

## Technical Specifications (In-Cash Procurement)

# Manufacturing of Sapphire Optical components for ITER diagnostic windows

Open Tender for:

The purpose of this document is to provide the technical specifications for the: Procurement of Sapphire Disks and beams for the qualification and final manufacturing of Diagnostics' Sapphire Windows Validation of mechanical properties Sapphire Measurement of Flexural strength Characterization of Sub critical crack growth Measurement of fracture toughness

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# 1 Purpose

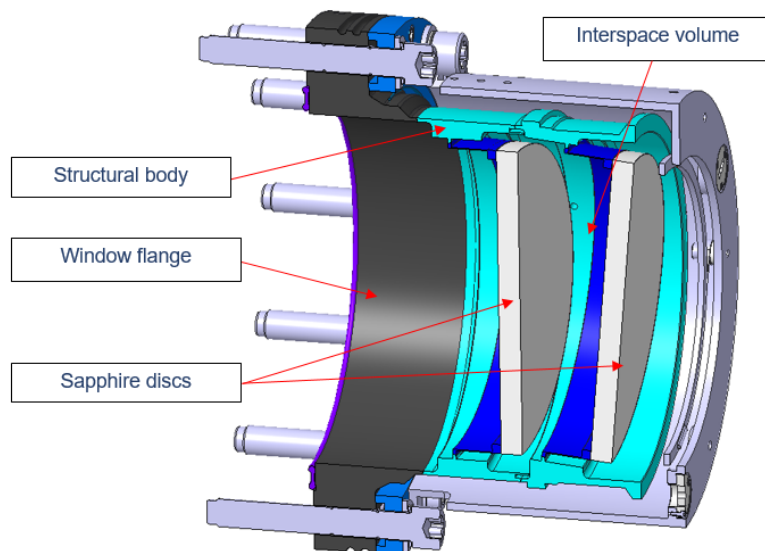
The purpose of this document is to provide the technical specifications for the:

- Procurement of Sapphire Disks and beams for the qualification and final manufacturing of Diagnostics' Sapphire Windows
- Validation of mechanical properties Sapphire
  - Measurement of Flexural strength
  - Characterization of Sub critical crack growth
  - Measurement of fracture toughness

For information, each window assemblies is composed by:

- A structural body provided with a bolted flange, for the mechanical and vacuum tight attachment on a vacuum extension also called “mating flange”.
- Two transparent discs assembled into metallic ferrules by aluminium diffusion bonding.
- An interspace volume between both discs, whose pressure is permanently monitored by the Service Vacuum System (SVS).

An example can be seen in Figure 1.



*Figure 1: Section of Window Assembly*

The design of the bolted flanges is similar to the one of the ITER standard vacuum flange. The size of the bolted flange is tailored to the clear aperture.

# 2 Scope

This specification covers the procurement of Sapphire (disks and beams) for the diagnostic windows assemblies. It addresses the following items.

- Technical specifications of the raw material, including the definition of additional samples required for material characterization,
- Technical specifications of the polished discs,
- Amount and types of discs to be procured.
- Mechanical testing specifications to be performed in order to guarantee

The coating of samples is outside of this contract and therefore is listed in this technical specification only for traceability reasons.

### 3 Definitions

AoI:	Angle of Incidence
AR:	Anti reflection
CV:	Clear View
DA:	Domestic Agency
FWHM:	Full width at half maximum
HP:	Hold Point
IO:	ITER Organization
IO-TRO:	ITER Organization technical Responsible Officer.
PPS:	Pro
RT:	Room Temperature
SIC	Safety Important Component
SSD:	See System Design
WA:	Window Assembly
WFE:	Wave Front Error

For a complete list of ITER abbreviations see: [ITER Abbreviations \(ITER\\_D\\_2MU6W5\)](#).

### 4 References

Ref	Title	IDM link
[R1]	ITER Procurement Quality Requirements	<a href="#">ITER_D_22MFG4</a>
[R2]	Requirements for Producing a Quality Plan	<a href="#">ITER_D_22MFMW</a>
[R3]	ITER Policy on Safety, Security and Environment Protection Management.	<a href="#">ITER_D_43UJN7</a>
[R4]	Order dated 7 February 2012 relating to the general technical regulations applicable to INB - EN	<a href="#">ITER_D_7M2YKF</a>
[R5]	System Design Description (DDD) 55.NW Windows	<a href="#">ITER_D_46NXUU</a>
[R6]	Cat2-#28-Outgassing-requirement-resolution-memo	<a href="#">ITER_D_2S6JQM</a>
[R7]	Appendix C20 Product Procurement Specifications Sapphire Disc	<a href="#">ITER_D_3QQF43</a>
[R8]	ITER Vacuum Handbook	<a href="#">ITER_D_2EZ9UM</a>
[R9]	IS 55.NW-55	<a href="#">UDS88X</a>
[R10]	Sub-System Requirement Document sSRD-55.NW: Windows	<a href="#">ITER_D_WYWVMP</a>
[R11]	55.NW System Loads Specifications For Sapphire Windows	<a href="#">ITER_D_XLCJWV</a>
[R12]	Existing Practices For Diagnostic Window Assembly	<a href="#">ITER_D_2WBW2V</a>
[R13]	WA manufacturing management specification	<a href="#">ITER_D_YHXUXZ</a>
[R14]	WA manufacturing technical specification	<a href="#">ITER_D_YHYAJK</a>

[R15]	ITER_D_SBSTBM - Provisions for Implementation of the Generic Safety Requirements by the External Actors/Interveners	<a href="#">ITER_D_SBSTBM</a>
[R16]	Propagation of the Defined Requirements for Protection Important Components Through the Chain of External Interveners	<a href="#">ITER_D_BG2GYB</a>
[R17]	Slow crack growth and fracture toughness of Sapphire for the international space station fluids and combustion facility. NASA/TM-2006-214023 Jonathan A.Salem Glenn Research center, Cleveland, Ohio	
[R18]	Development and manufacturing of AR coating for Diagnostic Windows	<a href="#">ITER_D_8G6ULU</a>

## 5 Estimated Duration

The duration shall be for 36 months. No work shall commence prior to the date of final signature of the Contract.

