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**65QCSD**

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EXTERNAL REFERENCE / VERSION

**Technical Specification**

# Technical Note Fast Shutter

This technical note will be used for the market survey launched jointly with F4E and INDA

| Change Log | | | |
|---|---|---|---|
| **Technical Note Fast Shutter (65QCSD)** | | | |
| ***Version*** | ***Latest Status*** | ***Issue Date*** | ***Description of Change*** |
| v0.0 | In Work | 03 Nov 2021 | |
| v1.0 | Approved | 03 Nov 2021 | first release |

# Fast Shutter
# Technical Note
# For
# Market Survey

# Contents

# 1 Scope

The scope of this document is to describe briefly the preliminary design of the Fast shutter (system, loads and interfaces) and to provide the main requirements of the components in order to launch an international market survey in order to supply the component on ITER project.

# 2 Abstracts

ITER is a joint international research and development project that aims to demonstrate the scientific and technical feasibility of fusion power.
In southern France, 35 nations* are collaborating to build the world's largest tokamak, a magnetic fusion device that has been designed to prove the feasibility of fusion as a large-scale and carbon-free source of energy based on the same principle that powers our Sun and stars.
Thousands of engineers and scientists have contributed to the design of ITER since the idea for an international joint experiment in fusion was first launched in 1985. The ITER Members—China, the European Union, India, Japan, Korea, Russia and the United States—are now engaged in a 35-year collaboration to build and operate the ITER experimental device, and together bring fusion to the point where a demonstration fusion reactor can be designed.
ITER will be the first fusion device to produce net energy. ITER will be the first fusion device to maintain fusion for long periods of time. And ITER will be the first fusion device to test the integrated technologies, materials, and physics regimes necessary for the commercial production of fusion-based electricity.

The Neutral Beam system for ITER consists of two heating and current drive (H&CD) NB injectors and a diagnostic neutral beam (DNB) injector. The layout allows a possible third HNB injector to be installed later. These NB injectors will be connected to equatorial ports #4 - #6 for the H&CD NBs. The DNB shares port #4 with the H&CD NB. The injectors will be located outside the cryostat inside a common enclosure, the NB cell, on north side of the Tokamak building in the L1 and the L2 levels. As they are directly coupled to the ITER vacuum vessel, the injectors are extensions of the primary confinement barrier of radioactive materials coming from the vacuum vessel. The NB cell will form the secondary confinement barrier.

