ISO/DIS 10110-2 [nm/cm]	0/20	0/20	-	-
Bubbles and inclusions acc. to ISO/DIS 10110-3	1/3x0,16	1/5x0,25	1/5x0,4	1/5x0,63
Inhomogeneity and striae acc. to ISO/DIS 10110-4	2/1;1	2/1;1	-	-
Surface form tolerances acc. to ISO/DIS 10110-5	3/5(1)	3/10(2)	3/10(2) (all Ø 30)	3/10(2) (all Ø 60)
Centring tolerances acc. to ISO/DIS 10110-6	4/30'	4/20'	4/10'	4/10'
Surface imperfection tolerances acc. to ISO/DIS 10110-7	5/3x0,16	5/5x0,25	5/5x0,4	5/5x0,63

Table 4: Toleranced data, ISO 10110-11

Part 12 of ISO 10110 involves specifying aspheric surfaces. The procedures used to indicate aspheres on optical drawings are similar to those for ordinary surfaces, with a few exceptions. First, the type of surface should be indicated clearly. The radius on the face of the drawing is replaced by the word "asphere" or by the type of asphere for standard types. The equation which describes the surface should be given in a note. Slope tolerance and sampling length should be specified. Datums and datum systems are defined differently in ISO 10110-12 than they are in ISO 5459. The details of the datum system used in Part 12 stem from the fact that aspheric surfaces are frequently located mechanically during fabrication and in the optical system. If an alternate datum system is desired, a note on the drawing should be included saying, for example, "Indications of datums according to ISO 5459".

Part 13 describes indications for laser power damage, or laser irradiation damage thresholds. The indication is given by $6/H_{th}$; λ; pdg; f_p; n_{TS} x n_p for pulsed lasers, or $6/E_{th}$; λ; n_{TS} for continuous lasers. The 6/ code is associated with 3/, 4/, and 5/ codes on the drawing. "6/" is the indication for laser damage specification. λ is the wavelength of the laser. "pdg" is the pulse duration group number from ISO 11254, "f_p" is the pulse repetition rate in Hz; "n_{TS}" is the number of test sites on the sample surface, and

"n_p" is the number of laser pulses applied to each site. The test level H_{th} is expressed in terms of maximum energy density (J/cm^2) in the target plane, and E_{th} is the maximum power density (W/cm^2) for continuous tests.

Examples of ISO 10110 standard drawings

Figure 5 is a ZEMAX-generated drawing which conforms to the ISO 10110 standard. This is a simple spherical convex-convex element which was the subject of several homework assignments in OPTI 521. In ZEMAX, this drawing is generated by selecting Analysis -> Layout -> ISO Element Drawing. Right click on the newly opened window and select the first surface of the element which is intended to be shown. In the "Show As.." menu, select singlet or doublet as appropriate.