## 6 Codes and Standards

[RQ-001] The following Standards shall be referred to in this specification:

- ISO 10110-2 Optics and optical instruments - Preparation of drawings for optical elements and systems - Part 2: Material imperfections - Stress birefringence
- ISO 10110-3 Optics and optical instruments - Preparation of drawings for optical elements and systems - Part 3: Material imperfections - Bubbles and inclusions
- ISO 10110-4 Optics and optical instruments -- Preparation of drawings for optical elements and systems -- Part 4: Material imperfections -- Inhomogeneity and striae
- ISO 12123 Optics and photonics - Specification of raw optical glass
- ASTM C1499 Standard Test Method for Monotonic Equibiaxial Flexural Strength of Advanced Ceramics at Ambient Temperature
- ASTM C1322 Standard Practice for Fractography and Characterization of Fracture Origins in Advanced Ceramics
- EN 14425-3 Advanced technical ceramics. Test methods for determination of fracture toughness of monolithic ceramics. Chevron notched beam (CNB) method
- EN 843-3 Advanced technical ceramics. Mechanical properties of monolithic ceramics at room temperature. Determination of subcritical crack growth parameters from constant stressing rate flexural strength tests
- ASTM C1368 Standard Test Method for Determination of Slow Crack Growth Parameters of Advanced Ceramics by Constant Stress-Rate Strength Testing at Ambient Temperature
- ASTM C1465 Standard Test Method for Determination of Slow Crack Growth Parameters of Advanced Ceramics by Constant Stress-Rate Flexural Testing at Elevated Temperatures
- EN 821-1 Advanced technical ceramics. Monolithic ceramics. Thermo-physical properties. Determination of thermal expansion

- ISO 21254-1:2011 Lasers and laser-related equipment — Test methods for laser-induced damage threshold

[RQ-002] All materials and testing standards mentioned in this PPS shall be considered in their last revision at the time of the sign of the contract.

[RQ-003] Other equivalent national or international standards and codes may be acceptable with prior written IO approval, provided all criteria are satisfied.

## 7 Sapphire disks and beams for qualification and manufacturing of windows

In total, to accommodate the requirements of the several diagnostic systems two disc variations are required. They differ in clear view (CV) size, thickness and coating requirements.

[RQ-004] For final window manufacturing purpose, the contractor shall supply the IO with the specimens listed in Table 1.

[RQ-005] The manufacturing of Batch#2 in Table 1 shall not start before clearing a hold point (HP) for the successful qualification of the Sapphire window assembly which IO will carry out with the specimens defined in Table 2. Note that the window assembly qualification is not the scope of this contract. The qualification failure may cause the design change of the sapphire disk.

*Table 1: Specimens to be supplied for the qualification of the window assemblies*

Mark	Main geometry features	Coating system*	Quantity (Batch #01)	Quantity (Batch #02)
N°1	Ø 160 mm CV T = 12 mm ±0.1 mm	CS#01-S	10	40
N°2	Ø 130 mm CV T = 10 mm ±0.1 mm	CS#02-S	0	6

\*Note: the definition of the coating systems is given in [R18].

[RQ-006] For window assembly qualification purpose, the contractor shall supply the IO with the specimens listed in Table 2

*Table 2: Specimens to be supplied for the qualification of the window assemblies*

Mark	Main geometry features	Coating system	Quantity
N°21	Disc Ø 30 mm CV T = 4 mm	No coating	5
N°22	Disc Ø 130 mm CV T = 10 mm	No coating	5
N°23	Disc Ø 160 mm CV T = 12 mm	No coating	2

[RQ-007] For material characterisation purpose, the contractor shall in addition manufacture the specimens listed in Table 3.

Table 3: Specimens required for material characterization

Mark	Main geometry features	Reference test	Coating system	Quantity
N°31	Beam 45 x 4 x 3 mm	Fracture toughness	No coating	10
N°32	Beam 25 x 2.5 x 2 mm	Slow crack growth	No coating	50
N°33	Beam 25 x 2.5 x 2 mm	Slow crack growth	CS#1-S	50
N°34	Beam 25 x 2.5 x 2 mm	Slow crack growth	CS#2-S	50
N°35	Beam 25 x 2.5 x 2 mm	Mechanical Strength	No coating	10

[RQ-008] For optical tests (transmission ratio) after irradiation, the contractor shall manufacture the cylindrical specimens specified in the Table 4. Irradiation and coating operations are not under the scope of this contract

Table 4: cylindrical specimens for optical testing

Mark	Main geometry features	Coating system	Bubbles & Inclusions	Quantity
N°41	Cylinder Ø20 mm x 10 mm	No coating	1/ 1x0.08	5
N°42	Cylinder Ø20 mm x 10 mm	CS#1-S	1/ 1x0.08	5

[RQ-009] For validation of the Anti-Reflective coating the contractor shall in addition manufacture the specimens listed in Table 5

Table 5: Disks for qualification of Anti-reflection coating system

Mark	Main geometry features	Coating system	Quantity
N°51	Ø 160 mm CV T = 12 mm ±0.1 mm	CS#1-S	5
N°52	Ø 160 mm CV T = 12 mm ±0.1 mm	CS#2-S	5

## 8 Requirements on Sapphire Material

This section defines the technical requirements as regards the material properties of crystal growth high-optical-quality Sapphire. They are related to the procurement of the blank material, i.e. regardless of the final forming and polishing of the disks.