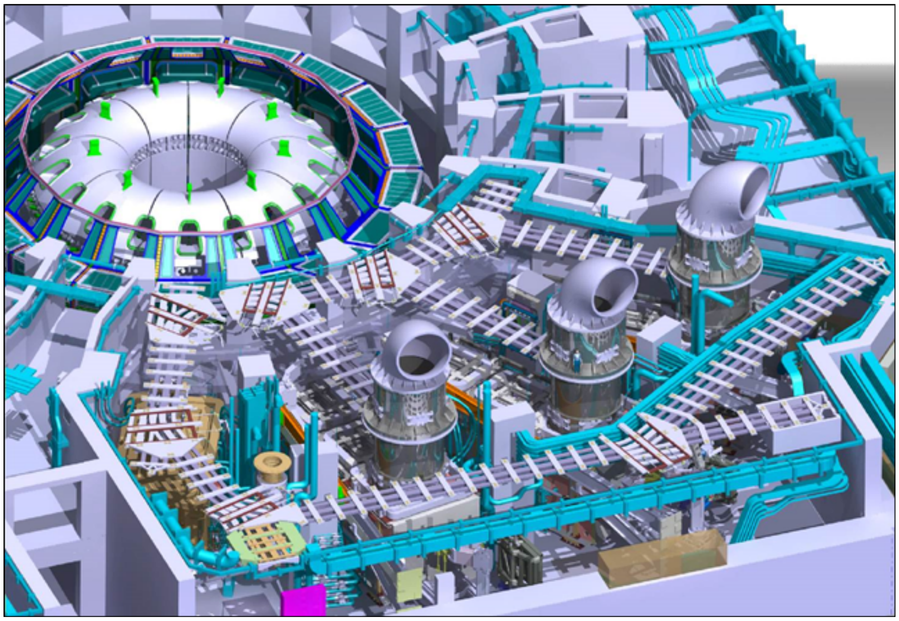

*Figure 1: Isometric view of the NB Cell*

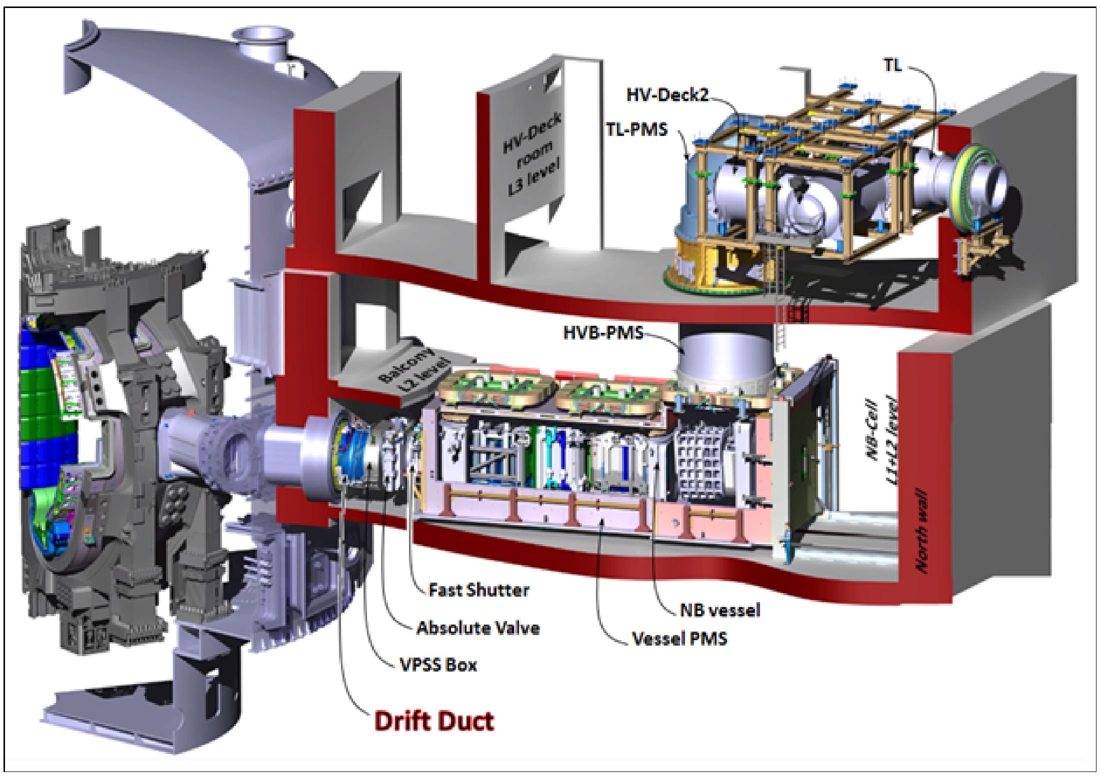


*Figure 2: Cross section of one NB Injector*

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In order to minimise the ingress of contaminants such as dust, tritium and beryllium hazards into the Neutral Beam Vessel, Each NB Injectors incorporate a Fast Shutter that remains closed at all times except when beams are being injected into the Tokomak.

This component shall provide the primary vacuum containment for this section of the NB system and therefore provides a part of the first confinement barrier of the in-vessel radioactive inventory.

The Fast Shutter forms an integral part of each of the four NB lines of ITER. It is located between the Beam Line Vessel (BLV) exit and the Absolute Valve (FS), as shown in Figure3 .

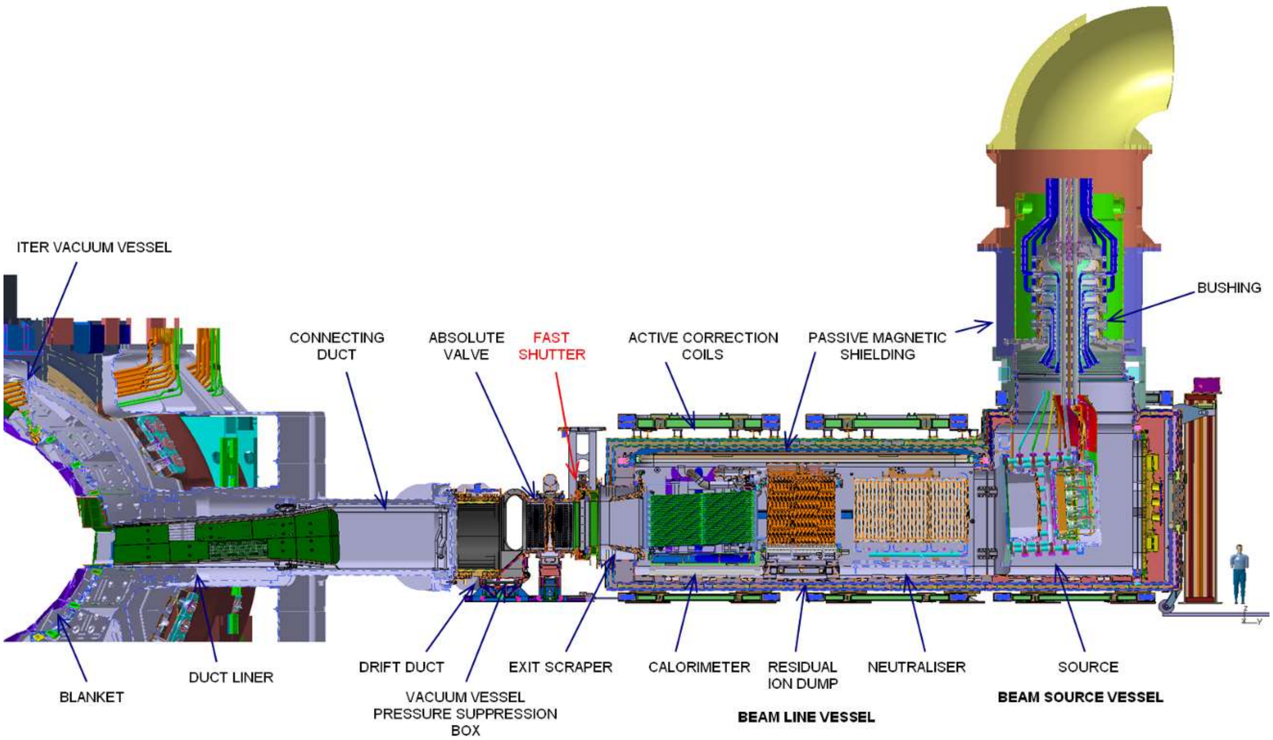



*Figure 3: Cross section of one NB Injector*

## 3 Abbreviations

The abbreviations use in this document is explained in the following list:

| | |
|---|---|
| AAR | Accident Analysis Report |
| ACCC | Active Compensation Cooled Correction Coils |
| ASCE | American Society of Civil Engineers |
| ASME | American Society of Mechanical Engineers |
| BLC | Beam Line Components |
| BS | Beam Source |
| BLV | Beam Line Vessel |
| BSV | Beam Source Vessel |
| CDR | Conceptual Design Review |
| DA | Domestic Agency |
| DD | Drift Duct |
| DDD | Design Description Document |

