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WDGZ9Z
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EXTERNAL REFERENCE / VERSION

Technical Specification

TS - FDR - Analysis - Drift Duct

TS - Drift Duct - FDR analysis

Approval Process			
	Name	*Action*	*Affiliation*
Author	**Urbani M.**	**19 Jun 2018:signed**	**IO/DG/COO/TED/HCD/NB**
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Change Log			
TS - FDR - Analysis - Drift Duct (WDGZ9Z)			
Version	***Latest Status***	***Issue Date***	***Description of Change***
v0.0	In Work	24 Apr 2018	
v1.0	Signed	25 Apr 2018	first Version
v1.1	Signed	26 Apr 2018	minors correction on the wording
v1.2	Signed	28 May 2018	Version updated taking into account comments of reviewers
v1.3	Signed	31 May 2018	correction section 4.3 RCCMR expertise about the DD liner expertise
v1.4	Approved	19 Jun 2018	Specific requirements added

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1 Abstract

The NB 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.

The Figure 1 shows the NB-Cell including the 3 HNBs and the DNB.
The Figure 2 shows a view of the HNB components. The DD is highlighted.

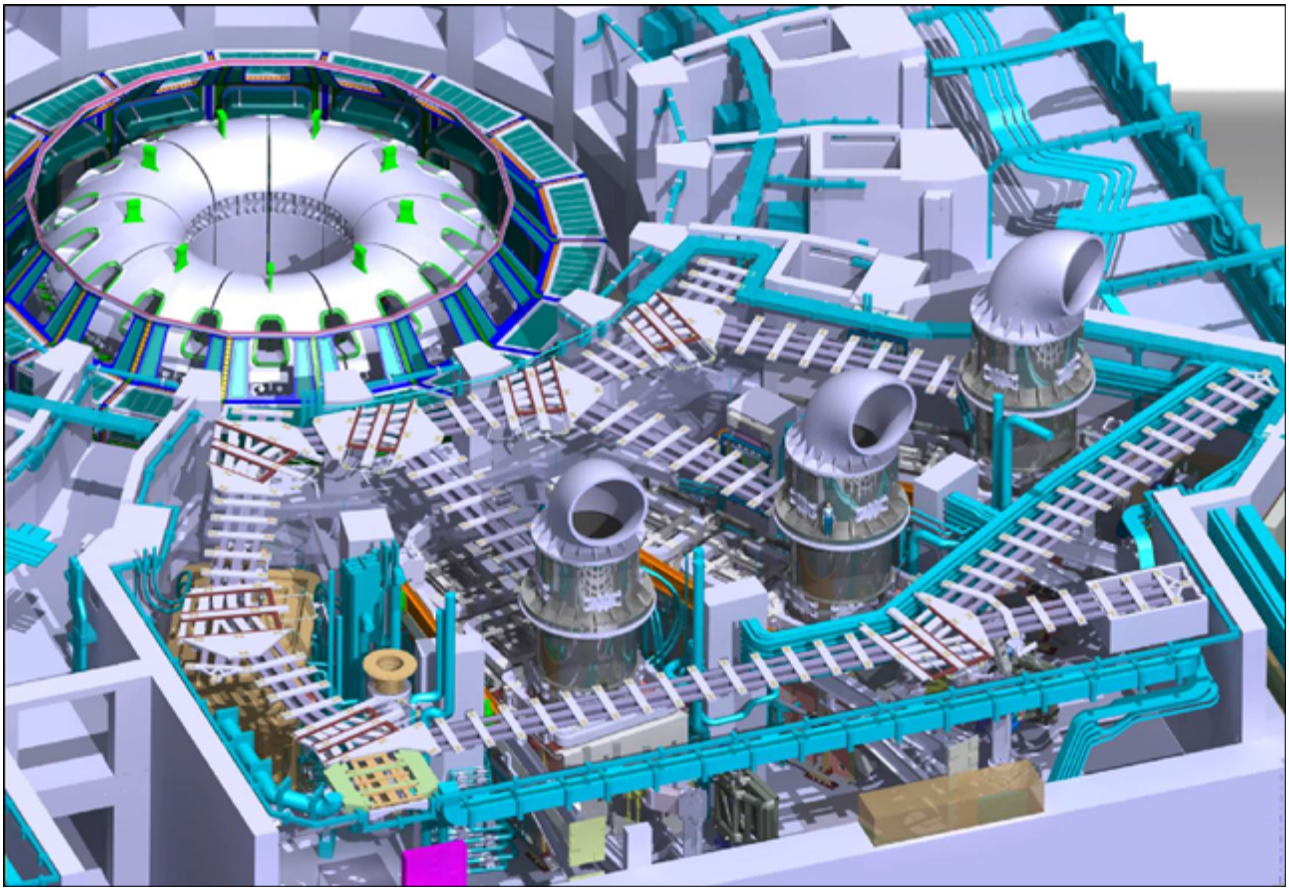

Figure 1: Isometric view of the NB Cell

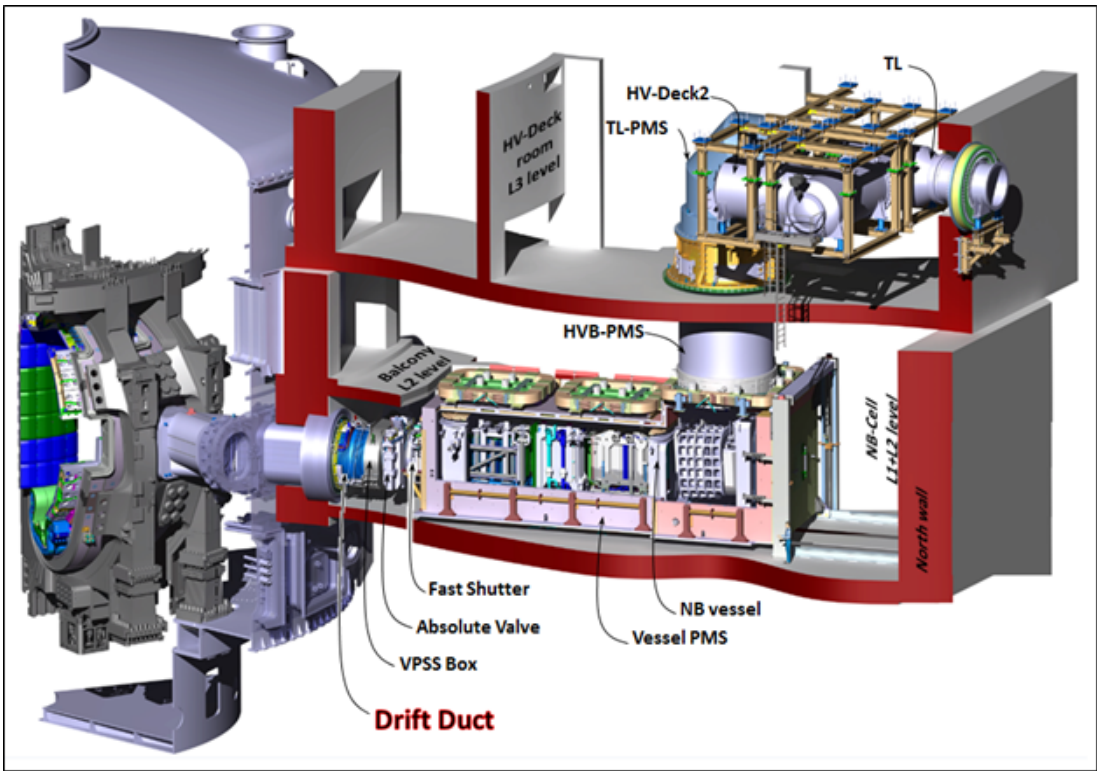

Figure 2: Front End Components in the NB Cell

2 Background and Objectives

2.1 Background

The present contract is intended for continuing the efforts of the activities for the development of the Drift Duct of the NBI system.

The DD forms a part of each of the four NB lines of ITER. The main function of the DD is to accommodate the relative displacements between the VV and the NB line. Flexibility is provided by a set of vacuum tight metal bellows that are protected from the NB re-ionisation heat load by a water cooled liner. The DD is located between the VV Connecting Duct (VVCD) on the Vacuum Vessel (VV) side and the VV Pressure Suppression System (VVPSS) box on the NB side. The position of the DD within the NB line is shown by figure 2.
The Drift duct is welded with the VVPSS Box and will be considered as one batch of component on ITER site.
The Contract will not cover the VVPSS Box design and analysis. The welded connexion between the DD and the VVPSS Box will be treated independently of this contract.

Basically, the NB Drift Duct consists of:

- The DD **bellows** have a universal joint arrangement, with two sets of convolutions separated by a common connector.
- Three **actuators**, surround the DD bellows to provide full control over the movement of the DD VVCD flange during installation and maintenance.
- The **DD Liner** is an actively water-cooled copper alloy sleeve that shields the bellows from heat emanating from the Neutral Beam due to re-ionization.