[RQ-010] According to the importance of the material property, with respect to the function of the disks on the ITER machine, the characterization of the property shall be achieved in different ways.

**Typical value / Existing measurements:** The material characteristic is an intrinsic property linked to the chemical composition of the material and the production process. The current technical specification presents the typical expected values. A value of the property shall be provided by the supplier of the material, based on existing measurements achieved on samples



of the same material grade and brand. In case the material property characteristic has not been measured, measurements performed on the first production batch could be carried out.

**Specific measurements:** The material property is a key characteristic of the material, which shall be measured at least once, on one production batch, when the manufacture and inspection plan has been approved by the IO.

**Systematic measurements:** A systematic measurement of the property shall be carried out, either on the pre-form material or on the final product, to control the quality of the production.

## 8.1 Radiation hardness

Located around the Tokamak the window assemblies are subjected to neutron and gamma irradiation. Irradiation fluences and doses given below are those expected for the most exposed window assemblies.

- Total neutrons fluence (> 1 MeV) in ITER lifetime :  $1.0 \times 10^{17}$  n/cm<sup>2</sup>, within 20 years,
- Gamma dose : 10 MGy
- Dose rate : 330 Gy/h,

This Technical Specification includes the supply of dedicated samples intended for radiation exposure and subsequent testing.

## 8.2 Composition / Impurities

[RQ-011] The material shall be high-quality Sapphire, got from crystal growth ensuring low thermal stress-induced defects within the bulk material as well as low level of impurities.

[RQ-012] A chemical analysis of the blank material shall be carried out according to the requirements defined in §10.2 This shall be a systematic measurement carried out on each production lot.

## 8.3 Optical Transmission

[RQ-013] Sapphire shall meet the transmission performances specified in the Table 6. The transmission ratio includes the attenuation in the bulk material (thickness = 12 mm), the reflection losses due to the refractive index on both sides. It does not include anti-reflection coating. This can be justified by using existing measurements.

*Table 6: Transmission requirements – 12 mm thick disc.*

Wavelength (μm)	Minimal transmission %
0,3638	0,84
0,4	0,84
0,4579	0,85
0,488	0,85

0,5145	0,85
0,694	0,85
0,8	0,85
1,3188	0,86
2,941	0,86
3	0,86
3,333	0,86
3,5	0,85
3,704	0,85
4	0,82
4,348	0,71
4,5	0,61
4,762	0,41
5	0,24

These requirements are given for the as-built material. I.e. it does not take into account further attenuation induced by the nuclear environment.

#### 8.4 Optical Index

[RQ-014] The contractor shall provide the IO with the optical index of Sapphire material within the wavelength range [0.4  $\mu\text{m}$  – 5 $\mu\text{m}$ ]. This can be based on existing measurements.

#### 8.5 Quality Grade

[RQ-015] The sapphire grade shall conform to the quality requirements listed in the table below, and reminded in the detailed drawings.

Criteria	Quality requirement	Standard
Bubbles and inclusions	1/1x0.08	ISO 10110-3
Stress birefringence	< 5 nm/cm (0/5)	ISO 10110-2
Inhomogeneity	Class 4 ( $\pm 1 \times 10^{-6}$ )	ISO 10110-4
Striae	Class 4	ISO 10110-4

[RQ-016] These requirements shall be demonstrated by measurements on samples drawn from the first production batch.

#### 8.6 Crystallographic orientation

[RQ-017] In order to benefit from uniform optical quality and constant mechanical strength for all sapphire discs, C-axis cut sapphire discs are required.

## 8.7 Lased Induced damage threshold

[RQ-018] The disc N°1 will transmit high power laser signal. The specifications of the laser loads are specified in the present section. These specifications shall apply to coated disks.

[RQ-019] The disc N°1 shall withstand the laser loads specified in Table 7. The damage threshold is the maximal crack size as the result of a damage either in the bulk or on the rear or the front surface of the disc. The maximal crack size shall be less than 10 microns after the total number of pulses.

Table 7: Laser load – 55.GL

Effective pulse duration	Continuous laser
Frequency	Continuous laser
Wavelength	800 nm
Beam diameter	Ø26 mm
Peak power at window level	200 W
Max. power density at window level	0.24 W/cm <sup>2</sup>
Total number of pulses	One laser pulse every 10 plasma pulses is expected (3000) but 30 000 laser pulses are considered as a conservative approach

[RQ-020] If tests are required to justify the laser damage threshold, the characterization of laser-induced damage threshold shall be carried out according to ISO 21254-1:2011.

## 8.8 Dielectric properties

[RQ-021] The dielectric properties of sapphire material shall be provided by the contractor, based on specific measurements of the relative permittivity and loss tangent  $\delta$ , at 60 GHz and at 170 GHz.

## 8.9 Thermal properties

[RQ-022] The thermal expansion coefficients of the Sapphire material (parallel and perpendicular with the C axis) in the range 20°C - 200°C shall be provided by the contractor based on its own measurements. This can be based on existing measurements.

[RQ-023] The thermal conductivity of Sapphire material (parallel and perpendicular with the C axis) in the range 20°C – 200°C shall be provided by the contractor, based on its own measurements. This can be based on existing measurements.

[RQ-024] The specific heat of sapphire material in the range 20°C – 200°C shall be provided by the contractor, based on its own measurements. This can be based on existing measurements.

## 8.10 Mechanical Properties

[RQ-025] The mechanical properties of Sapphire material shall conform to the requirements listed in Table 8. During the test the tensile surface of the specimen shall correspond to the c-plane.