| | |
|---|---|
| DOF | Degree Of Freedom |
| DRS | Design Response Spectra |
| EM | Electro Magnetic |
| ESP | French decree dated December 13, 1999 related to the manufacture of pressure equipment (Implementation of the European Pressure Equipment Directive 97/23/EC PED in French law). |
| ESPN | French order dated December 12, 2005 related to the manufacture of Nuclear Pressure Equipment (NPE) |
| FEC | Front End Component |
| FRS | Floor Response Spectra |
| FS | Fast Shutter |
| HNB | Heating Neutral Beam |
| ICE | Ingress of Coolant Event |
| kN | Kilo Newton |
| LOCA | Loss of Coolant Accident |
| LOFA | Loss of (forced) Flow Accident |
| LOOP | Loss Of Off-site Power |
| LOVA | Loss of Vacuum Accident |
| MD | Major Disruption |
| MFD | Magnet Fast (current) Discharge |
| MN | Mega Newton |
| MPa | Mega Pascal |
| MQP | Management Quality Program |
| NBI | Neutral Beam Injector |
| NRC | Nuclear Regulatory Commission |
| NSC | Non-Seismic Class |
| PA | Procurement Arrangement |
| PR | Project Requirement (Document) |
| PHTS | Primary Heat Transfer Systems |
| PRS | Point Response Spectra - Spectra calculated at specific points of a structure (also called "In-Structure Spectra" and "Secondary Spectra |
| RD | Rupture Disk |
| RPrS | Preliminary Safety Report (Rapport Préliminaire de Sûreté) |
| SC | Seismic Class |
| SIC | Safety Importance Class (-1 or -2) |
| SL | Seismic Level |
| SL-1 | Seismic Level 1 – Defined by ITER for investment protection |
| SL-2 | Seismic Level 2 – equivalent to Safe Shutdown Earthquake |
| SMHV | Séismes Maximaux Historiquement Vraisemblables = Maximum Historically Probable Earthquakes |
| SRD | System Requirement Document |
| SRSS | Square Root of Sum of Square |
| SSE | Safe Shutdown Earthquake |
| ST | Suppression Tank |

| | |
|---|---|
| ST-VS | Suppression Tank Venting System |
| SVS | Service Vacuum System |
| TGCS | Tokamak Global Coordinate System |
| VDE | Vertical Displacement Event |
| VV | Vacuum Vessel |
| VVPSS | Vacuum Vessel Pressure Suppression System |
| ZPA | Zero Period Acceleration |

# 4 Functions/ Main requirements

| ID | Requirements |
|---|---|
| **R1** | The Fast Shutter will have a moving shutter that remains closed at all times except when the Neutral beam is injecting |
| **R2** | Closing time will be less than 5s. The Shutter must be able to shut quickly in the event of nuclear incidents and accidents in either the Torus or the BLV. |
| **R3** | The support closing systems shall have a redundancy |
| **R4** | The status is failed safe closed and passive closure shall be performed between 10s and 15s. |
| **R5** | Leak tightness shall be effective 30 s after the beginning of the transient |
| **R6** | When first closed, the Fast Shutter must exhibit a conductance during beam-on/beam-off of 1x10-3 m3/s with fast closure/opening of less than 1 second, whilst the gas flow remains in a molecular regime. This is in order to protect the Beam Line Components and Beam Source in the BLV&BSV from excessive contamination from the main Tokomak vacuum vessel. |
| **R7** | When closed and sealed, the Fast Shutter must seal well enough (a leak-rate of less than $10^{-2}$ Pa.m$^3$/s of D2 at 2000 Pa) to allow regeneration of the cryo-pumps in the BLV without excessive contamination of the main Tokomak vacuum vessel, with a BLV internal pressure of 2000 Pa (20 mbar). |
| **R8** | The Fast shutter shall protect the components in the BLV and BSV from contaminants coming from the Main Tokomak by providing the means to rapidly separate the Tokomak from the BLV and BSV. |
| **R9** | The shutter must be able to withstand a Cat IV main Tokomak Vacuum Vessel accident (multiple water pipe break) when the Tokomak pressure can rise to 0.2MPa (2 bara ) with full vacuum in the BSV & BLV. |
| **R10** | The shutter must be able to withstand a Cat III main Tokomak Vacuum Vessel accident (a double-ended pipe rupture of the largest diameter (Ø66mm) cooling pipe of the FW/BLK PHTS) when the Neutral Beam Cell pressure can rise to 0.16 MPa (1.6 bara ) with full vacuum remaining in the BSV & BLV. |
| **R11** | The shutter must be able to withstand a Cat III Beam Line Vessel accident (water pipe break within the BLV) when the BLV pressure can rise to 0.02 MPa (0.2 Bara) with full vacuum in the Tokomak Vessel. |
| **R12** | The Fast Shutter, when open, shall maximise the transmission of the beam. The current opening is a rectangular duct of 1457 mm X 597 mm; This is the minimum size allowed. |
| **R13** | For low conductance operation, the maximum leak rate shall be $10^{-2}$ Pa.m$^3$/s for 3000 cycles. |
| **R14** | For low conductance operation, the capability of the Fast Shutter shall assume 3000 cycles during the life of ITER. |
| **R15** | This component shall be compatible with $H^0$ and $D^0$ beams. |

**Summary of requirements that the Fast Shutter** *(yellow)* **and the Absolute Valve [10] shall fulfil**

| **Requirements** | **FS** | **AV** | **AV + FS** |
|---|---|---|---|
| 3,000 cycles with low leak rate ($10^{-2}$ Pa.m$^3$/s) during Cryopump regeneration | √ | √ | √ |
| 40,000 cycles OPENING to enable NB pulse (no requirement on leak rate) | √ | √ | √ |
| 10 cycles of VV LOCA event : Protection of the BLV against ingress of Tritium in 5 sec. | √ | X | √ |
| 10 cycles of BLV LOCA event : Mitigate the loss of vacuum in VV in 5 sec | √ | X | √ |
| 100 cycles: Absolute sealing ($10^{-8}$ Pa.m$^3$/s) to isolate the BLV from VV vacuum in 15 mn | X | √ | √ |
| Isolate the NB Vessels from VV in order to enable maintenance operations (VV under depression – no absolute sealing is required) | √ | √ | √ |
| Failed safe closed and passive closure of the component | √ | X | - |

# 5 Classifications

- As part of the first confinement barrier, the casing of this component has Safety Importance Classification (SIC) SIC 1 (**) and shall be designed in accordance with safety requirements. This statement also applies to any part of the casing which is attached to the internal removable mechanism.
- The closure of the Fast Shutter is SIC 1 (**) (redundant system shall be deployed to ensure this function in case of incident/accident)