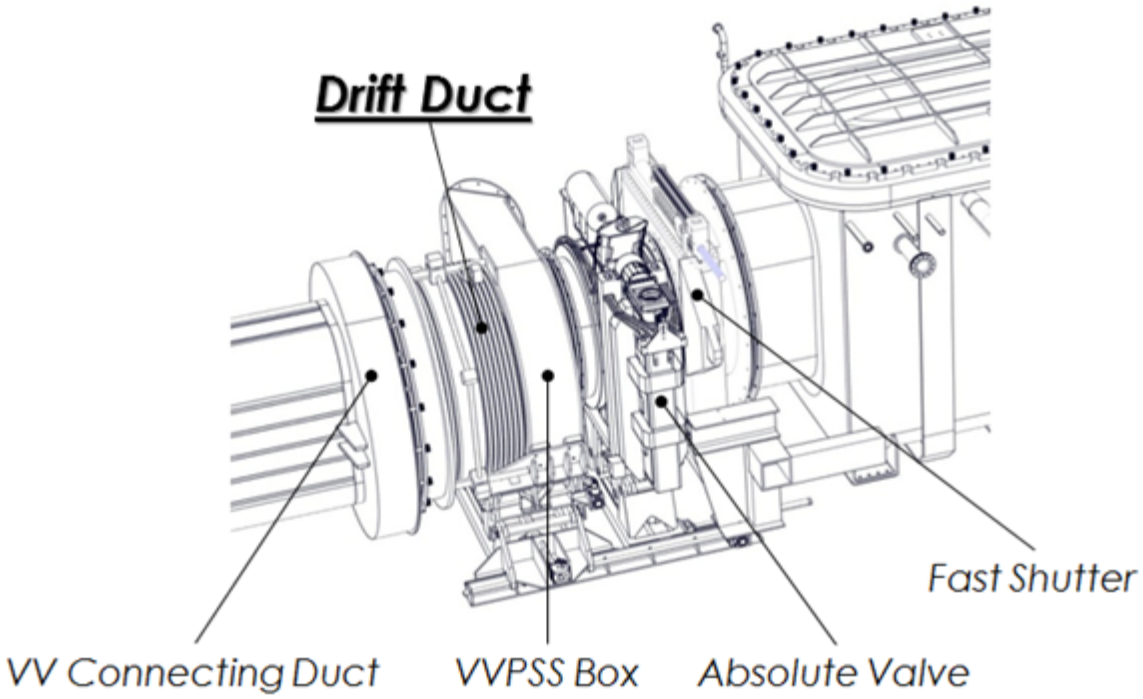

Figure 3: NB Front End Components

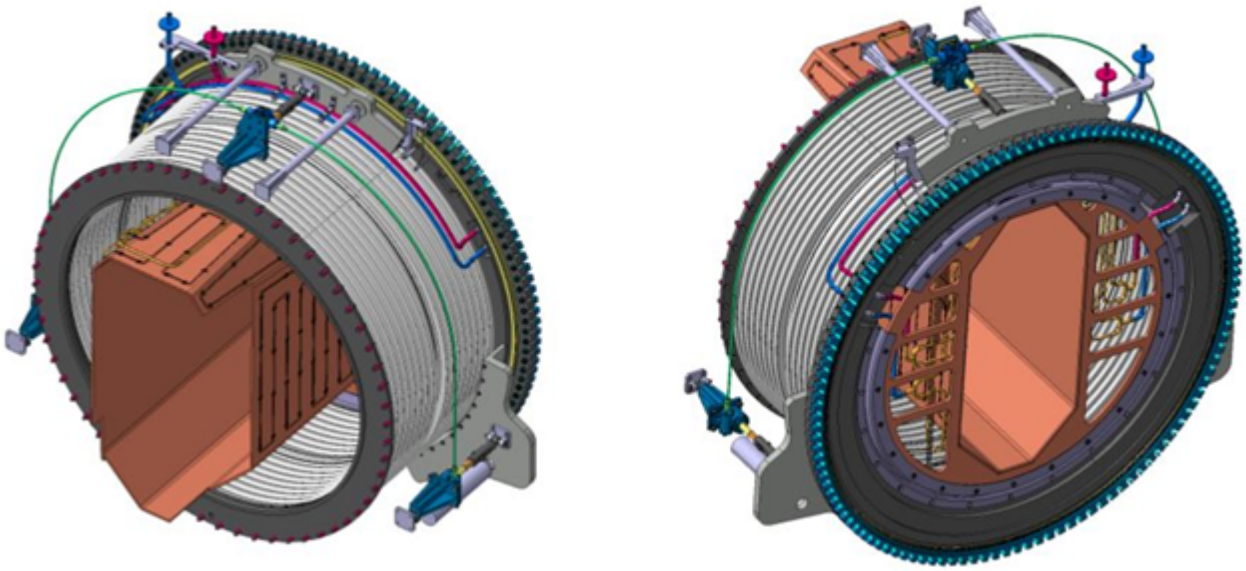

Figure 4: NB Drift Duct

The Drift Duct can be divided in three main sub-systems:

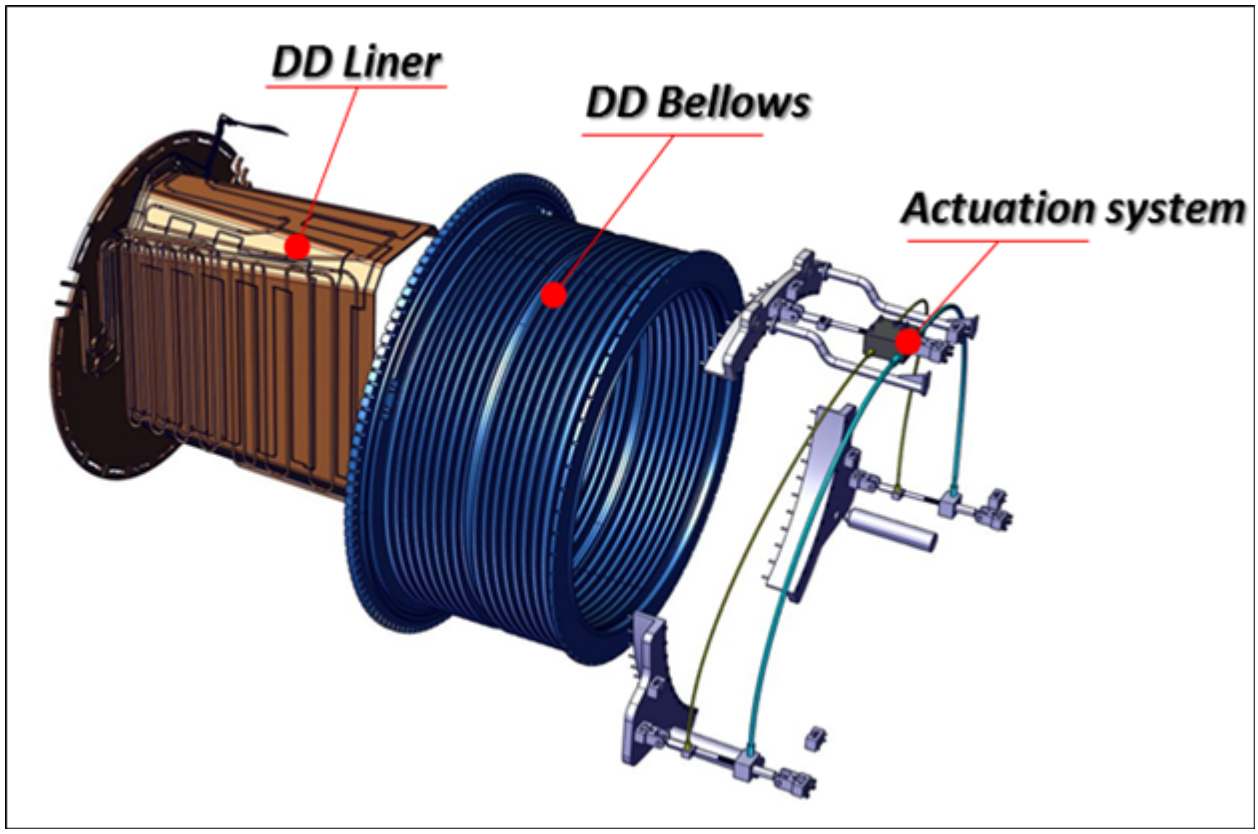

Figure 5: Exploited view of the Drift Duct

- **The DD Bellows**

The DD bellows decouples mechanically the VV Equatorial port and the NB Injector. Two sets of concentric bellows in a universal joint configuration are used. Each set of bellows is welded on to fittings on the DD VVCD flange at one end and the VVPSS box at the other. The universal joint configuration consists of two sets of bellows convolutions, one at each end, separated by a common connector, as shown below in figure 6.