Table 8 : Technical requirements regarding material properties

Requirements on mechanical properties		
<b>Flexural strength (perpendicular direction)</b>	> 690 MPa	EN 843-1:2006
<b>Fracture toughness - <math>K_{IC}</math> (m or a-plane)</b>	> 2.0 MPa.m <sup>1/2</sup>	EN 14425-3
<b>Slow crack growth exponent (m or a -plane)</b>	n > 20	EN 843-3:2005

[RQ-026] The mechanical properties shall be measured on samples drawn from the first production batch, according to the specifications defined in §10.1.

## 9 Requirements on finished polished products

[RQ-027] The quality of the optical polishing shall be checked by systematic measurements on every finished product, after coating. This includes the surface form tolerances, surface imperfection tolerances and surface texture, defined according to the standards given in Table 9.

[RQ-028] The requirements on optical quality after coating are defined in the detailed drawings of the discs given in §ANNEX I and in Table 9. This shall be verified by systematic measurements carried out on every polished disc after coating deposition.

Table 9: Technical requirements on the final products: formed and polished discs.

Optical quality	
<b>Surface form tolerances</b>	ISO 10110-5
<b>Surface imperfection tolerances</b>	ISO 10110-7
<b>Surface texture</b>	ISO 10110-8

[RQ-029] Although the edges of the disc are not functional from the optical point of view, they shall be polished according to the requirements defined in the detailed drawings, to avoid the presence of cracks, which might be the root of crack propagation. This applies to the chamfers as well.

## 10 Testing

### 10.1 Mechanical Testing

The objective of the characterization is to get the key properties of the material from a structural perspective. The properties to be identified are:

- Fracture toughness
- Slow crack growth parameter A and exponent n
- Mechanical strength

The samples to be tested shall be manufactured and polished (P3 ;  $< 2 \text{ nm}_{\text{rms}}$  ) according to the specifications of the final products (§ ANNEX I).ones.

### 10.1.1 Fracture toughness

[RQ-030] The samples to be tested are beams of  $45 \times 4 \times 3 \text{ mm}^3$

[RQ-031] Test according to EN-14425-3:2010

[RQ-032] The number of samples tested and temperatures at which the test are to be carried out are detailed in Table 10

Table 10: List tests for Fracture toughness

Test Reference	Mark	Quantity samples	Testing Temperature
FT #1	N°31	10	RT

### 10.1.2 Slow crack growth exponent

[RQ-033] The samples to be tested are beams of  $25 \times 2.5 \times 2 \text{ mm}^3$

[RQ-034] Test according to EN-843-3:2005

[RQ-035] The number of uncoated samples tested and temperatures at which the test are to be carried out are detailed in Table 11.

Table 11: List of tests for uncoated slow crack growth exponent

Test Reference	Mark	Quantity samples	Testing Temperature
SCCG #1	N°32	50	RT
SCCG #2	N°33	50	RT
SCCG #2	N°34	50	RT

### 10.1.3 Mechanical strength

[RQ-036] The samples to be tested are beams of  $25 \times 2.5 \times 2 \text{ mm}^3$

[RQ-037] Test according to EN-843-1:2006

[RQ-038] The number of samples tested and temperatures at which the test are to be carried out are detailed in Table 12

Table 12: List of tests for Mechanical strength

Test Reference	Mark	Quantity samples	Testing Temperature
MS #1	N°35	10	RT

### 10.1.4 Acceptance criteria for tests

The acceptance criteria for each test is:

[RQ-039] Fracture toughness  $FT > 2.0 \text{ MPa.m}^{1/2}$

[RQ-040] Sub critical crack growth exponent on coated and uncoated samples  $n > 20$

[RQ-041] Flexural strength  $MS > 690 \text{ Mpa}$  (**Hold point to assess material characteristics**)

## 10.2 Chemical Analysis

[RQ-001] The chemical composition of the blank material shall be carried out on samples extracted from the pre-form (before polishing).

[RQ-042] The Manufacturer shall supply a chemical composition analysis certified by the Manufacturer accredited representative. Chemical analyses and crosschecks shall be performed in a laboratory of the Manufacturer's choice according to the laboratory usual methods. In the event of disagreement, the chemical analyses shall be performed in accordance with standards and in the laboratory selected and/or agreed by all parties. Calibration methods and results of verifications performed on testing equipment shall be available for consultation in the laboratory.

## 10.3 Optical Testing

[RQ-043] They shall be verified by systematic measurements carried out on every polished disc, before or after coating as specified in the Table 13.

*Table 13: Manufacture step of the quality control*

Requirement (according to ISO 10110)	Before polishing	Before coating	After coating*
0 / Birefringence	X	X	
1 / Bubbles and Inclusions	X		
2 / Heterogeneity and striae	X		
3 / Surface form tolerance		X	
5 / Surface texture		X	X
6 / Laser Damage threshold (qualification process), if this cannot be demonstrated by existing data.			X

*\* Outside scope of this contract*

## 11 Manufacturing Programme

[RQ-044] The transparent element blank material shall be clearly specified before being manufactured.

[RQ-045] Before manufacturing process starts, the Manufacturer shall draw up a manufacturing programme and a qualification test plan. The various processes, treatments, sampling and examinations shall be presented in chronological order.

[RQ-046] During the production work, various parameters on the material design must be controlled to ensure that the tested data remains valid for the disks production. This shall include the composition and growth process parameters (temperature, time, and environment).

[RQ-047] The forming process from the rough to the finish cutting shall consider the most suitable way to limit residual stresses and cracks into the material. The grit sizes of the

grinding tools shall be relevant throughout the forming process. Acceptance criteria based on blank material dimensions shall be defined by the manufacturer during the qualification process, to guarantee the reproducibility of the final manufacturing process.

[RQ-048] A qualification test plan for the materials procurement shall be approved by the ITER organization before the beginning of the procurement.

[RQ-049] The number of tests to be performed for each production batch shall be specified in the qualification test plan.

## 12 Documentation and test reports

[RQ-050] All documents shall be in the English language and all measures shall be given in the metric system SI. Each document shall be provided as an electronic file in PDF format.

