INTERNATIONAL

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Standard Test Method for
Measuring Optical Retardation in Flat Architectural Glass[1]

This standard is issued under the fixed designation C1901; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε^1 NOTE—The title of Section 9 was corrected editorially in March 2021.

1. Scope

1.1 This test method addresses the measurement of optical anisotropy in architectural glass.

1.2 This test method is a test method for measuring optical retardation. It is not an architectural glazing specification.

1.3 The optical retardation values may be used to calculate/predict the amount of visible pattern, commonly known as anisotropy or iridescence, present in heat-treated glass.

1.4 This test method applies to monolithic heat-treated (heat-strengthened and fully tempered) clear, tinted and coated glass.

1.5 This test method does not apply to:

1.5.1 Glass that diffuse light (that is, patterned glass, sand blasted glass, acid etched, etc.), or

1.5.2 Glass that is not optically transparent (that is, mirrors, enameled or fritted glass).

1.6 The optical measurement is integrated through the glass thickness, and therefore cannot be used to assess the level of tempering. It does not give information on the surface stress or center tension.

1.7 The values stated in SI units are to be regarded as standard. The values given in parentheses after SI units are provided for information only and are not considered standard.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 Reference to these documents shall be the latest revision unless otherwise specified by the authority applying this test method.

2.2 *ASTM Standards for Glass:*[2]

C162 Terminology of Glass and Glass Products
C1036 Specification for Flat Glass
C1048 Specification for Heat-Strengthened and Fully Tempered Flat Glass

2.3 *ASTM Standards for Optical Stress and Retardation Measurements:*[2]

C1279 Test Method for Non-Destructive Photoelastic Measurement of Edge and Surface Stresses in Annealed, Heat-Strengthened, and Fully Tempered Flat Glass
D4093 Test Method for Photoelastic Measurements of Birefringence and Residual Strains in Transparent or Translucent Plastic Materials

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of terms used in this test method, refer to Specifications C1036, C1048, and Terminology C162, as appropriate.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *analyzer, n*—a polarizing element, typically rotatable and positioned between the specimen being evaluated and the observer.

3.2.2 *anisotropy, n*—property of being directionally dependent whereby measurements taken along different axes produce differences in a material's physical or mechanical properties (absorbance, refractive index, conductivity, etc.).

3.2.3 *Babinet-Soleil compensator, n*—an optical compensator that can be used to measure phase shifts locally in a polariscope or polarimeter using shifting quartz wedges.

3.2.4 *birefringence, n*—the optical property of a material having a refractive index that depends on the polarization and propagation direction of light.

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[1] This test method is under the jurisdiction of ASTM Committee C14 on Glass and Glass Products and is the direct responsibility of Subcommittee C14.08 on Flat Glass.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2.5 *compensation methods, n—(1)* Sénarmont compensator uses linearly polarized light incident to the specimen; it couples a quarter wavelength plate with a 180° rotating analyzer to provide retardation measurements; *(2)* Tardy compensator uses circularly polarized light incident to the specimen, thus independent of the specimen orientation; it also couples a quarter wavelength plate with a 180° rotating analyzer to provide retardation measurements.

3.2.6 *index of refraction, n*—the ratio of speed of light (c) in vacuum and the phase velocity of light in the medium (v).

3.2.7 *iridescence, n*—also known as quench pattern/marks, strain pattern or anisotropy, visible pattern in heat-treated glass that may be visible under certain polarized lighting conditions.

3.2.8 *isochromatic, adj*—having the same color or wavelength.

3.2.9 *photoelasticity, n*—the property exhibited by transparent isotropic solids of becoming doublerefracting when subjected to either tensile or compressive stress.

3.2.10 *polarizer, circular, n*—an optical assembly that creates circularly polarized light for a given wavelength.

3.2.11 *polarizer, linear, n*—an optical assembly that transmits light vibrating in a single planar direction.

3.2.12 *retardation, n*—the optical path difference between two perpendicular polarized light waves created in a birefringent material.