**:

*Systems, structures and components (SSCs) are identified as Safety Importance Class (SIC) based on the consequences of their failure:*

*Criterion A: Their failure can directly initiate an incident or accident leading to significant risks of exposure or contamination.*

*Criterion B: Their operation is required to limit the consequences of an incident or accident leading to significant risks of exposure or contamination.*

*Criterion C: Their operation is required to ensure functioning of SIC components.*

- ***SIC-1*** *SSCs are those required to bring and to maintain ITER in a safe state*
- ***SIC-2*** *SSCs are those used to prevent, detect or mitigate incidents or accidents, but not SIC-1 (not required for ITER to reach a safe state)*
- ***SR*** *"Safety Relevant" SSCs have some relevance to safety, but their failure will not impact any safety function.*

***Non-SIC*** *All other SSCs.*

- This component shall meet the requirements of vacuum class VQC 1A as outliner in [3]
- Any coolant piping of this component that is exposed to the primary vacuum has vacuum class VQC 1A [3].

- The casing of the FS is RH class3
- The shutter mechanism is RH Class2

*<u>RH Class 2</u>: Maintenance Task probability > 10-1 but not scheduled tasks (in 20 year period) Plant designed to be RH compatible for maintenance / Maintenance equipment procured and operation sequences planning in detail prior to machine operations. Novel aspects of maintenance tasks verified on physical mock-ups before design is finalized.*

*<u>RH Class 3</u>: Maintenance Task probability > 10-6 but < 10-1 (in 20 year period) Plant designed to be RH compatible for maintenance/Maintenance equipment and operation sequences designed prior to machine operations.*

- This component shall meet the requirements of Quality Class 1[1].

- The casing of this component shall meet the requirements of Seismic Class SC 1(S).
- The mechanism shall meet the requirements of Seismic Class SC 1(SF)

*<u>SC1 (SF) - Seismic class one-SF</u>: Structural stability and required functional seismic safety performance maintained in the event of an earthquake, The respect of this level of requirement guarantees the level of safety as throughout the normal operation of the equipment. Nevertheless, taking into account seismic load characteristics, fatigue is not taken into account.*
*<u>SC1 (S) - Seismic class one-S</u>: Structural stability maintained in the event of an earthquake, i.e. no rupture of piping, no collapse of structures or equipment, limited plastic strain, limited concrete cracking, structural support functions maintained. With this level of requirement, it is possible that a small level of deformation could occur. Consequently, it could be necessary to inspect equipment before re-using it.*

# 6 Codes & standards

## 6.1 First Confinement barrier / Vacuum boundary

For metallic parts which form the first confinement barrier of plasma vacuum chamber it is proposed to use one code. This code shall be used for nuclear pressure and for other components, which are non-pressure equipment. The proposed Code is RCC-MR (edition to be chosen by the supplier).
The supplier may propose other Nuclear code equivalent to RCC-MR code that will subject to IO approval (*).

Using this code has some benefits for licensing of the ITER plasma chamber which provide first confinement. These advantages are:
- Reduction of risk with delay of licensing ITER facility
- Unification of technical procedures for connections of various components
- Simplification of interface requirements

(*) If the supplier encounters technical showstoppers on the design following the RCC-MR code, it shall be clearly identified and justified to IO. IO shall accept the need of deviation to the code with the prerequisite that IO approve the justification of the issue. The deviation will be raised by the supplier. IO shall approve the deviation with the prerequisite that the supplier develop a mitigation/qualification procedure compliant with the regulations

## 6.2 Non-First Confinement barrier / Vacuum boundary

The Internal, non-first confinement boundary parts of this component shall be designed to SDC-IC [8].

SDC-IC consists of the main Design Criteria document and annexed appendixes.

The main document includes definitions and classifications of different damage and failure modes, type of stresses, joints, thermal creep phenomena, buckling, etc. The other parts of document include design rules for general single layer homogeneous structures at low and elevated temperatures, rules for welded joints and rules for bolts. Design rules for multilayer heterogeneous structures are included also, but they are limited to only low temperature application.

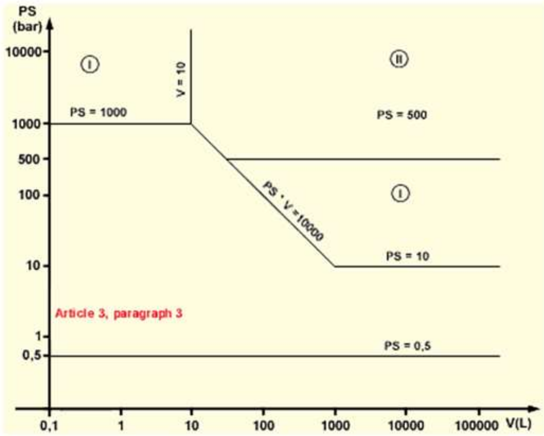
## 6.3 PED/ESPN Requirements

The design of the FS needs to comply with the requirements of ESP/ESPN. Note that in the context of ESP and ESPN the pressure designation 'PS' is here taken to be equivalent to the Maximum Allowable Working Pressure (MAWP).

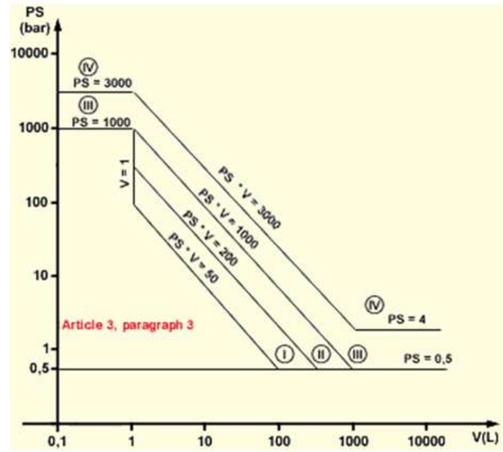
Note that embedded coolant pipes that have a heat exchange function are classed as 'vessels' in the context of ESP/ESPN.

Note that if the coolant temperature exceeds 110˚C, the coolant is classed as a gas.