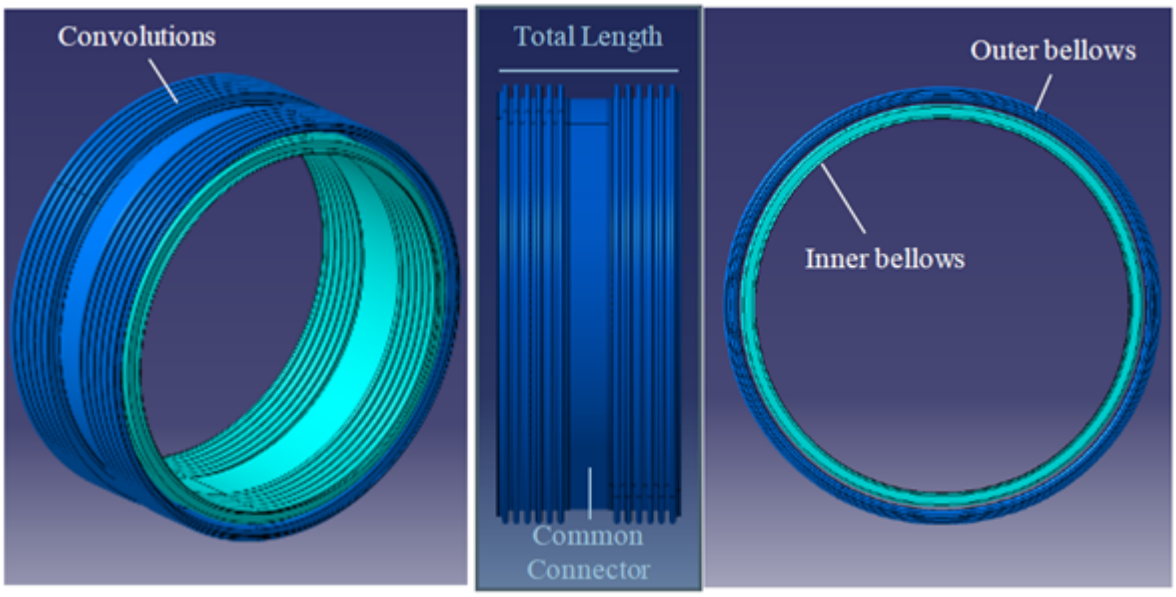

Figure 6: General view of DD bellows

- **The DD Liner**

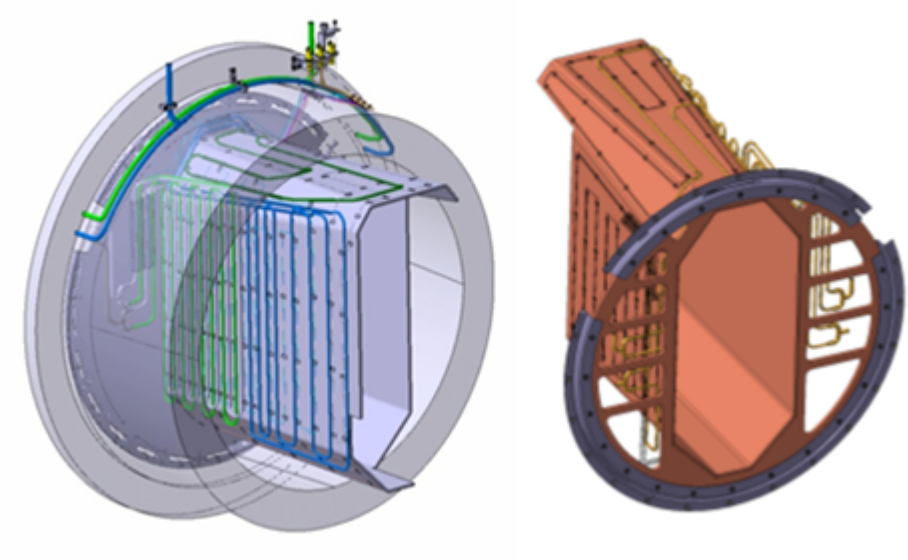

Figure 7: General views of DD liner

Within the bellows is the DD liner. This is an actively water-cooled copper alloy component that shields the bellows from heat emanating from the neutral beam due to re-ionization. Currently the liner is fixed to the DD VVCD flange via the DD liner flange using a series of bolts. By mounting the DD liner to the DD VVCD flange this allows for the installation of the liner from the DD VVCD flange end of the assembly. The arrangement also allows the bellows and VVPSS box to be protected at all times with the liner retracting further into the VVPSS box as the DD length shortens.

Coolant feed and return for the liner is provided through two feedthrough points on the DD flange each located at the 2 and 10 O'clock positions. At each point there are two pipes, a feed and a return.

- **Drift Duct Actuation Mechanism**

The purpose of the actuator mechanism is to control the length of the integrated DD unit during assembly and maintenance. The system is released to allow free movement during Plasma operations which is important to allow satisfactory operation of the bellows to accommodate the displacements between the VV CD and the NB line.
The actuator system is made of three actuators and a parking clamp system. The top actuator is integrated with a control box which provides the mechanical drive of the two side ones.
Also present is a parking clamp system which constrains the lateral movement of the bellows during installation and transportation.