3.2.13 *retardation standard, n*—see *waveplates.*

3.2.14 *specular light, n*—radiation emerging from the specimen is parallel to the beam entering.

3.2.15 *wave retarder, n*—see waveplates.

3.2.16 *waveplates, n*—birefringent materials that retard the polarization state or phase of light traveling through them.

4. Summary of Test Method

4.1 This test method provides an accurate non-destructive method of quantifying optical retardation in transparent glass using principles of photoelasticity and high-speed image processing. The result is a high-resolution retardation map in nanometres (nm). Optionally, the apparatus can compute an additional map of retardation axis orientation (azimuth) in degrees. This test method provides a process for monitoring these variations.

5. Significance and Use

5.1 Stress may be applied intentionally through a heat treatment or tempering process to increase mechanical strength and improve safety characteristics of glass sheets. The process itself makes it practically impossible to achieve a homogenous residual stress profile over a full glass panel. These variations are due to variations in type of glass (clear, tinted, coated, etc.), the fabrication, sheet geometry, heating, quenching, and cooling. Even though the level of inhomogeneity may not interfere with the global mechanical property of the glass sample, it can produce optical patterns called anisotropy (often commonly referred to as leopard spots). Today to evaluate this stress homogeneity people may use the subjective, non-standardized method of viewing through a polarized filter or employing a polariscope. The present test method provides guidelines for measuring a physical parameter, the optical retardation, directly linked to the local residual stress, at many locations on each heat-treated glass sheet.

5.2 Through this test method one can obtain in a non-destructive manner, on-line to the tempering furnace equipment, a map of the retardation value of all glasses. That information can then be used:

5.2.1 By the tempering operator to adjust the settings of the heat treatment process to optimize/tune both the levels optical retardations and its homogeneity on heat treated glass sheets.

5.2.2 To provide a standardized way to measure optical retardation values for each glass panel that can be archived and communicated when desired.

5.2.3 By customers and other stakeholders to develop/write specifications for the optical retardation values (not the visibility of the pattern) that are independently verifiable.

5.3 This test method can also be used off-line to evaluate the optical retardation level and homogeneity of any heat-treated glass, for quality assurance or other purposes.

6. Limitations

6.1 A series of factors will affect the results. These factors should be either avoided or documented to explain how they affect results.

6.1.1 The *light transmission* of the specimen at the wavelength(s) being used to measure optical retardation should be in accordance with apparatus manufacturer specification.

6.1.2 The deviation from *flatness* of the glass after the heat treatment process might affect the measurement, as the light may travel out of the equipment range. The glass flatness, overall bow, edge kink, roller wave must be in accordance with apparatus manufacturer specifications.

6.1.3 The *thermal state* of the specimen when measured will affect the results as non-uniform temperature across the thickness and from one region to another on the same pane will induce stresses. Variance can occur with glass temperature.

6.1.4 When measuring optical retardation using photoelastic devices, attention should be paid to external *mechanical stresses* applied to glass.

6.1.5 Area around *geometric features* (holes, notches, openings) and edges will have high retardation values that may exceed equipment range (see example of edge stress in Test Method C1279). Including retardation values in these regions may bias calculations such as uniformity and averages. Exclusion zones can be setup to eliminate some regions, for example: perimeter bands or partially enameled areas. These zones should be properly identified in the report.

6.1.6 See Fig. 1 for example of exclusion zones.

6.1.7 See Appendix X1 for further discussion about more complex circumstances (that is, laminates, insulated glass units) that must be approached carefully when applying the test method.