The graphs below allow the correct classification of the coolant pipework to be determined:




Vessels containing group 2 **liquids**




Vessels containing group 2 **gases**

- The FS shall be designed to be cooled, drained and dried under PED (*) class 0 or max class 1 (*to avoid any requalification/inspection during life time of the valve*)

(*): The Pressure Equipment Directive (PED) was adopted by the European Parliament and the European Council in May 1997. From 29 May 2002 the PED is obligatory throughout the European Union. The directive provides, together with the directives related to simple pressure vessels (87/404/EC), for an adequate legislative framework on European level for equipment subject to a pressure hazard.

Following this European Directive the French Decree 99-1046, 13th December 1999 concerning pressure equipment (Amended by Decree No. 2003-1249 dated 22nd December 2003, by Decree No. 2003-1264 dated 23rd December 2003 and Decree 2007-1557 dated 2nd November 2007 and Decree 2010-882 dated July 27, 2010) and French Order dated 21st December 1999 concerning the classification and evaluation of the conformity of pressure equipment put the PED in force in France. Acronym ESP is proposed to be used for above mentioned documents.

# 7 Interfaces

## 7.1 Environment

- This component shall be positioned downstream of the NB Vessels and upstream of the Absolute Valve - *see figure 4*

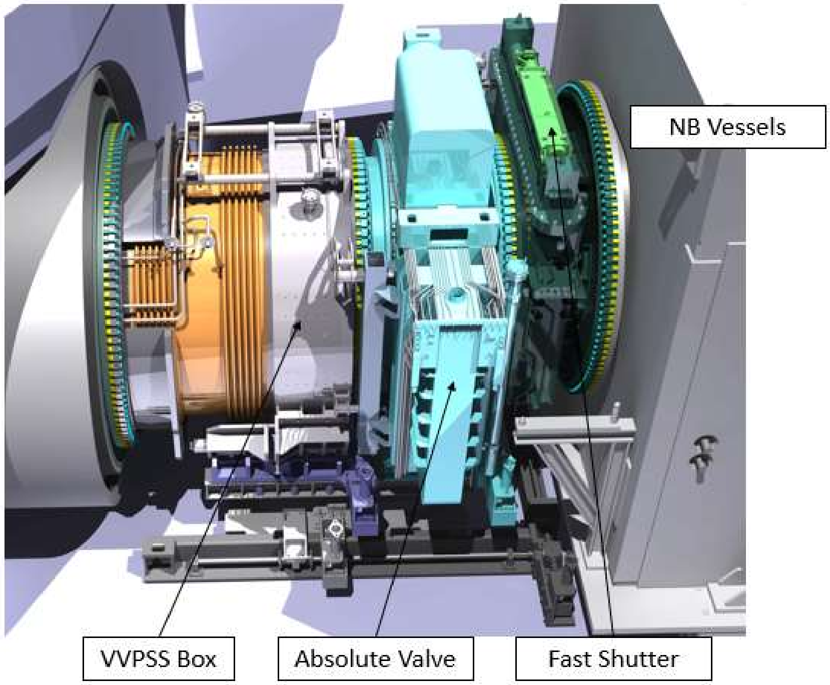



*Figure 4: NB Front End Components integration*

- The Fast Shutter is mounted between the BLV end flange (DNB/HNB) and the Absolute Valve. The weight of the Fast Shutter is nominally equally supported by the Fast Shutter end flanges.

- The flanges at either end of this component shall be compatible with the mating interface of the adjacent component.

- The FS services include:
  - coolant from the NBI PHTS (see section 6.4)
  - system, pneumatic actuator "air" lines,
  - Power-electric connections from casing and seal seat ring heating systems connections for C&I systems.

- The FS will be connected to the Service Vacuum System in order to monitored any interspaces used for sealing when needed.

- It is also assumed that the integration of the Fast Shutter in the Beam line will not result in any significant constraint of the casing against thermal expansion

- The flange design has been defined, along with associated remote handling procedures and tooling. The FS flanges shall be compatible with the Absolute flange and the NB Vessels ( Beam Line Vessel) flange taking into account the sealing solution adopted by IO and the RH requirements. The interfaces flanges design have already been frozen. The Fast Shutter shall integrate these interfacing flanges as defined below