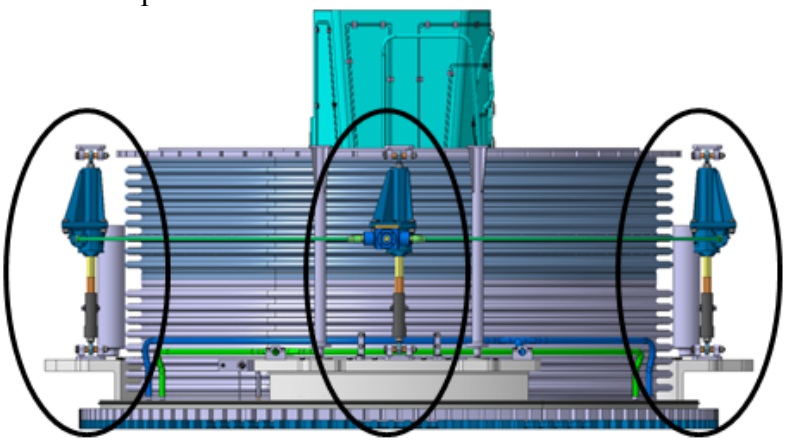

Figure 8: Actuation mechanism

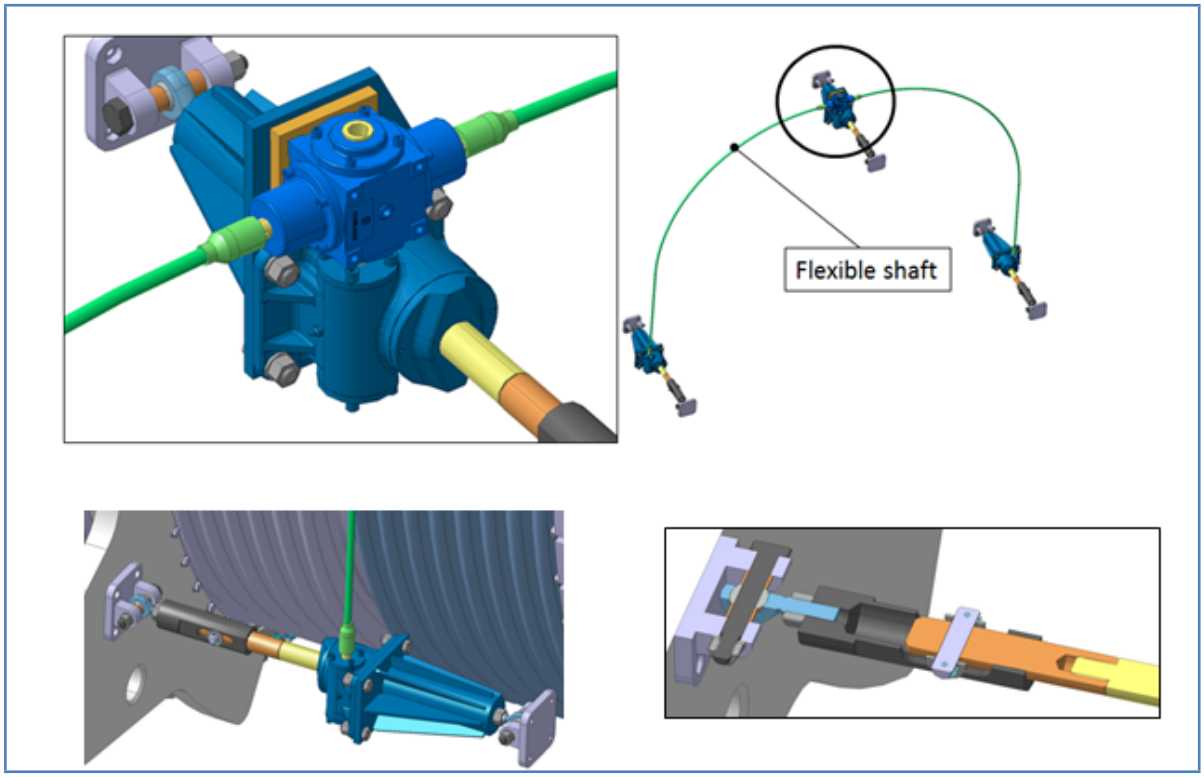

Figure 9: Details of Actuation mechanism

3 Objectives

IO has carried out the integration of the Drift Duct to the Conceptual Design up to the Detail Design according to the IO procedure (ITER_D_2832CF - Design Review Procedure [1]). The 3D CAD models have been developed in details and finalised. For this work, the main ITER constraints, which are Remote Handling consideration for maintenance, building dimensions, internal components dimensions and penetrations for services, have been taken into account. The results of this second phase permitted to hold the PDR meeting in accordance with the IO procedure (ITER_D_2832CF - Design Review Procedure [1]). Some improvements have been recently done in order to align the design with the updated IO inputs. The DD shall fulfill the IO requirements defined in the PBS 53 SRD [4].

R-01	During this new phase, the contractor shall update and continue with the development of the DD in order to prepare the final step of the design consisting of providing full analysis reports.

R-02	The results of this phase shall permit to perform the FDR meeting in accordance with IO procedure (ITER_D_2832CF - Design Review Procedure [1])

4 Scope of Work

The scope of work (design, analysis & CAD) has been redefined accordingly with the Procurement Package definition of the component through the PCR 809.
The Drift Duct has been included in a Built-to-Print Procurement Package. This means that IO is responsible to provide the DAs with a design maturity up to a FDR level. The IO is responsible for carrying out the complete design starting from Conceptual Design, through Preliminary design and up to Final Design with the related Technical Specifications and documents.