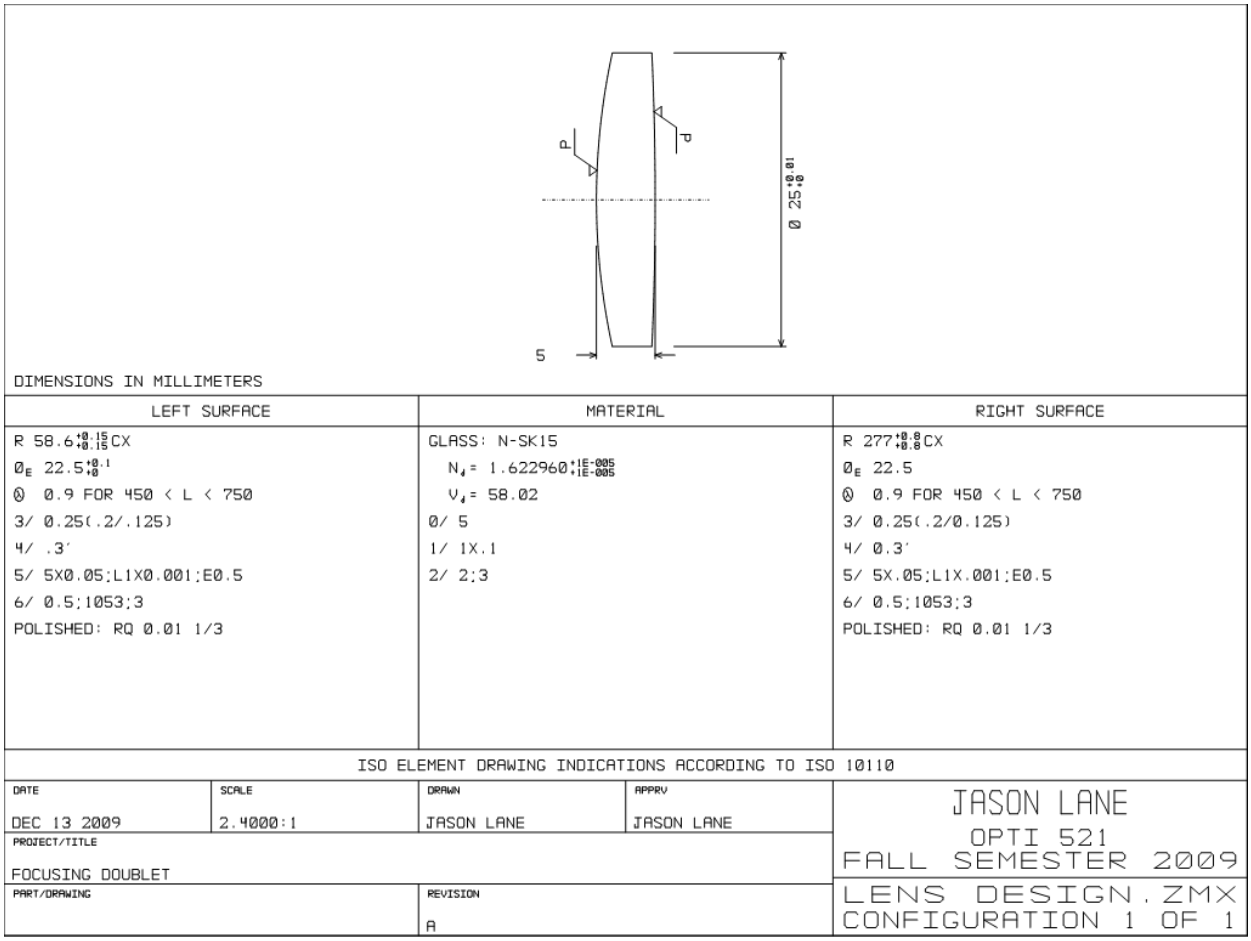

Figure 5: ISO 10110 compliant drawing generated by ZEMAX

Specifications	Value	Notes
R1, R2	58.6 / 277	Tolerances are +/- 0.15 for R1, +/- 0.8 for R2
Center Thickness	5	Default tolerance (+/- 0.2)
Material	N-SK15 or equivalent	
Lens diameter	25 +0.01/-0	
Clear (Effective) Aperture	22.5 +0.1 / - 0	
Stress birefringence	0/5	Maximum OPD is 5nm/cm
Bubbles and inclusion	1/1x0.1	Allow up to 1 inclusion, no larger than 100 um in size, over clear aperture
Inhomogeneity and Striae	2/2:3	Homogeneity class 2 is +/-5e-06 Striae class 3 is < 2%
Surface form error for both surfaces	3/0.25(0.2/0.125)	0.25 fringe of sag (power) error 0.2 fringe of irregularity error 0.125 fringe of symmetric irregularity error
Centering error	4/0.3'	Element wedge is 0.3 arc minute
Surface form error	5/5x0.05;L1x0.001;E0.5	Allow up to 5 digs, each no larger than 50 um in size, over the clear aperture Allow 1 additional long scratch, no wider than 1um and longer than 4mm over the optical clear aperture (this is a 10-5 scratch/dig spec) Allow 1 edge chip no larger than 0.5 mm. Polish out all edge chips
Laser damage threshold	0.5 J/cm^2	λ=1053 nm 3 ns FWHM Gaussian pulse
AR coating	T > 90% for spectral band from 450 to 750 nm	

Conclusion

This tutorial describes the basic premises of the ISO 10110 standard. This tutorial covers basic information about the different parts of the ISO standard, including feature callouts for simple optical components. It is by no means a substitute for a thorough understanding of the ISO 10110 standard. For a more complete reference, please refer to *ISO 10110 Optics and Optical Instruments – Preparation of drawings for optical elements and systems: A User's Guide, Second Edition* by Ronald K. Kimmel and Robert E. Parks, or refer to the ISO 10110 standards themselves. In addition, SPIE regularly hosts ISO 10110 Drawing Standard short courses taught by David M. Aikens. For more information, see the spie.org website.