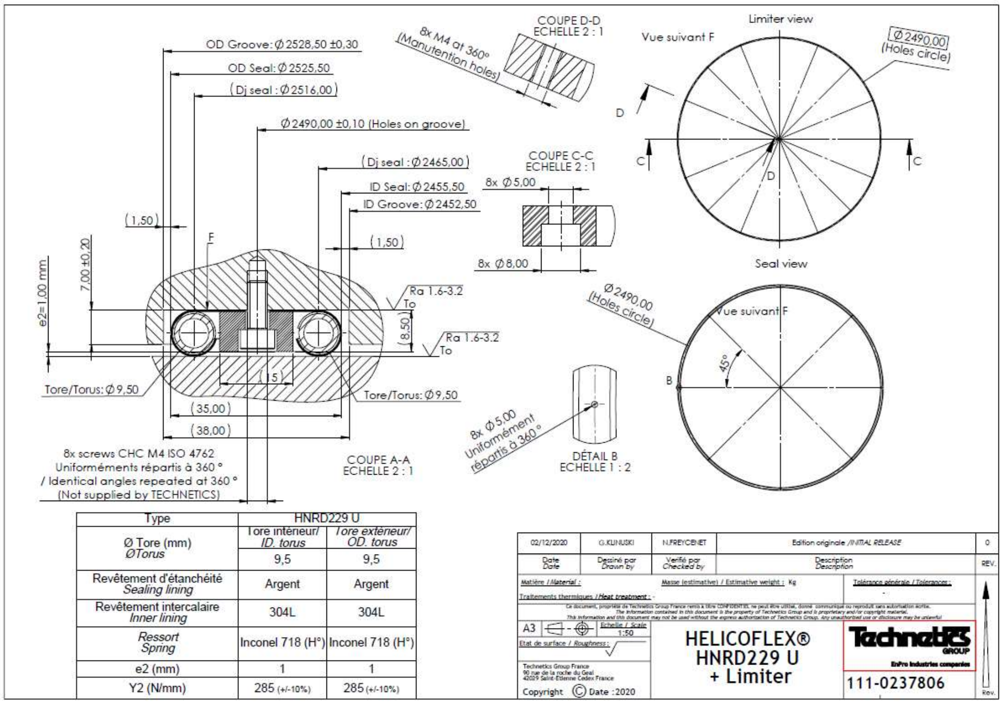



*Figure 5: Sealing interface between the Fast Shutter and the Beam Line Vessel*

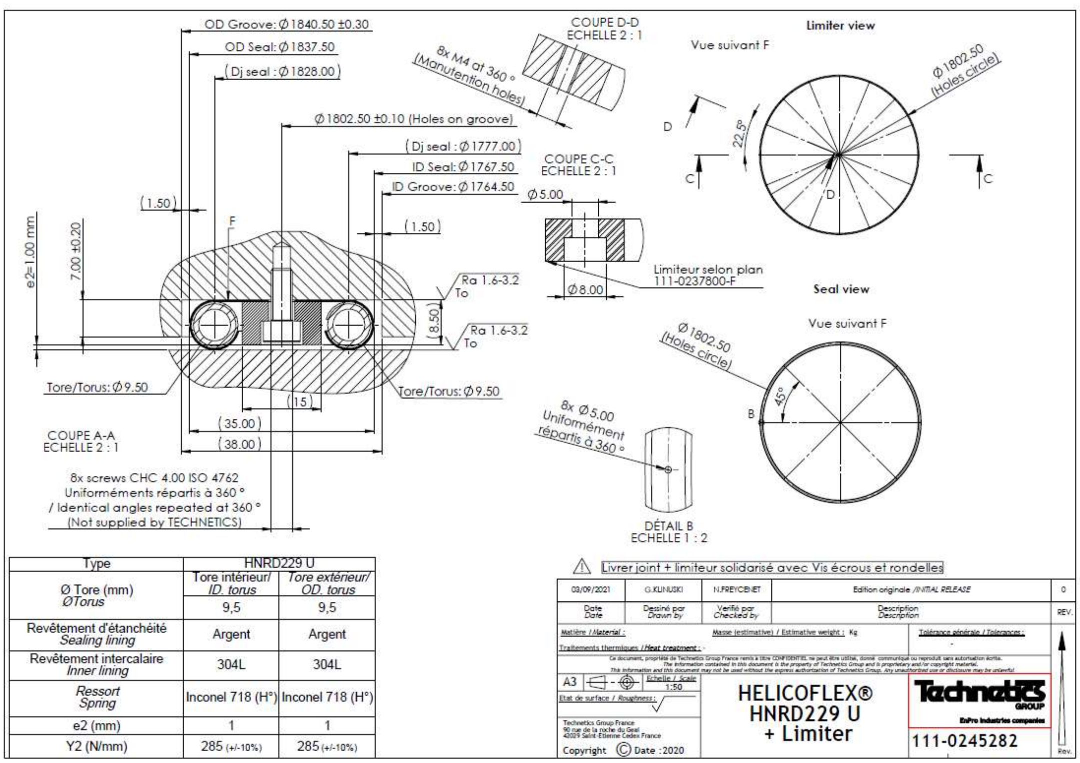



*Figure 6: Sealing interface between the Fast Shutter and the Absolute Valve*

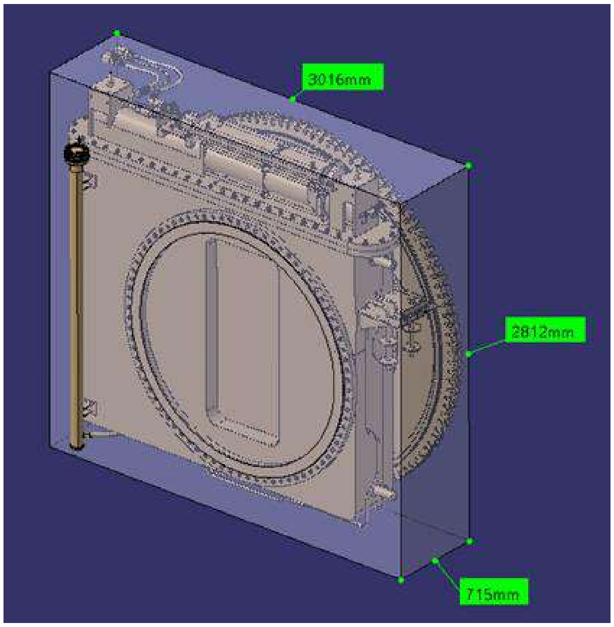



*Figure 7: maximum envelope of the Fast Shutter*

- The maximum space envelope of the Fast Shutter integrated in the NB cell environment shall be : 3000mm by 2800mm by 700 mm
- Weight max of the FS : 7 500 kg

## 7.2 Vacuum

This component shall have a maximum allowable leak rate of 1E-10 Pa.m$^3$/s air equivalent from exterior atmosphere to internal vacuum.

All Interspaces used in vacuum confinement shall be connected to the Service Vacuum System (SVS).

Sealing for the first confinement boundary shall be by either:

- Welding
- metallic seal rings.

All components that have vacuum confinement functions shall comply with the vacuum handbook [3].

The leak rate between the vacuum vessel and the neutral beam vessel of the fast shutter (when closed) shall be less than 1E-2 Pa.m$^3$/s of Helium at a differential pressure of 2000Pa (100 K regeneration pressure).

The sealing of flanges shall be a double metallic seals with monitored interspace for both the deuterium phase, and the tritium phase when tritium may be used in the plasma and/or neutral beam.

## 7.3 Lifting

The Fast Shutter shall have lifting points of identical design to the crane twist-lock fittings (design provided by IO). The triangle between the centres encloses the valve centre of gravity.