The scope of the work is limited to the Drift Duct for Heating Neutral Beam Injector # 1 (HNB1) and HNB2 only. Moreover, the two Drift Ducts are similar for HNB1 and HNB2.
The HNB Drift Ducts are welded to the VVPSS Boxes and will be considered as one batch of component on ITER site.
The scope of work does not cover the VVPSS Box design and analysis. The welded connexion between the DD and the VVPSS Box will be treated independently of this contract.

According to the Design Review Procedure [1], the Final phase of the component must be completed with the procurement of the following results.

R-03	The contractor shall be limited to the procurement defined in the table below:

Maturity of System Design Documents at the end of the Design Phases	Design Phases		
	Conceptual	Preliminary	Final
	IO scope		Responsibility
REQUIREMENTS			
System Requirements Document (SRD) / (DRD)	Completed	Minimal Update	
Interface Control Documents (ICD)	Completed		

Maturity of System Design Documents at the end of the Design Phases	Design Phases		
	Conceptual	Preliminary	Final
	IO scope		Responsibility
Interface Sheet (IS)	Preliminary	**completed**	
Load Specification	Preliminary	**completed**	
Configuration Management Model Mock-Up (CMM) of the DD	Preliminary	consolidated	IO
DESCRIPTION			
System Design Description Document (DDD)/(Annex B)	Preliminary	consolidated	IO
Process Flow Diagram (PFD) / Detailed Diagrams (P&ID)	**Completed**	Minimal Update	
Mechanical Engineering 3D Model	Preliminary	consolidated	**Contractor**
Component Classification	Preliminary	**completed**	
Bill of Material (BOM)	Preliminary	**consolidated**	**Contractor**
Design drawings and associated design documents defining the fundamental design dimensions and tolerances and coordinate data as per MRP2, MRP5 - Paragraph 6.4 of Dimensional Metrology Handbook [NBDD-AD-048]	*NO*	Preliminary	IO
OPERATION			
System Integrated Logistics Support Plan (ILS) (transport)			IO
Operation Plan – see SRD		Preliminary	IO
Maintenance Plan – RH documentation (PDF/TDF/RHCR)		Preliminary	IO
Periodic Test and Inspections Plans		Preliminary	IO
JUSTIFICATION			
Design Compliance Matrix (DCM)/ RPM	Preliminary	consolidated	IO
Engineering Analysis Reports including the FEA files	Preliminary	consolidated	**Contractor**
Factory Qualification Test Plan (Annex B)		Preliminary	IO
TESTS & Commissioning			
On Site Assembly Plan	Preliminary	**Completed**	
On Site Testing and Commissioning Plan	Preliminary	**Completed**	

Table 1 – List of documents to be provided regarding the maturity of the design

R-04 Regarding the table above and based on the Preliminary Design inputs, the scope of the contractor shall be divided in the following tasks:

A. An RCC-MRX [3] expertise shall be carried out for the first confinement barrier in order to justify the technical choice in term of type of weld and examination foreseen. The 3D models could be affected by the results and shall be updated accordingly.

B. The 3D models shall be corrected, finalized or improved regarding the feedback of the analysis defined just above.

C. Running the Load Combinations defined for the FDR scope of Work enlightened in the table below:

Cat. #Load	Status	Pressure	Seismic	Plasma	Magnet	# of events	FDR
I-1	Operating	NO (Dead Weight)				1	X X

	Operating	NO (Coolant Pressure)					X
	Operating	NO (Coolant Pressure)					X
	Operating	NO (NB injection)				30 000[(3)]	X
	Operating	NO (Nuclear heating)				50 000	X
I-2	Operating	Baking				30 000	X
I-3	Maintenance					500	X
	Assembly					-	X
	Lifting					1	X
II-1	Operating	NO		VDE II		500 3 300	X
II-2	Operating	VV ICE II (NO)				15	X
II-3	Operating	VV ICE II (NO)		VDE II		15	X
II-4	Operating	NO	SL-1			5	X
II-5	Operating	Baking	SL-1			5	X
II-6	Maintenance		SL-1			5	X
	Assembly		SL-1			5	X
II-7	Operating	NO	SL-1		MDI	5	X
III-1	Operating	NO		VDE III		-	X
III-2	Operating	VV ICE II (NO)		VDE III		-	X
III-3	Operating	NO[(3)]	SL-1	VDE II		-	X
III-4	Operating	VV ICE III (NO)				-	X
III-5	Operating	VV ICE III (Baking)				-	X
III-6	Operating	VV ICE III (NO)		VDE II		-	X
III-7	Operating	LOCA NB III (NO)				-	X
III-8	Operating	NO	SMHV			-	X
III-9	Operating	Baking	SMHV			-	X
III-10	Maintenance		SMHV			-	X
IV-1	Operating	NO		VDE IV		-	X
IV-2	Operating	VV ICE III (NO)		VDE IV		-	X
IV-3	Operating	VV ICE IV (NO)				-	X
IV-4	Operating	VV ICE IV (NO)		VDE III		-	X
IV-5	Operating	NO	SL-2			-	X
IV-6	Operating	Baking	SL-2			-	X
IV-7	Maintenance		SL-2			-	X
IV-8	Operating	VV ICE IV (Baking)				-	X
IV-9	Operating	NO	SL-1	MD II		-	X
IV-10	Operating	VV ICE IV (NO)		VDE IV		-	X
IV-11	Fire					-	X
IV-12	Fire		SL-2			-	X

Table 2 – Load combinations to perform for the FDR

The Load combinations have been defined according to the Load Specification [ITER_D_434UT4 - Load specification for Drift Duct] [2].

D. The 3D models shall be corrected, finalized or improved regarding the feedback of the analysis defined just above.

E. A second loop of analysis may be needed according to D

F. The **Final Design Review** meeting shall be organized based on the results provided by A, B, C, D, E and F. The category 1 and 2 chits defined in the IO Design Review procedure [ITER_D_2832CF - Design Review Procedure [1]] shall be solved in order to close the process.