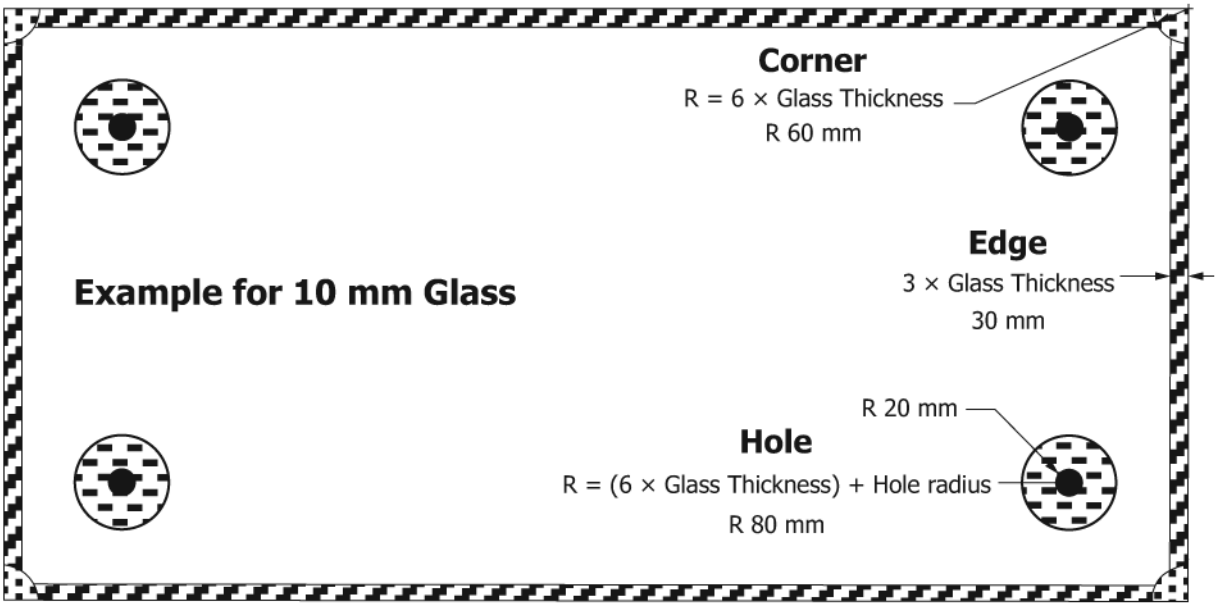

FIG. 1 Exclusion Zones Example

7. Apparatus and Compatibility

7.1 *General:*

7.1.1 The apparatus measures the spatially resolved optical retardation of an area according to the principles of digital photoelasticity. The apparatus must be designed in such a way that reproducible, direction-independent retardation values are generated. The optical components must match the wavelength range of the light source. The image acquisition may be done with any suitable digital sensor (camera, linear sensor, etc.).

7.1.2 See Fig. 2(a) and Fig. 2(b) for images of apparatus.

7.1.3 Please consult Appendix X2 for more nonmandatory information on apparatus, their suggested range, precision, and bias.

7.2 *Procedure A—Calibrated Polarimeter:*

7.2.1 A polarimeter directly measures the optical retardation and its axis orientation (azimuth) by means of a polarization-sensitive matrix or line scan detector ("polarization camera") using quasimonochromatic circularly polarized light. Instead of using a mechanical or electro-optical rotating analyzer, as known from the Sénarmont or Tardy polarimeter setup, it is sufficient to analyze a few discrete polarization planes, typically 0, 45, 90, and 135°.

7.2.2 Commercially available or proprietary polarization cameras can contain multiple sensors (one for each polarization orientation) or a subdivided sensor (one quadrant for each polarization orientation) in combination with suitable beam-splitting optics. Alternatively, each pixel of the camera can be equipped with individual micro-scale polarizers (like the color filters of a single-sensor RGB camera).

7.2.3 Since the measuring range is physically limited to a certain fraction of the illumination wavelength (the value of which is depending on the used optical setup and the quality of the used optical components), the measuring range can be extended by analyzing multiple wavelengths and correlating the results mathematically or by using phase-unwrapping image algorithms, or both, as known from interferometric evaluation.

7.2.4 The linearity and absolute correctness of the measurement can be ensured by comparison to reliable retardation-generating devices such as Babinet-Soleil compensators. If necessary, a characteristic line curve can be generated to calibrate the measurement.