References

1. Ahmad, A., *Handbook of Optomechanical Engineering*, CRC Press, 1997

2. Yoder, P., *Opto-Mechanical Systems Design, Third Edition*, CRC Press, 2006

3. http://spie.org/samples/PM173.pdf

4. Sinclair Optics, *Singelem.len – An ISO 10110 element drawing example*, available at http://www.sinopt.com/software1/usrguide54/examples/singelem.htm

5. MIL-STD-34 (now obsolete) available for download at http://www.everyspec.com/MIL-STD/MIL-STD+(0000+-+0099)/MIL-STD-34_7031/

6. Kimmel, R. and Parks, R., *ISO 10110 Optics and Optical Instruments, A User's Guide, Second Edition*, Optical Society of America, 2002.

7. Wang, D., English Jr., R., Aikens, D. M., *Implementation of ISO 10110 Optics Drawing Standards for the National Ignition Facility, Optical Manufacturing and Testing III Proceedings Vol. 3782,* 11 November 1999. Available in pdf form through SPIE at http://spie.org/x648.html?product_id=369230

Appendix A. ISO Standards Pertaining to Optics, under purview of TC 172. From http://www.iso.org

Under direct cognizance of TC 172

ISO 7944:1998	Optics and optical instruments -- Reference wavelengths
ISO 20473:2007	Optics and photonics -- Spectral bands
ISO 23584-1:2009	Optics and photonics -- Specification of reference dictionary -- Part 1: General overview on organization and structure

TC 172 / SC 1: Fundamental Standards

ISO 517:2008	Photography -- Apertures and related properties pertaining to photographic lenses -- Designations and measurements
ISO 8478:1996	Photography -- Camera lenses -- Measurement of ISO spectral transmittance
ISO 9022 (21 Parts)	Optics and optical instruments -- Environmental test methods
ISO 9039:2008	Optics and photonics -- Quality evaluation of optical systems -- Determination of distortion
ISO 9334:2007	Optics and photonics -- Optical transfer function -- Definitions and mathematical relationships
ISO 9335:1995	Optics and photonics -- Optical transfer function -- Principles and procedures of measurement
ISO 9336-1:1994	Optics and optical instruments -- Optical transfer function -- Application -- Part 1: Interchangeable lenses for 35 mm still cameras
ISO 9358:1994	Optics and optical instruments -- Veiling glare of image forming systems -- Definitions and methods of measurement
ISO 10109 (Parts 1, 6, 7, 8, 11, 12 under SC 1)	Optics and photonics -- Environmental requirements
ISO 10110 (Parts 1-12, 14, 17 under SC 1)	Optics and photonics -- Preparation of drawings for optical elements and systems
ISO 11421:1997	Optics and optical instruments -- Accuracy of optical transfer function (OTF) measurement
ISO 13653:1996	Optics and optical instruments -- General optical test methods -- Measurement of relative irradiance in the image field
ISO 14997:2003	Optics and optical instruments -- Test methods for surface imperfections of optical elements
ISO/TR 14999 (4 Parts)	Optics and photonics -- Interferometric measurement of optical elements and optical systems
ISO 15368:2001	Optics and optical instruments -- Measurement of reflectance of plane surfaces and transmittance of plane parallel elements

ISO 15529:2007	Optics and photonics -- Optical transfer function -- Principles of measurement of modulation transfer function (MTF) of sampled imaging systems
ISO 15795:2002	Optics and optical instruments -- Quality evaluation of optical systems -- Assessing the image quality degradation due to chromatic aberrations

TC 172/SC 3 - Optical materials and components

ISO 8424:1996	Raw optical glass -- Resistance to attack by aqueous acidic solutions at 25 degrees C -- Test method and classification
ISO 9211 (4 Parts)	Optics and optical instruments -- Optical coatings
ISO 9385:1990	Glass and glass-ceramics -- Knoop hardness test
ISO 9689:1990	Raw optical glass -- Resistance to attack by aqueous alkaline phosphate-containing detergent solutions at 50 degrees C -- Testing and classification
ISO 9802:1996	Raw optical glass -- Vocabulary
ISO 10629:1996	Raw optical glass -- Resistance to attack by aqueous alkaline solutions at 50 degrees C -- Test method and classification
ISO 11455:1995	Raw optical glass -- Determination of birefringence
ISO 12123:1996	Raw optical glass in bulk and preshaped forms -- Bubbles and other inclusions -- Test method and classification
ISO 12844:1999	Raw optical glass -- Grindability with diamond pellets -- Test method and classification