**The maximum height available for components shall be 3,000 mm.**

## 7.4 Coolant

The Fast Shutter can be served by the NBI PHTS (high resistivity) cooling circuit. It has the following properties:

- Operational Inlet pressure 2.2MPa (+/-0.2MPa) => 2.4 MPa (absolute)

- Max Operational inlet temperature. 38°C

-Max outlet temp. <90°C

-resistivity >5 MΩ.cm

## 7.5 Compressed air

Compressed air, or other ITER specified gas is required to drive various actuators and mechanisms on the component .
The Fast Shutter shall incorporate air lines and an interface block to connect them to the supply system. It is assumed that all the control valves and systems will be located in a cubicle outside of the NB cell in a location that is easily accessible for maintenance.

## 7.6 Electrical power

It is assumed that standard 240 V AC will be available and supplied to the Fast Shutter via the interface defined.

## 7.7 Control & instrumentation

Since the instrumentation set for the component has not yet been defined. The I&C connections should either be installed on the interface block or use a separate connector. This work shall be developed during the study.

## 7.8 Electromagnetic

Subassemblies of this component whose function may be unacceptably affected by electromagnetic fields at their installation location shall be shielded so that their performances are not unacceptably affected by the fields.

The most important fluxes generated by the tokamak will induce loop voltages in the horizontal planes and not in the vertical (radial) ones. This shall be taken into account when tracing cable routes to reduce loop voltages and when designing insulation layout to reduce eddy currents.

# 8 Preliminary Design (for information)

The preliminary design described in this section is to provide the supplier with information related to the preliminary study of the component. It can be considered as guidelines; the supplier shall not be bounded by the technical solutions to fulfil the requirements and environment described in this document in table 1.

## 8.1 General Description

The Fast Shutter can be broken down into the following sub-assemblies:

- Movable shutter
- Shutter movement actuation and bearings
- Shutter and Shutter Seal
- Main casing and actuating mechanism for active seal.
- Remote Handling Interface
- Services (pneumatic, cooling, drainage, actuation)
- Control & Instrumentation Hardware

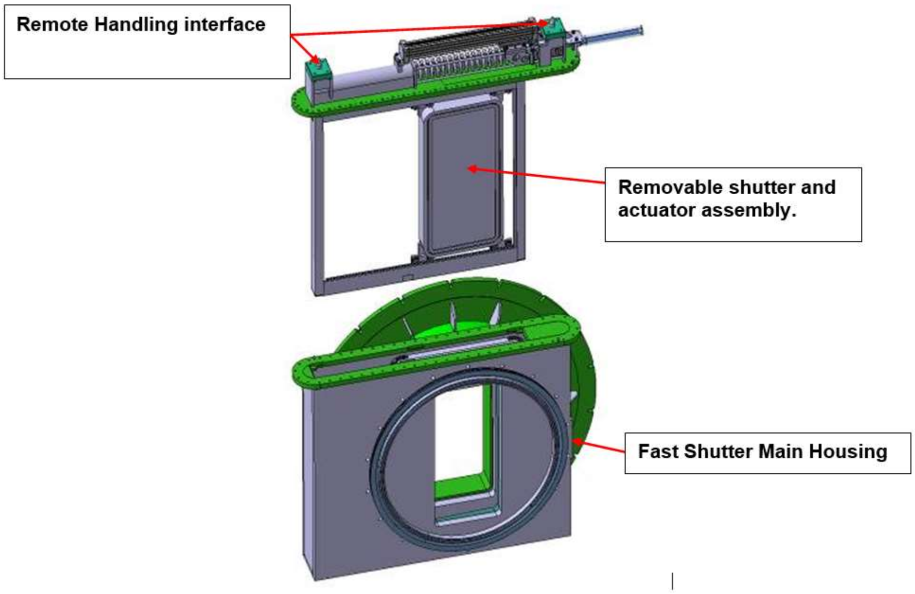



*Figure 8: Concept of the Fast Shutter*

- ➢ The current opening is a rectangular duct of 1400mm X 600mm; This is the minimum size allowed.
- ➢ The casing shall be fabricated from stainless steel 316 LN.
- ➢ The Shutter shall be sealed sealed onto the seal-face of the Fast shutter housing during specific NB System operation .

## 8.2 Material

- The use of Halogenated materials, sulphur and phosphorus for the NB Vessels that is Tritium Classified shall be avoided. Indeed, these materials lead to potential for oxidation catalyst poisoning and to metallic corrosion due to acid formation.
- All the materials for use in vacuum shall respect the requirements from chapter 5 of the Vacuum Handbook [3].
- The FS Stainless Steel (SS) shall be the X2CrNiMo17-12-2 controlled nitrogen(the X2CrNiMo17-12-2 controlled nitrogen is described in the RCC-MR Code Section A3.1S)
- The chemical composition determined by ladle and product analyses of X2CrNiMo17-12-2 controlled nitrogen shall comply with the requirements given in Table below : Chemical composition of X2CrNiMo17-12-2 controlled nitrogen for the NB Vessels

| **Chemical composition,**<br><br>X2CrNiMo17-12-2 controlled nitrogen | **Content in Wt. %** |
|---|---:|
| *Elements* | *Range or Max* |
| Fe | balance |
| C | 0.030 |
| Mn | 1.60 - 2.00 |
| Si | 0.50 |
| P | 0.030 |
| S | 0.015 |
| Cr | 17.00 - 18.00 |
| Ni | 12.00 – 12.50 |
| Mo | 2.30 – 2.70 |
| N | 0.060-0.080 |
| Cu | 1.00 |
| B | 0.0020 |
| | |
| **Additional ITER specific requirements [6] and [93]:** | |
| Co | 0.05 |
| Nb | 0.01 |

| | |
|---|---|
| Ta | 0.01 |
| Ti | 0.10 |

# 9 Design basis conditions & events

- This component shall be designed to cope with real-time power control of the beam which is designed to vary by +25%/-50%, whilst keeping below the maximum of 16.7MW to ITER, with a maximum frequency of 7 Hz.
- The design of this component shall not preclude pulse lengths of up to 3,600s at all beam powers and energies.
- The design of this component shall provide a thermal fatigue life consistent with the total number of pulses/pulse duration (50 000) foreseen by ITER operation, and by the commissioning and testing of the system as shown below:
- It can also be assumed that breakdowns do not adversely affect fatigue life of this component.
- The design life of this component is 20 years.