7.3 *Procedure B—Calibrated Polariscope:*

(a) Camera System

(b) Line Scan Bar System With Light

FIG. 2 Camera and Line Scan Bar With Light Sytems

7.3.1 By calibration, circular polariscopes can be used practically to quantify retardation based on isochromatic images. Due to the optical configuration, the maximum optical retardation is measured independently of the direction. There are several approaches to correlate intensity values (RGB colors or gray values) with retardation values. One method is a calibration using a Babinet-Soleil compensator. A correlation of the acquired calibration, in nm, with the isochromatic image (intensity values) using an evaluation algorithm creates a new image with retardation (nm) per pixel.

8. Hazards

8.1 Glass is a brittle material and may result in glass fracture. Glass handling safety gear should always be worn during specimen handling, testing, evaluation, and disposal. Apparatus discussed in this test method may utilize high intensity light sources such as a laser. Proper care and manufacturer's instructions must be followed by the operator.

9. Calibration and Verification

9.1 Apparatus manufacturers use proprietary methods to convert their sensor output into workable retardation values. Through self-calibration or recalibration, it ensured that this conversion method generates valid and constant values during the life of their instrument in given environmental conditions: temperature, humidity, vibration, and dust.

9.2 Operator should verify that the calibration and verification be done in accordance with apparatus manufacturer suggested practices and authorities having jurisdiction (see Table 1).

9.3 A minimum of three retarders should be run though the scanner. After recording the zero (blank area), sample A, B, C values, the plate should be rotated a fraction of a complete rotation and run again. This procedure is repeated four times. Obtaining the retardation at 0, 1/16 (22.5 ± 5°), 1/8 (45 ± 5°), 1/4 (90 ± 5°) allowing to confirm the angle independence, precision, and the bias (repeatability) of measurements. Additional measurements continuing at 22.5° increments may be done.

TABLE 1 Retarder Specification

Minimum Number of Retarders	3 (to cover the useful range)
Minimum Dimension	Workable area of 25 × 25 mm
Range[A]	Sample A: 20–40 nm Sample B: 60–80 nm Sample C: 100–120 nm
Precision	±2 nm (averaged over any 25 × 25 mm area)
Wavelength	570 nm as in accordance with Test Method D4093
Environmental Conditions	Should maintain above precision within specified conditions by the retarder manufacturer.

[A] Retarders offer certified fixed values within each value.

9.4 This procedure can be repeated in different area in the width of the scanner to verify that all light emitting, and sensing elements yield the correct values.

10. Procedure

10.1 Operator should use the apparatus in accordance with manufacturer suggested practices and authorities having jurisdiction.

10.2 See Appendix X3 for guidelines on operational procedures.

11. Report

11.1 *Required Information:*
11.1.1 Glass geometry (thickness and size, in mm).
11.1.2 Definition of the area analyzed (base × height, in mm).
11.1.3 Analyzed area in m^2.
11.1.4 Data aggregation methods definitions. Examples include:
11.1.4.1 Mean value of the analyzed area.
11.1.4.2 Maximum value of the analyzed area.
11.1.4.3 95th percentile distribution level of the analyzed area.
11.1.5 Measured value(s) of retardation, in nm, based on data aggregation method.
11.1.6 Retardation image.
11.1.6.1 Resolution of the image (px/mm).
11.1.6.2 Scale of the image.

11.2 *Optional Information:*
11.2.1 Please see Appendix X4 for description of "Glass Quality Open Interchange Format" (GQOIF).
11.2.2 Version of datafile.
11.2.3 *Date/Time:*
11.2.3.1 Measurement.
11.2.3.2 File creation.
11.2.4 *Scanning Device Information:*
11.2.4.1 Manufacturer.
11.2.4.2 Model.
11.2.4.3 Software version.
11.2.5 *Glass Part Information:*
11.2.5.1 Glass type.
(1) Color.
(2) Coatings.
11.2.5.2 Product designation (FT, HS).
11.2.5.3 Serial number.
11.2.6 *Customer/Glass Use Information:*
11.2.6.1 Customer name.
11.2.6.2 Project.
11.2.6.3 Order.
11.2.6.4 Line number.
11.2.7 *Exclusion Zones.*
11.2.8 *Retardation Mean Value.*