TC 172/SC 4 – Telescopic Systems

ISO 9336-3:1994	Optics and optical instruments -- Optical transfer function -- Application -- Part 3: Telescopes
ISO 10109-4:2001	Optics and optical instruments -- Environmental requirements -- Part 4: Test requirements for telescopic systems
ISO 14132 (5 Parts)	Optics and optical instruments -- Vocabulary for telescopic systems
ISO 14133 (2 Parts, General Purpose Instruments and High Performance Instruments)	Optics and optical instruments -- Specifications for binoculars, monoculars and spotting scopes
ISO 14134:2006	Optics and optical instruments -- Specifications for astronomical telescopes
ISO 14135 (2 Parts, Same breakdown as 14133)	Optics and optical instruments -- Specifications for telescopic sights
ISO 14490 (7 Parts)	Optics and optical instruments -- Test methods for telescopic systems
ISO 21094:2008	Optics and photonics -- Telescopic systems -- Specifications for night vision devices

TC 172/SC 5 - Microscopes and endoscopes

ISO 8036:2006	Optics and photonics -- Microscopes -- Immersion liquids for light microscopy
ISO 8037 (2 Parts)	Optics and optical instruments -- Microscopes -- Slides
ISO 8038 (Part 1, Standard. Part 2, Metric)	Optics and optical instruments -- Microscopes -- Screw threads for objectives and related nosepieces
ISO 8039:1997	Optics and optical instruments -- Microscopes -- Magnification
ISO 8040:2001	Optics and optical instruments -- Microscopes -- Dimensions of tube slide and tube slot connections
ISO 8255 (2 Parts)	Optics and optical instruments -- Microscopes -- Cover glasses
ISO 8576:1996	Optics and optical instruments -- Microscopes -- Reference system of polarized light microscopy
ISO 8577:1997	Optics and optical instruments -- Microscopes -- Spectral filters
ISO 8578:1997	Optics and optical instruments -- Microscopes -- Marking of objectives and eyepieces
ISO 8600 (6 Parts)	Optics and photonics -- Medical endoscopes and endotherapy devices
ISO 9344:1996	Optics and optical instruments -- Microscopes -- Graticules for eyepieces
ISO 9345 (2 Parts)	Optics and optical instruments -- Microscopes -- Imaging distances related to mechanical reference planes
ISO 10934 (2 Parts)	Optics and optical instruments -- Vocabulary for microscopy
ISO 10935:2009	Microscopes -- Interfacing connection type C
ISO 10936-1:2000	Optics and optical instruments -- Operation microscopes -- Part 1: Requirements and test methods
ISO 10937:2000	Optics and optical instruments -- Microscopes -- Diameter of interchangeable eyepieces
ISO 11882:1997	Optics and optical instruments -- Microscopes -- Interfacing connection for 35 mm SLR photo cameras (T-thread adaptation)
ISO 11883:1997	Optics and optical instruments -- Microscopes -- Marking of stereomicroscopes
ISO 11884 (2 Parts)	Optics and photonics -- Minimum requirements for stereomicroscopes
ISO 12853:1997	Optics and optical instruments -- Microscopes -- Information provided to the user
ISO 15227:2000	Optics and optical instruments -- Microscopes -- Testing of stereomicroscopes
ISO 15362:1998	Optics and optical instruments -- Stereomicroscopes -- Information provided to the user
ISO 19012 (2 Parts)	Optics and photonics -- Designation of microscope objectives

TC 172 / SC 6 – Geodetic and Survey Instruments

ISO 9849:2000	Optics and optical instruments -- Geodetic and surveying instruments -- Vocabulary
ISO 12858 (3 Parts)	Optics and optical instruments -- Ancillary devices for geodetic instruments
ISO 17123 (7 Parts)	Optics and optical instruments -- Field procedures for testing geodetic and surveying instruments