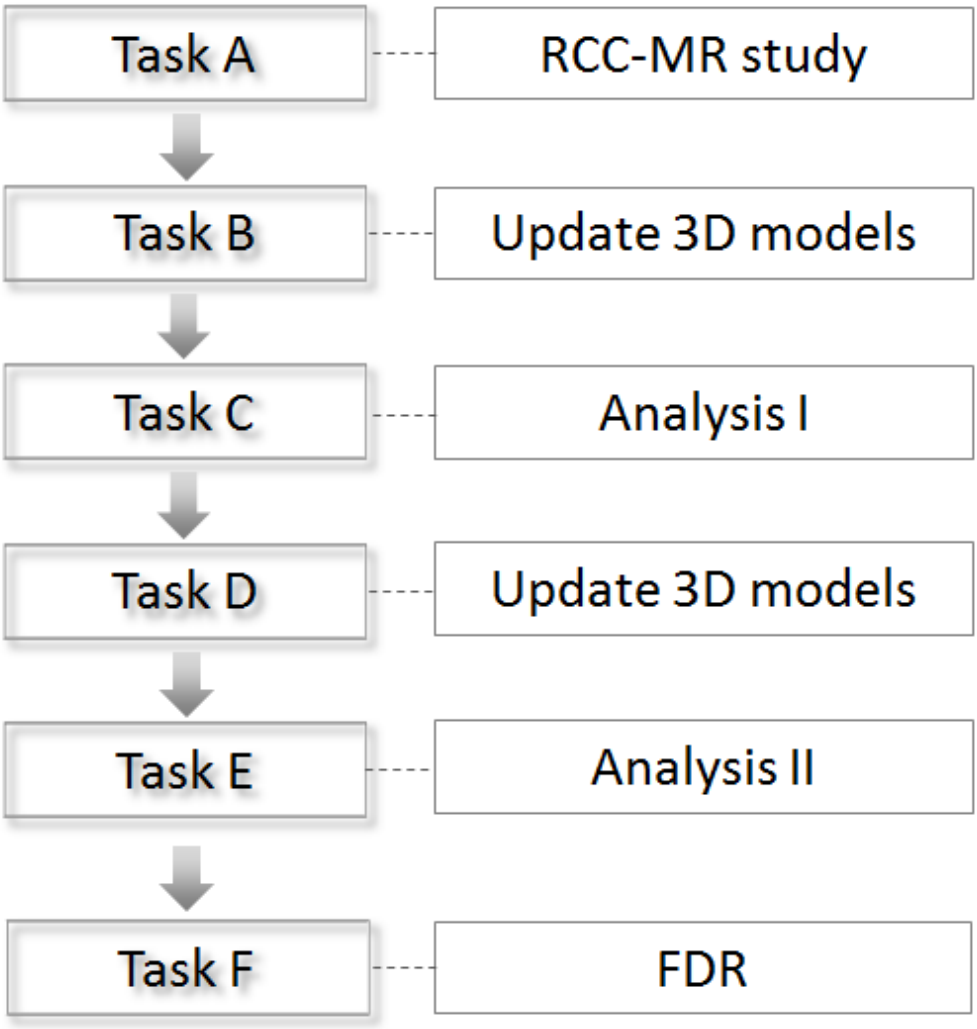

Figure 10 – Flow chart of the scope of the contract

5 Work Description

5.1 Coordination of the Contract

A close and regular interaction will be required with the different parties (Contractor and ITER Organization). The scope of the work is limited to the components for HNB1 and HNB2 only.
The Preliminary Design has been completed by IO, this leads to develop and finalise the design during the Final phase.

R-05	The contractor shall supply the deliverables in electronic form. File formats are MS-Word for reports (and optionally PDF in addition).

5.2 General requirement

R-06	As the scope of this contract is limited to the finalisation of the design only the description and requirements related to the design, Drift Duct Annex B [section 4 and 5 (except 5.4.17) of 20] shall be fulfilled.

5.3 Task A – RCC-MR expertise

R-07	The contractor shall identify all the welds connection and re-assess: • the categorization, • the choice of the type of weld, • the joint coefficient • the strength reduction factor if needed

R-08	The contractor shall demonstrate manufacturing feasibility of the welds according to RCC-MR (welding requirements) during the design task and shall fill in weld table (see template in Annex 3) showing evidence that all welds as designed are compliant with RCC-MR.

R-09	In case a weld, as preliminary designed by IO is not compliant or cannot be inspected (on the full extent as requested by RCC-MR) it shall be clearly identified and solution shall be proposed.

The template of the welds Table is provided in the Annex 3 of the document As well the excel format. The template and examples can be found in the document [REF-22].
The template has been done for another component (the NB Vessel) using code RCC-MR 2007. For the Drift-Duct, the template shall be modified to be used with the code RCC-MRX 2015.
Considering the above RCC-MR documents, a welding analysis of the Drift Duct has been studied:

- [28] ITER_D_TWMSS6 - Final Deliverable - Technical Specification on RCCM Expertise - TO 37 - Drift Duct - NOVAE Deliverable

For the NB Drift Duct, based on the deliverable [28] from IO study and from F4E study [REF-22], a RCC-MR analysis of all the welds has already been done using an External Expert

(RCC-MR) contract. The contractor shall take advantage of this analysis (that can be criticised) to build its own analysis when reassessing the welds.

For the Drift-Duct Liner being designed with SDC-IC code and fabricated with ASME VIII Div-2 (see 4-5-3), for the welds, a comparison shall be done and a welds table (similar to the RCC-MR welds table) proposed (category, type of joint, joint efficiency,..) to align IC-4000 - Rules from Welded Joints (IC4000) from SDC-IC with section 4-2, Design Rules for Welded Joints of ASME Section VIII Div-2.