12. Precision and Bias

12.1 An intercompany study of this test method will be conducted, so precision and bias can be provided.

13. Keywords

13.1 architectural glass; iridescence; optical anisotropy; optical retardation

APPENDIXES

(Nonmandatory Information)

X1. FURTHER DISCUSSION OF INTERFERENCES

INTRODUCTION

The techniques to map retardation information for an area can be applied across a wide range of situations, but care should be given to interpretation and use of the data. There are many things that will affect the results that should be either avoided or documented how they are handled.

X1.1 Laminates

X1.1.1 While initially intended to measure single thicknesses (mono) the technique can be applied to laminates. The plastics associated with inner layers may induce their own retardation characteristics. The manufacturing process of the laminate layer, the thermal cycle bonding temperatures and many more things will influence the resulting retardation. The retardation characteristics of individual glass (mono) layers will also interact in ways that may not be merely the sum of the retardations, or even their vector sum (particularly with the added influence of the lamination materials).

X1.2 Patterned

X1.2.1 As an optical measurement, the integrity of the optical path through the specimen needs to be known to properly measure the retardation. Pattern, that is non- parallel surfaces, will act like a lens or optical wedge so the length through the specimen of the light path is different at different locations in the specimen. This is different from an angle due to camera position relative to the sheet which might also affect the path length. Depending upon the optical design of the instrument, for example a highly collimated light source and camera view, these regions may limit transmission enough to not be able to report data in regions of high slope. For example, with a highly diffuse light source, values will be reported, but the optical path length could be several times the glass thickness, potentially increasing the values in the results. Snell's Law can be used to calculate the change in path length for locations in a particular pattern. The Path Length should not vary by more than 10 % of the stated precision of the instrument. Said otherwise, variation in path length in the specimen should contribute no more than 10 % of the variability in the precision of the results. If the pattern is localized, it may be added as an exclusion region. If the pattern is affecting the path length, it should be reported.

X1.3 Translucent

X1.3.1 Translucent glass that may depolarize the light. Depending upon the technique used to make it translucent, the optical path may also be affected. Choice of measuring with a surface treatment Camera Side versus Light Source side may also affect results. Translucent treatments that are highly scattering may have the effect of depolarizing the light. Depending upon the optical design of the instrument, the magnitude of the measured retardation will likely be reduced, or not able to be measured at all.

X1.3.2 How the translucent character will affect the measurement performance can be checked by measuring verification reference parts placed on the translucent specimen at various locations and orientations. Preferably the translucent specimen is an annealed piece with the same translucent characteristics as the part to be measured. It may be ok to test with the verification reference parts on a tempered part to detect if the translucent treatment is completely depolarizing the light. In that case the retardation of the verification reference would be zero.

X1.3.3 The report the results of verification reference parts with transparent annealed glass (normal verification) and with the translucent glass.

X1.4 Enameled/Partially Enameled

X1.4.1 The interaction of enamel with glass can cause localized stresses, adjacent and under the enameling.

X1.5 Colored, Insulating, Coated

X1.5.1 Colored, Insulating, Coated, that affect the transmittance at the measurement system wavelength(s) may significantly bias or blind the measurement system. The transmission capability beyond "clear glass" will likely be apparatus specific, depending on the technique and illumination designed into the system.

X1.6 Measurement Validity and Application Life Cycle

X1.6.1 The future processing of a specimen into the application (heat-treatment, lamination, mechanical mounting, insulating glass unit (IGU) assembly; coating) may change the values initially reported.