TC 172 / SC 7 – Ophthalmic Optics and Instruments

ISO 7998:2005	Ophthalmic optics -- Spectacle frames -- Lists of equivalent terms and vocabulary
ISO 8429:1986	Optics and optical instruments -- Ophthalmology -- Graduated dial scale
ISO 8596:2009	Ophthalmic optics -- Visual acuity testing -- Standard optotype and its presentation
ISO 8598:1996	Optics and optical instruments – Focimeters
ISO 8612:2009	Ophthalmic instruments -- Tonometers
ISO 8624:2002	Ophthalmic optics -- Spectacle frames -- Measuring system and terminology
ISO 8980 (5 Parts)	Ophthalmic optics -- Uncut finished spectacle lenses
ISO 9342 (2 Parts)	Optics and optical instruments -- Test lenses for calibration of focimeters
ISO 9394:1998	Ophthalmic optics -- Contact lenses and contact lens care products -- Determination of biocompatibility by ocular study using rabbit eyes
ISO 9801:2009	Ophthalmic instruments -- Trial case lenses
ISO 10322 (2 Parts)	Ophthalmic optics -- Semi-finished spectacle lens blanks
ISO 10341:2009	Ophthalmic instruments -- Refractor heads
ISO 10342:2003	Ophthalmic instruments -- Eye refractometers
ISO 10343:2009	Ophthalmic instruments -- Ophthalmometers
ISO 10936-2:2001	Optics and optical instruments -- Operation microscopes -- Part 2: Light hazard from operation microscopes used in ocular surgery
ISO 10938:1998	Ophthalmic instruments -- Chart projectors
ISO 10939:2007	Ophthalmic instruments -- Slit-lamp microscopes
ISO 10940:2009	Ophthalmic instruments -- Fundus cameras
ISO 10942:2006	Ophthalmic instruments -- Direct ophthalmoscopes
ISO 10943:2006	Ophthalmic instruments -- Indirect ophthalmoscopes
ISO 10944:2009	Ophthalmic instruments -- Synoptophores
ISO 11380:1994	Optics and optical instruments -- Ophthalmic optics -- Formers
ISO 11381:1994	Optics and optical instruments -- Ophthalmic optics -- Screw threads
ISO 11978:2000	Ophthalmic optics -- Contact lenses and contact lens care products -- Information supplied by the manufacturer

ISO 11979 (10 Parts)	Ophthalmic implants -- Intraocular lenses
ISO 11980:2009	Ophthalmic optics -- Contact lenses and contact lens care products -- Guidance for clinical investigations
ISO 11981:2009	Ophthalmic optics -- Contact lenses and contact lens care products -- Determination of physical compatibility of contact lens care products with contact lenses
ISO 11985:1997	Ophthalmic optics -- Contact lenses -- Ageing by exposure to UV and visible radiation (in vitro method)
ISO 11986:1999	Ophthalmic optics -- Contact lenses and contact lens care products -- Guidelines for determination of preservative uptake and release
ISO 11987:1997	Ophtalmic optics -- Contact lenses -- Determination of shelf-life
ISO 12864:1997	Ophthalmic optics -- Contact lenses -- Determination of scattered light
ISO 12865:2006	Ophthalmic instruments -- Retinoscopes
ISO 12866:1999	Ophthalmic instruments -- Perimeters
ISO 12867:1998	Ophthalmic instruments -- Trial frames
ISO 12870:2004	Ophthalmic optics -- Spectacle frames -- Requirements and test methods
ISO 13212:1999	Ophthalmic optics -- Contact lens care products -- Guidelines for determination of shelf-life
ISO 13666:1998	Ophthalmic optics -- Spectacle lenses -- Vocabulary Fundamental requirements
ISO 14534:2002	Ophthalmic optics -- Contact lenses and contact lens care products --
ISO 14729:2001	Ophthalmic optics -- Contact lens care products -- Microbiological requirements and test methods for products and regimens for hygienic management of contact lenses
ISO 14730:2000	Ophthalmic optics -- Contact lens care products -- Antimicrobial preservative efficacy testing and guidance on determining discard date
ISO 14889:2003	Ophthalmic optics -- Spectacle lenses -- Fundamental requirements for uncut finished lenses
ISO 15004 (2 Parts)	Ophthalmic instruments -- Fundamental requirements and test methods
ISO 15253:2000	Ophthalmic optics and instruments -- Optical devices for enhancing low vision
ISO 15254:2009	Ophthalmic optics and instruments -- Electro-optical devices for enhancing low vision
ISO 15752:2000	Ophthalmic instruments -- Endoilluminators -- Fundamental requirements and test methods for optical radiation safety
ISO 15798:2001	Ophthalmic implants -- Ophthalmic viscosurgical devices
ISO 16034:2002	Ophthalmic optics -- Specifications for single-vision ready-to-wear near- vision spectacles
ISO 16284:2006	Ophthalmic optics -- Information interchange for ophthalmic optical equipment