### 12.1 Material acceptance

[RQ-051] Material inspection certificate (Type 3.1 EN 10204) and material tests report have to be provided by the Manufacturer before starting the manufacture of the final products (polished and coated discs specified in Table 1 and Table 2).

[RQ-052] To be accepted, the material shall be proven to conform to the requirements of the present document.

### 12.2 Material test reports

[RQ-053] Material test report shall provide the results of all measurements (existing, specific or systematic) performed on both material grades. It shall include the following results:

- Chemical composition,
- Optical transmission,
- Optical index,
- Optical quality (according to § 8.5)
- Dielectric properties,
- Thermal expansion coefficient, (if a test is required to ascertain the property),
- Thermal conductivity, (if a test is required to ascertain the property),
- Specific heat, (if a test is required to ascertain the property),
- Flexural strength,
- Fracture toughness,
- Slow crack growth exponent.

[RQ-054] A particular attention shall be paid to the traceability of the measurements. For that purpose, these reports shall include:

- Blank material identification
- Manufacturer identification
- Purchase order number
- Name of the inspection agency, where applicable
- Test method and measurement sensitivity
- Test and retest results together with required values

- Localisation and identification of extracted samples with respect to geometry of the pre-form (dimension; length; thickness); sample number

### 12.3 Disc acceptance

[RQ-055] The acceptance of the final products (finished and coated discs) is based on

- Material conformity certificate,
- Inspection report.

[RQ-056] The inspection report shall collect the following pieces of information.

- Dimensional measurement report,
- Measurements of the optical quality – Wave front error, Surface imperfection tolerances and Surface texture.
- Results of inspection and measurements specified in the present document.

[RQ-057] The supplier factory acceptance procedure shall be submitted to the ITER Organization for acceptance. The acceptance procedure shall at least include:

- Measurement of the optical characteristics over the relevant wavelength range,
- Surface imperfection tolerances measurement in accordance with ISO 10110-7. It shall be carried out for all windows and spread on the whole coated surfaces.
- Adhesion Testing, Abrasion Testing, Cleaning Ability Testing on witnesses for all coating batch.
- Review of the control and inspection reports.

### 12.4 Dimensional check - tolerances

[RQ-058] The dimensions shall be checked in accordance with the requirements of procurement drawings. The main dimensions shall be recorded. The values shall be within the tolerances given on the procurement drawing.

## 13 Identification and Marking

[RQ-059] By agreement between IO, the blank material manufacturer and the window manufacturer, an agreed methodology for traceably identifying individual window blanks throughout their processing into finished windows shall be defined.

[RQ-060] Any method of physically marking the window shall not introduce damage or stress which might subsequently affect the mechanical performance.

[RQ-061] Only painted or inked marking is permitted. They shall be neither indelibly marked, nor engraved, nor laser inscribed. Allowed inks and paints shall be specified to ensure material compatibility.

## 14 Cleanliness

[RQ-062] [Appendix N Cleanliness surface finish vacuum requirements](#) requirements shall apply.



## 15 Packaging / marking

[RQ-063] Each disc shall be packed individually

- First packing in a lens paper (after cleaning)
- Second packing in a plastic bag with the identification reported in the control report
- A third packing in a hermetically sealed plastic bag
- And a fourth packing in a rigid box (each component or sample is packed in a rigid box). The marking shall be identified on the rigid box.

## 16 Safety requirements

The diagnostic window assemblies are classified Protection Important Components Class 1.

[RQ-064] The Manufacturer shall comply with the requirements defined in of [ITER\\_D\\_YHXUXZ-WA manufacturing management specification](#) [R13] and [ITER\\_D\\_YHYAJK- WA manufacturing technical specification](#) [R14], making sure that the safety requirements are properly propagated to any sub-contractors involved in the manufacture activities of the discs, according to [R15] and [R16].

## 17 Quality Assurance requirements

[RQ-065] The Manufacturer shall comply with all requirements of ISO 9001 Certification. A quality assurance organization shall be implemented as required for fabrication in nuclear and ultra-high vacuum systems.

[RQ-066] All procedures and specifications related to the materials procurement, qualification testing and acceptance testing shall be accepted by ITER before starting the manufacturing process.

[RQ-067] Particular attention shall to be paid to the traceability of all materials:

- Material origin; date of manufacturing
- Material manufacturing process identification
- Batch number of the pre-form
- Tests and inspections records
- Samples extracted from the blank shall be identified and kept after the tests
- Dates of inspections, instrumentation used for inspections, date of last calibration

[RQ-068] All data, which can have an impact on the reproducibility of the properties, shall be recorded and kept.

### 17.1 Access of Inspectors

[RQ-069] Representatives of the IO and of Third Party Inspectors (TPI) shall at reasonable notice have right to check at the Manufacturer premises the progress and status of the task and to witness the specified tests.

[RQ-070] The Manufacturer shall hold and make available to the IO and TPI all necessary information and documentation to determine the progress and status of the task.

## 17.2 Manufacture and inspection plan

[RQ-071] Prior to commencement of the contract, the contractor shall draw up a manufacture and inspection plan clarifying the responsibilities with regard to testing of the material by Manufacturer, Purchaser of Material, ITER and any Third Party Inspector. The table below shows typical requirements for the testing plan.

[RQ-072]

Table 14. Testing plan (tentative)

M – Manufacturer PoM – Purchaser of Material TPI – Third Party Inspector P – Performance and Evaluation of Tests Results S – Supervision and Evaluation of Tests Results		Test performance			
		M	PoM	ITER	TPI
1	Manufacturing program	P	S	S	
2	Qualification test plan	P	S	S	
3	Chemical analysis	P		S	S
4	Mechanical test	P	S	S	S
5	Optical test	P	S	S	
6	Dimensional examination of each product according to the drawings. Actual dimensions shall be recorded	P	S		S
7	Material identification	P			
8	Marking control	P	P		S
9	Check of final documentation	P	P	S	
10	Certification of compliance	P			S

[RQ-073] The manufacture and inspection plan shall identify the protection important activities. Note that a tentative list of PIA is given in [R13]

## 18 Development milestones and deliveries

[RQ-074] The development milestones and associated deliveries shall be specified by the customer in the purchase order.