X1.7 Potential Instrument Bias Related to Retardation Orientation

X1.7.1 . The rotation angles need to include at least 45° and should also include 22.5°. The results at 0, 180, and 360°

would be expected to be identical, polarization wise, there is no change. Similar for 90 and 270°, polarization wise there is not a change. For apparatus of Procedure A all of 0, 90, 180, 270, and 360° would only exercise one set of the discrete polarizers (45, 135°). At these multiples of 90° degrees, one would get proper results of these orientations in old fashioned manual polarimeter with linear polarizers. 45° exercises different polarizers (0, 90°) in apparatus of Procedure A—Calibrated Polarimeter. 22.5° would exercise the apparatus's ability to properly interpolate between data from the sets of polarizers. Apparatus of Procedure B may still have some orientation bias due to the fabrication axis and across spectrum retardation magnitude accuracy of the retarder intended to be a ¼ wave used to make the circular polarizers.

X1.8 Other Sample Limitations

X1.8.1 Many other sample characteristics may affect the transmission of polarized light to the detection system. Any of these (or other) things that may affect the results should be documented in the report.

X2. SUGGESTED MEASURING RANGE, PRECISION AND BIAS

TABLE X2.1 Suggested Measuring Range of Retardation Apparatus

NOTE 1—There are several ways to quantify the optical retardation of an area. Automated acquisition with cameras or line scan bars offer advantages in online operation. Depending on apparatus type and glass application, the technical capabilities of the polarimeter or polariscope can vary.

Usage	Minimum Retardation Range		Precision	Retardation Azimuth	Bias (repeatability)
	Lower	Upper			
Tempering furnace process control, glass <10 mm	0 nm	120 nm	±10 nm	optional	±5 %
Tempering furnace process control, glass 10–19 mm	0 nm	250 nm	±10 nm	optional	±5 %
Computer modeling of anisotropy in building facades	0 nm	according to modeling needs	±5 nm	±4°	±5 %

X3. GUIDELINES ON OPERATIONAL PROCEDURES

X3.1 The test specimen is illuminated with polarized light. Mechanical stresses in the test specimen lead to stress birefringence which influences the polarization of the light. The change of polarization can be described by optical retardation (magnitude in nm and, optionally, direction in degrees). The variation of the light polarization state is recorded by photosensitive sensors. A computer evaluates the intensity images and calculates the optical retardation independently of other specimen characteristics such as transmittance. To compensate for polarization changes in the optical path that are unrelated to the specimen (for example stresses in cover glasses of the light source or in the objective lenses used) and for other imperfections, an empty field measurement ("zero calibration") is performed at a regular interval and taken into consideration in the calculation.

X3.2 Since the described method requires an almost normal incidence of light, several photosensitive sensors might be used to cover a larger field of view. The necessary number of sensors depends on the desired spatial resolution and the acceptable deviation from normal light incidence. Each sensor observes a segment of the test specimen and the overall result is stitched together by the computer software.

X3.3 To measure the optical retardation in large test specimens in a continuous way, the test specimen is moved in a right angle to the line of sensors. The transport speed of the test specimen is used as an input parameter to stitch together the image segments.

X3.4 To determine the optical retardation distribution for individual test specimens, those must be detected in the overall image. For this purpose, the computer software detects objects in the image by an appropriate algorithm and separates each detected test specimen. Background pixels in the extracted image segment are masked out in process.

X4. TRANSFER FILE FORMAT

INTRODUCTION

The Glass Quality Open Interchange Format (GQOIF) is defined here as an open, nonproprietary, royalty-free format for transferring information on glass quality measurements. The file format is extensible markup language (xml). xml formatted files are a widely used industry standard and provide flexibility in what data is stored. The enclosed "GQOIF Tag Summary Table" (Table X4.1) and "GQOIF Full Example File" (X4.5.2) encompass the current definition of the format though the format is extensible meaning that none of the defined tags are required and new tags may be added by users and equipment manufacturers as desired. Below are some clarifications on the format.