ISO 16671:2003	Ophthalmic implants -- Irrigating solutions for ophthalmic surgery
ISO 16672:2003	Ophthalmic implants -- Ocular endotamponades
ISO 18369 (4 Parts)	Ophthalmic optics -- Contact lenses
ISO/TS 19979:2004	Ophthalmic optics -- Contact lenses -- Hygienic management of multipatient use trial contact lenses
ISO 19980:2005	Ophthalmic instruments -- Corneal topographers
ISO/TR 20824:2007	Ophthalmic instruments -- Background for light hazard specification in ophthalmic instrument standards
ISO 21987:2009	Ophthalmic optics -- Mounted spectacle lenses
ISO/TR 22979:2006	Ophthalmic implants -- Intraocular lenses -- Guidance on assessment of the need for clinical investigation of intraocular lens design modifications
ISO 24157:2008	Ophthalmic optics and instruments -- Reporting aberrations of the human eye
ISO/TS 24348:2007	Ophthalmic optics -- Spectacle frames -- Method for the simulation of wear and detection of nickel release from metal and combination spectacle frames
ISO/TR 28980:2007	Ophthalmic optics -- Spectacle lenses -- Parameters affecting lens power measurement
IEC 80601-2-58:2008	Medical electrical equipment -- Part 2-58: Particular requirements for basic safety and essential performance of lens removal devices and vitrectomy devices for ophthalmic surgery

TC 172/SC 9 - Electro-optical systems

ISO 11145:2006	Optics and photonics -- Lasers and laser-related equipment -- Vocabulary and symbols
ISO 11146 (3 Parts. Part 3 is ISO/TR 11146)	Lasers and laser-related equipment -- Test methods for laser beam widths, divergence angles and beam propagation ratios
ISO 11151 (2 Parts)	Lasers and laser-related equipment -- Standard optical components
ISO 11252:2004	Lasers and laser-related equipment -- Laser device -- Minimum requirements for documentation
ISO 11254 (3 Parts)	Lasers and laser-related equipment -- Determination of laser-induced damage threshold of optical surfaces
ISO 11551:2003	Optics and optical instruments -- Lasers and laser-related equipment -- Test method for absorptance of optical laser components
ISO/TR 11552:1997	Lasers and laser-related equipment -- Laser materials-processing machines -- Performance specifications and benchmarks for cutting of metals
ISO 11553 (2 Parts)	Safety of machinery -- Laser processing machines
ISO 11554:2006	Optics and photonics -- Lasers and laser-related equipment -- Test methods for laser beam power, energy and temporal characteristics

ISO 11670:2003	Lasers and laser-related equipment -- Test methods for laser beam parameters -- Beam positional stability
ISO 11807 (2 Parts)	Integrated optics -- Vocabulary
ISO 11810 (2 Parts)	Lasers and laser-related equipment -- Test method and classification for the laser resistance of surgical drapes and/or patient protective covers
ISO 11990:2003	Optics and optical instruments -- Lasers and laser-related equipment -- Determination of laser resistance of tracheal tube shafts
ISO 12005:2003	Lasers and laser-related equipment -- Test methods for laser beam parameters -- Polarization
ISO 13694:2000	Optics and optical instruments -- Lasers and laser-related equipment -- Test methods for laser beam power (energy) density distribution
ISO 13695:2004	Optics and photonics -- Lasers and laser-related equipment -- Test methods for the spectral characteristics of lasers
ISO 13696:2002	Optics and optical instruments -- Test methods for radiation scattered by optical components
ISO 13697:2006	Optics and photonics -- Lasers and laser-related equipment -- Test methods for specular reflectance and regular transmittance of optical laser components
ISO 14880 (4 Parts)	Optics and photonics -- Microlens arrays
ISO 14881:2001	Integrated optics -- Interfaces -- Parameters relevant to coupling properties
ISO 15367 (2 Parts)	Lasers and laser-related equipment -- Test methods for determination of the shape of a laser beam wavefront
ISO 15902:2004	Optics and photonics -- Diffractive optics -- Vocabulary
ISO 17526:2003	Optics and optical instruments -- Lasers and laser-related equipment -- Lifetime of lasers
ISO/TR 22588:2005	Optics and photonics -- Lasers and laser-related equipment -- Measurement and evaluation of absorption-induced effects in laser optical components
ISO 24013:2006	Optics and photonics -- Lasers and laser-related equipment -- Measurement of phase retardation of optical components for polarized laser radiation