## 19 Purchase order for pre-form material

[RQ-075] Purchase order for blank (pre-form) material shall:

- refer to a product special procurement specification
- include a technical appendix providing the following supplementary information
  - material ordered
  - quantity ordered
  - form of the product
  - nominal dimensions
  - the dimensions tolerances

## 20 Responsibilities

### 20.1 Contractor's Responsibilities

In order to successfully perform the tasks in this Technical Specification, the Contractor shall:

- Strictly implement the IO procedures, instructions and use templates;
- Provide experienced and trained resources to perform the tasks;
- Contractor's personnel shall possess the qualifications, professional competence and experience to carry out services in accordance with IO rules and procedures;
- Contractor's personnel shall be bound by the rules and regulations governing the IO ethics, safety and security IO rules.

### 20.2 IO's Responsibilities

The IO shall:

- Nominate the Responsible Officer to manage the Contract;
- Organise a monthly meeting(s) on work performed;
- Provide offices at IO premises.

## 21 List of Deliverables and due dates

D#	Description	T0 + x months
D1	Work plan and organization <ul style="list-style-type: none"> <li>- IP#1 Verification Control Plan</li> <li>- IP#2 Quality Plan</li> <li>- IP#3 Detailed Scheduled</li> </ul>	T0 (Kick off meeting) + 1
D2	Manufacturing and inspection plan	2
D3	Delivery uncoated samples for material and optical characterization	5
D4	Delivery of samples for AR coating and qualification	5
D5	Result Testing (mechanical, chemical and optic)	8
D6	FAT Protocol for disks	12
D7	Delivery disks batch #01 to IO	13
	Hold point specified in [RQ-005]	
D8	Delivery disks batch #02	36

## 22 Acceptance Criteria

The deliverables will be posted in the Contractor's dedicated folder in IDM, and the acceptance by the IO will be recorded by their approval by the designated IO TRO. These criteria shall be the basis of acceptance by IO following the successful completion of the services. These will be in the form of reports as indicated in section 21, Table of deliverables.

## 23 Work Monitoring / Meeting Schedule

Work is monitored through reports (see List of Deliverables, section 21) and at monthly project meetings for each of the projects.

## 24 Delivery time breakdown

See Section 8 "List Deliverables section and due dates".

## 25 AD Design Requirements (if applicable)

For the contracts where CAD design tasks are involved, the following shall apply:

The Supplier shall provide a Design Plan to be approved by the IO. Such plan shall identify all design activities and design deliverables to be provided by the Contractor as part of the contract.

The Supplier shall ensure that all designs, CAD data and drawings delivered to IO comply with the Procedure for the Usage of the ITER CAD Manual ([2F6FTX](#)), and with the Procedure for the Management of CAD Work & CAD Data (Models and Drawings [2DWU2M](#)).

The reference scheme is for the Supplier to work in a fully synchronous manner on the ITER CAD platform (see detailed information about synchronous collaboration in the ITER [GNJX6A](#) - Specification for CAD data production in ITER Contracts.). This implies the usage of the CAD software versions as indicated in CAD Manual 07 - CAD Fact Sheet ([249WUL](#)) and the connection to one of the ITER project CAD data-bases. Any deviation against this requirement shall be defined in a Design Collaboration Implementation Form (DCIF) prepared and approved by DO and included in the call-for-tender package. Any cost or labour resulting from a deviation or non-conformance of the Supplier with regards to the CAD collaboration requirement shall be incurred by the Supplier.

## 26 Safety requirements

ITER is a Nuclear Facility identified in France by the number-*INB-174* ("Installation Nucléaire de Base").

For Protection Important Components and in particular Safety Important Class components (SIC), the French Nuclear Regulation must be observed, in application of the Article 14 of the ITER Agreement.

In such case the Suppliers and Subcontractors must be informed that:

- The Order 7th February 2012 applies to all the components important for the protection (PIC) and the activities important for the protection (PIA).
- The compliance with the INB-order must be demonstrated in the chain of external contractors.
- In application of article II.2.5.4 of the Order 7th February 2012, contracted activities for supervision purposes are also subject to a supervision done by the Nuclear Operator.

For the Protection Important Components, structures and systems of the nuclear facility, and Protection Important Activities the contractor shall ensure that a specific management system is implemented for his own activities and for the activities done by any Supplier and Subcontractor following the requirements of the Order 7th February 2012 ([PRELIMINARY ANALYSIS OF THE IMPACT OF THE INB ORDER - 7TH FEBRUARY 2012 \(AW6JSB v1.0\)](#)).

Compliance with [Defined requirements for PBS 55 - Diagnostics \(NPEVB6 v2.0\)](#) or its flowed down requirements in [SRD-55 \(Diagnostics\) from DOORS \(28B39L v5.5\)](#) is mandatory.