X4.1 Data Types

X4.1.1 Data type contains a date/time specification in an ISO-8601 (also referenced as ANSI INCITS 30-1997 (R2008)) compliant string. Note that the "T" separator is not required. Fractional seconds and time zone indicators are allowed but not required. Typically, acceptable date/time string examples include:

2019-04-13 14:53:22
2019-04-13T14:53:22
2019-04-13 14:53:22.453+01:00

X4.1.2 **arrayf1** type contains a **size** tag containing the number of entries and a **data** tag that encodes an array of floats as space separated text values. For example, the 3-element array [1.02, 1.5, 3] is stored as:

<arrayf1><size>3</size><data>1.02 1.5 3</data></arrayf1>

X4.1.3 **arrayf2** type contains a **size** tag containing the number of entries and a **data** tag that encodes an array of 2d floats as space separated text values. For example, the 3-element array of 2d points [(1.02, 400.1), (1.5, 500.321), (3, 123.1)] is stored as:

<arrayf2><size>3</size><data>1.02 400.1 1.5 500.321 3
123.1</data></arrayf2>

X4.1.4 **arrayf3** type contains a **size** tag containing the number of entries and a **data** tag that encodes an array of 3d floats as space separated text values. For example, the 2-element array of 3d points [(1.02, 400.1, 1.1), (1.5, 500.321, 2.2)] is stored as:

```
  <arrayf3><size>2</size><data>1.02 400.1 1.1 1.5 500.321
2.2</data></arrayf3>
```

X4.1.5 Extra whitespace in the form of space, tab, cr, or lf is permitted in **arrayfX** types to provide for ease of human readability. Any amount of continuous whitespace is considered as 1 delimiter.

X4.2 Data Specification

X4.2.1 The **dataset** tag specifies the measurement type, data format, and how the data is stored. It provides the ability to specify different data formats, sizes, compression types, and data locations.

X4.2.2 **meastype** tag specifies the format of each measurement.

retardation – optical retardation (typically in nm)
stressangle – angle of principal stress axis in degrees (parallel to conveyor travel = 0 deg)
(other measurement such as defects or reflected optical power (opr) may be added as desired)

X4.2.3 **datatype** tag specifies the format of each measurement

f32 – IEEE 754 single-precision binary floating-point format
i16 – 16bit signed integer; range = [-32,768 to 32,767]
ui16 – 16bit unsigned integer; range = [0 to 65,535]
text – numbers are encoded as an ASCII text string or arrayfN

X4.2.4 **datascale** tag specifies scaling be applied to each measurement default is 1.0, For example if datascale was 0.1 then i16 (16bit signed integer) would have a range = [–3276.8 to 3276.7].

X4.2.5 **structure** tag specifies the spatial structure of the data.

grid2d – data is structured in an ordered 2d grid 3tuple – data is a set of 3tuples (x, y, value) with arbitrary spacing
3tuple – data is a set of 3tuples (x, y, value) with arbitrary spacing

X4.2.6 compression tag specifies how the data is compressed.

none – store data uncompressed
zlib – use zlib compression

X4.3 Data Storage

X4.3.1 The **dataset** tag values also determine where the data is stored. There are three distinct methods for storing actual data determined by tags:

X4.3.1.1 *Embedded Text Data*—If filepath is undefined and dataoffset is undefined and datatype is text and a data tag is provided then the data is embedded as a ASCII data as shown in the "GQOIF – Minimal Example File" section.

X4.3.1.2 *Embedded Binary Data*—If filepath is undefined and dataoffset is defined then the data is stored at fileoffset bytes from the start of the current file where this xml data is being read. Typically, one would store the binary data immediately after readable xml data. This allows the possibility of storing both texts, and possibly compressed, binary data in the same file.

X4.3.1.3 *External Binary Data File*—If filepath is defined then the data is stored at dataoffset bytes (or at 0 offset if dataoffset is not defined) from the start of the filepath. Note that often a complete set of files including the xml descriptor and binary data files will be packaged in a single container. This is typically a directory that is compressed with ZIP format and named with the ".gqoif" extension. This is considered a valid GQOIF file and all file paths are resolved relative to the zipped directory.