- The different states in which the FS will operate during its life are listed below:
    - State 1: transport & handling

The FS will have to be transported on ITER site. No additional load apart from those described below should be applied to the FS. The valve shall be equipped with some mechanical locks that stops it moving during handling.

- State 2: leak tests

After manufacturing and welding, the FS leak rate will be helium leak tested on the manufacturing plant following the VHB [5] – Appendix 12 [8].

- State 3: **during NB injection pulse**

This state describes normal operation when the beam is launched in the plasma. The Fast shutter (casing) becomes Vacuum boundary. **The Fast Shutter shall be opened**. As the injector works and Plasma launched, the risk of re-ionization is high. Re-ionised power could appear on the internal side surfaces of the FS.

<u>Re-ionisation</u>: *The re-ionised power inside the FS has been defined regarding several potential scenario of the gas profile inside the NB ducts. A liner actively cooled shall withstand the heating loads when the Fast Shutter is opened.*

- State 4: **between NB injection pulse**

This state describes the period between pulses when the system is waiting for the next NB injection pulse. The Fast shutter is Vacuum boundary. **The Fast Shutter shall be closed**. - **The status is failed safe closed and passive closure.**

- State 5: Incident and Accident Events

Accident and incident events are pressure loads which are described in the Load Specification document [5]

Upset operating conditions may result in pressure differentials across the shutter in excess of 0.1 MPa, up to a maximum design value of 0.2 MPa. The shutter shall withstand these events without any significant permanent deformations. This will be defined in the Load Specification document [5]

During normal operation the pressure in the NB cell is 0.1MPa absolute. During maintenance of a NB internal component the valve will be exposed to the same pressure as in the NB cell. The pressure in the VV can at the same time be between 0 and 0.1 MPa

Tokamak load case of category 4 leads to a pressure in the VV of 0.2 MPa which results into a pressure difference across the closed shutter of 0.1 MPa.

# 10 Load Specification

The FS design shall be compliant with all loads incident and accident events defined in the Load Specification [5]

# 11 Assembly

The Fast Shutter is design as a stand-alone component and will be manufactured, assembled and tested off-site. It may, therefore, be installed as a module with no further setup required. It is envisaged that the component will have a transport locking mechanism to prevent movement of the shutter while the actuators are not active. This may require some minor intervention to deactivate or remove the mechanism. Ideally the interfaces for first assembly must be the same than for RH lifting in case of maintenance.

# 12 Maintenance / (Remote Handling interface)

As an RH class 3 component, it is a requirement that the component continue to function adequately throughout the duration of the ITER experimental programme. As such, no maintenance operations are foreseen. In the event of a failure of the component or degradation of performance to unacceptable levels, the Fast Shutter would need to be removed and replaced by a new component. Refurbishment of the component is not expected.

The operation of maintenance are:

- replacement of the FS mechanism (RH Class2 shall be done Remotely (no human intervention).
- replacement of the full FS (RH Class3 shall be done Remotely (no human intervention).

The component shall be equipped with RH interfaces during design development.

- Fast Shutter casing maintenance:

No periodic maintenance (repairing actions) plan is foreseen on the FS, this means that the FS is considered as Remote Handling Class3 on IO.As it is RH class 3, the only way to maintain the FS is to remove the whole component, in this case, the state will be similar to the state 1 ‘’Transport & Handling’’ ensured only with Remote operations.

The sequences of this recovery scenario imply to close the FS to avoid the contamination of Tritium dust during the operations. The requirement of the leak tightness is not required, the gate shall just limit the displacement of the dust. All the service pack lines of the FS (cooling, pressurized air, SVS …) shall be cut and disconnected.

- Fast shutter mechanism maintenance:

As RH Class 2, the Full Shutter mechanism can be replaced independently from the its casing (RH Class3) . The requirement of the leak tightness is not required, the gate shall just limit the displacement of the dust. All the service pack lines of the FS (cooling, pressurized air, SVS …) shall be cut and disconnected

# 13 Manufacturing

The manufacturing feasibility shall be clearly demonstrated. As first confinement barrier, the casing of the FS must be developed and manufactured in accordance of the code and standards defined in the section 6. This component shall be designed to RCC-MR class 2.

For the manufacturing of the in-vessel components (in the case of the FS, this correspond to the internal system which are not part of the first confinement barrier) generally there are two types of technical procedures:

1) Manufacturing procedures for parts or components which are addressed by conventional Codes and directive requirements. These procedures are typically related to conventional welding, brazing joining, and NDT. The related specifications shall be prescribed in accordance with Code or Directive or Order requirements. To be compatible with ESP and ESPN requirements, the recommended manufacturing Code is EN 13445.

2) Manufacturing procedures for parts or components which are not addressed by conventional Code requirements (e.g. beryllium/Cu joints for first wall, non-metallic material joining, etc.). For the this type of manufacturing procedures ITER specific Technical Specification Documents shall be prepared or they will be defined in the Procurement technical specification Documents. The justifications shall be supported by R&D.

## *References:*


[1] Quality Classification Determination: ITER_D_24VQES - Quality Classification Determination

[2] Safety Important Components - Abstract for Presentation of Methodology to the French regulator: ITER_D_282VAQ - Safety Important Components - Abstract for Presentation of Methodology to the French regulator

[3] ITER Vacuum Handbook: ITER_D_2EZ9UM - ITER Vacuum Handbook

[4] ITER_D_25EW4K - Codes and Standards for ITER Mechanical Components

[5] Loads Specification ITER_D_353BEH - Load Specification for HNB Fast Shutter

[6] ITER_D_347SF3 - Safety Important Functions and Components Classification Criteria and Methodology

[7] RCC-MR- RCC-MR code, 2007 edition. Design and construction rules for mechanical components of nuclear installations ISBN 2-913638-22-8

[8] ITER_D_222RHC - In-vessel Components, SDC-IC

[9] Vacuum Handbook Appendix 12 Leak Testing link ITER_D_2EYZ5F - Appendix 12 Leak Testing

[10] ITER_D_65QGKS - Technical Note of the Absolute Valve