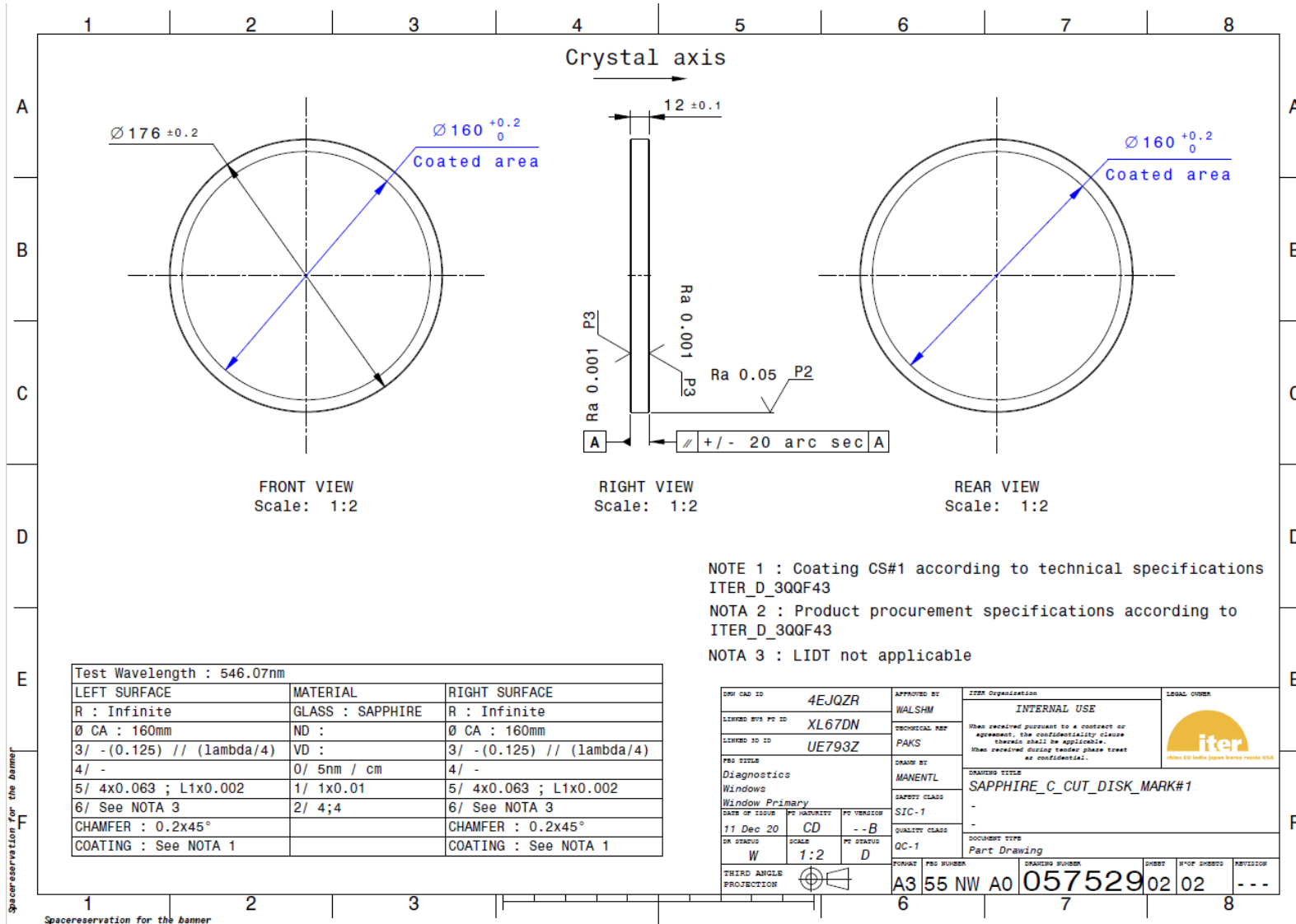
The safety requirements shall be propagated to the suppliers and subcontractors by following the following documents:

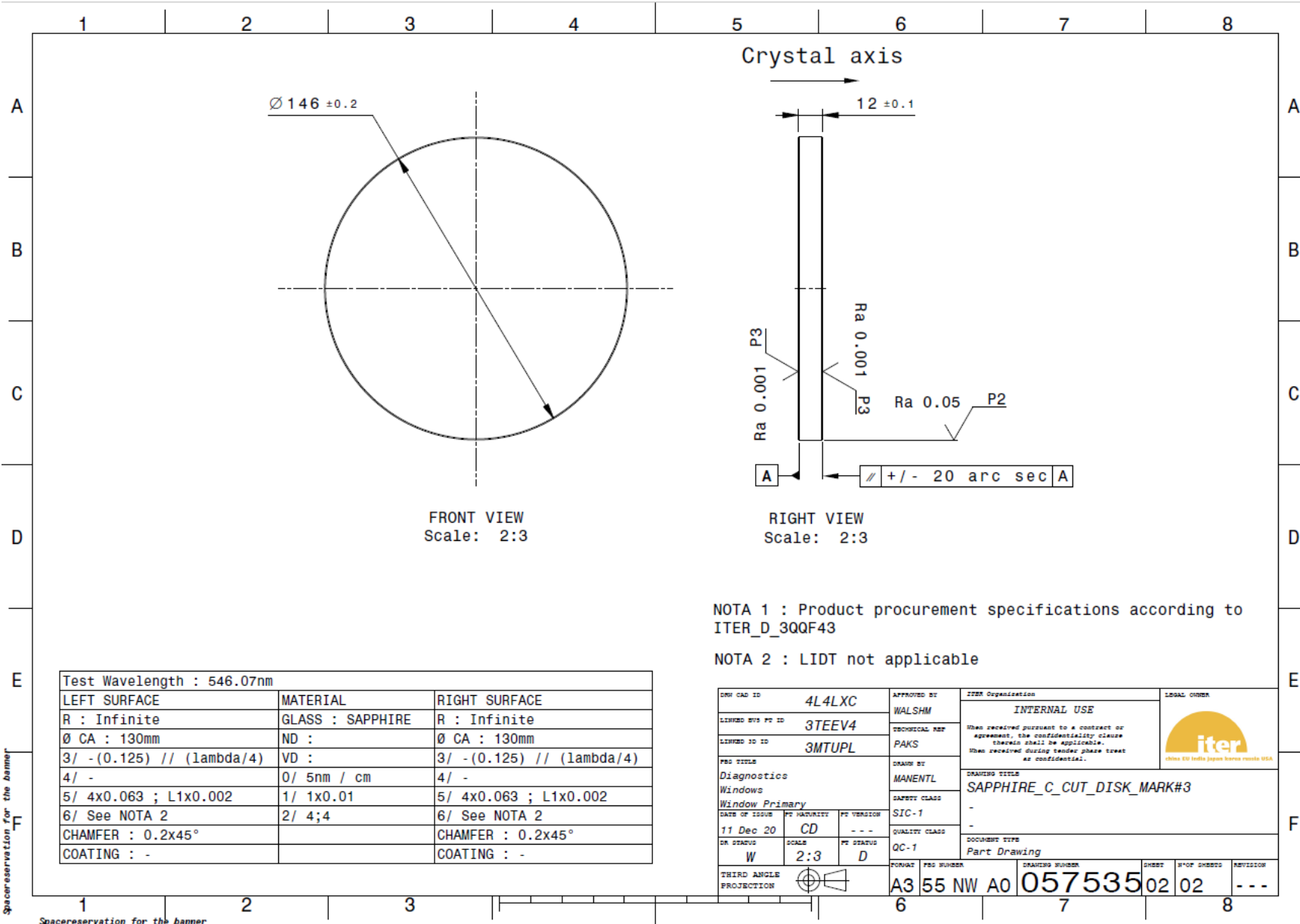
- Provisions for Implementation of the Generic Safety Requirements by the External Actors/Interveners (SBSTBM v2.2)
- Propagation of the Defined Requirements for Protection Important Components Through the Chain of External Interveners (BG2GYB v3.3)

This task is a PIA.

“The supplier must comply with the all requirements expressed in “Provisions for implementation of the generic safety requirements by the external actors/interveners” (SBSTBM)”

# ANNEX I – Manufacturing drawings of the disks







NOTA 1 : Product procurement specifications according to ITER\_D\_30QF43

NOTA 2 : LIDT not applicable

Test Wavelength : 546.07nm		
LEFT SURFACE	MATERIAL	RIGHT SURFACE
R : Infinite	GLASS : SAPPHIRE	R : Infinite
Ø CA : 130mm	ND :	Ø CA : 130mm
3/ -(0.125) // (lambda/4)	VD :	3/ -(0.125) // (lambda/4)
4/ -	0/ 5nm / cm	4/ -
5/ 4x0.063 ; L1x0.002	1/ 1x0.01	5/ 4x0.063 ; L1x0.002
6/ See NOTA 2	2/ 4;4	6/ See NOTA 2
CHAMFER : 0.2x45°		CHAMFER : 0.2x45°
COATING : -		COATING : -

DWG CAD ID	4L4LXC	APPROVED BY	ITER Organization	LEGAL OWNER
LIMITED BVS PT ID	3TEEV4	WALSHM	INTERNAL USE	 <small>ITER is the logo of the International Thermonuclear Experimental Reactor (ITER) project, which is a joint venture between the European Union, India, Japan, Korea, Russia, and the USA.</small>
LIMITED 3D ID	3MTUPL	TECHNICAL REP	PAKS	
PT TITLE	Diagnosics Windows	MANENTL	SAPPHIRE_C_CUT_DISK_MARK#3	
DATE OF ISSUE	11 Dec 20	SAFETY CLASS	SIC-1	
DR STATUS	W	QUALITY CLASS	QC-1	
SCALE	2:3	DOCUMENT TYPE	Part Drawing	
THIRD ANGLE PROJECTION		FORNAGE	A3 55 NW A0	DRAWING NUMBER
			057535	SHEET
			02	N° OF SHEETS
			02	REVISION
			---	

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Spacereservation for the banner

# ANNEX II – Record of original requirements

For traceability purpose, the diagnostic requests are reminded in the table below.

*Table 15: Diagnostic systems requests*

Loc	Port	Diagnostic system	Disk variation	Mark	WA variation	Sub-variation	Qty
Upper	2	GA Wide angle viewing system	Ø160 CV - T = 12 mm	1	160_SAPPH_B_2Y_2Z	CS#1-S	1
Upper	8	GA Wide angle viewing system	Ø160 CV - T = 12 mm	1	160_SAPPH_B_2Y_2Z	CS#1-S	1
Upper	11	GA Wide angle viewing system	Ø160 CV - T = 12 mm	1	160_SAPPH_B_2Y_2Z	CS#1-S	1
Upper	14	GA Wide angle viewing system	Ø160 CV - T = 12 mm	1	160_SAPPH_B_2Y_2Z	CS#1-S	1
Upper	17	GA Wide angle viewing system	Ø160 CV - T = 12 mm	1	160_SAPPH_B_2Y_2Z	CS#1-S	1
Equatorial	3	G1 Vis/IR	Ø160 CV - T = 12 mm	1	160_SAPPH_B_2Y_2Z	CS#1-S	4
Equatorial	9	G1 Vis/IR	Ø160 CV - T = 12 mm	1	160_SAPPH_B_2Y_2Z	CS#1-S	4
Equatorial	12	G1 Vis/IR	Ø160 CV - T = 12 mm	1	160_SAPPH_B_2Y_2Z	CS#1-S	3
Equatorial	17	G1 Vis/IR	Ø160 CV - T = 12 mm	1	160_SAPPH_B_2Y_2Z	CS#1-S	4
Equatorial	16	G1.E0 Temporary	Ø160 CV - T = 12 mm	1	160_SAPPH_B_2Y_2Z	CS#1-S	1
Equatorial	17	G6 Divertor IR Thermography	Ø130 CV - T = 10 mm	3	130_SAPPH_B_2Y_2Z	CS#2-S	2