R-10	The Welds Table from contractor shall be reviewed and approved by IO before integration of the changes in the CATIA Model.

R-11	The 3D model shall be updated, accordingly, after approval of the welds table

5.4 Task B – 3D design work (*Feedback from task A results*)

The Detail Design 3D model may be impacted by the results of task B above.

R-12	CAD models of the Drift Duct shall be finalized taking into account comments, recommendations and improvements if required by task B.

R-13	The level of maturity of the 3D models shall cover all the details as defined in Section 5.2.1. The model shall be conformed to rules and specification described on the ITER CAD manuals ITER_D_249WHA v5.0.

R-14	This update shall be performed only if released by the IO approval.

Those deliverables will be approved by IO only and only if the CATIA models are compliant with the IO CAD manual. The IO approval will be done as soon as the models will be drafted in IO ENOVIA data base. It is important to mention that all extra work to be done to re-integrate the models in the IO data base due to non-compliance of the IO procedure or all extra work that would come from clashes or non-conformance with the NB cell environment shall be endorsed by the customer itself.

5.5 Task C – Analysis of the Load combinations

5.5.1 Modelling for the FE analysis

5.5.1.1 FEA models supports

R-15	The contractor shall perform the modelling of the component for the Finite Element Analysis.

R-16	Regarding the FE model provided by IO, The contractor shall follow the instructions and guidelines for structural analysis and structural analysis reports given in the IO document ITER_D_35BVV3 - Instructions for Structural Analyses [5], especially the Appendix A.2 and Appendix B.

R-17	These FEA models shall correspond to the geometry of the parts (CATIA Model)

	supplied by IO.

R-18	Each FEA model shall be accompanied by an explicative notice that will be part of the Final Technical Supporting Report.

5.5.2 General Requirements

R-19	The contractor shall perform the full analysis described in the table 3.

R-20	The contractor shall provide Supporting documentations and calculation reports (Finite Element Analysis, etc.) following ITER Codes & Standards (code RCCMRX-2007, boiler and pressure vessel code, SDC-IC.) for all the detailed parts, including bolts and welds.
. R-21	The contractor shall use the instructions and guidelines for structural analysis and structural analysis reports given in the table 3 below:

Applicable document		IDM link
Instructions for Structural Analyses	[30]	ITER_D_35BVV3
	Procedure for Analyses and Calculations [32]	ITER_D_22MAL7
	Template for structural analysis reports [31]	ITER_D_VQVTQW
	Software Qualification Policy [29]	ITER_D_KTU8HH
Instructions for Seismic Analyses	[35]	ITER_D_VT29D6
	Procedure for Analyses and Calculations [32]	ITER_D_22MAL7
	Template for seismic analysis reports [33]	ITER_D_VAET99
	Software Qualification Policy [29]	ITER_D_KTU8HH
Instructions for CFD Analyses	[36]	ITER_D_VUEEDB
	Procedure for Analyses and Calculations [32]	ITER_D_22MAL7
	Template for CFD analysis reports [34]	ITER_D_TL7H73
	Software Qualification Policy [29]	ITER_D_KTU8HH

Table 3 – Applicable documents for Analysis

Since the storage of every analysis on IO's analysis database is a required step, the Applicable Document ITER_D_U34WF3 [37] shall be fulfilled. These instructions detail the requirements related to the storage of analysis models in the Analysis Model Database that are already given in Analyses and Calculations [36] but in succinct form. Examples of implementation are given in a "How To" referenced by this document [37] to remove any ambiguity/doubt in interpretation.

Basically, all analysis and design requirements for the DD (Bellows, flanges, bolts, liner, and actuation system) can be found in the two following documents:

- The Load Specification ITER_D_434UT4 - Load specification for Drift Duct [2] is the document which gathers all information relative to the loads applied to the Drift Duct.
- The Annex B of the DD ITER_D_T3BK4M - ANNEX B DRIFT DUCT [20] contents the full design and manufacturing requirements of the component.

R-22	The contractor shall provide Supporting documentations and calculation reports (Finite Element Analysis, etc.) following ITER Codes & Standards defined in table 3 section 4.5.3 for all the detailed parts, including bolts and welds.

5.5.3 Applicable Codes & Standards

The choice of the design and manufacturing code depend mainly from the Quality Classification [21].
The Drift Duct consists of three mains sub-systems:

- The DD bellows (consists of the double walls bellows and the flanges welded on each side)
- The DD liner
- The Actuation system

Drift Duct	First Confinement	Safety Classification	Quality Classification	Vacuum Classification	Design code	Manufacturing code
DD Bellows	YES	**SIC-1**	QC-1	VQC-1A	RCC-MRX class 2	RCC-MRX Class 2
DD Liner	NO	NON-SIC	QC-2	VQC-1B	SDC-IC	ASME VIII Div. 2
Actuation System	NO	NON-SIC	QC-3	VQC N/A	EN harmonized Standards	EN harmonized Standards

Table 3 – Classifications for the main sub-system of the DD

5.5.3.1 The DD Bellows

R-23	The DD bellows shall comply with the RCC-MRX code [3]

R-24	The DD bellows shall comply with the loads defined in the Load Specification [2].

The DD **Bellows** includes the flange interfacing the CC Connecting Duct (with the double metallic seals) and the flange interfacing the VVPSS Box.
The DD bellows can be divided in 5 sub-items to be analysed:

- Flange interfacing the VV connecting Duct
- The metallic seals
- The Double wall Bellows
- The Flange interfacing the VVPSS Box
- The Bolts

5.5.3.1.1 Metallic seals

- The definition of the metallic seals is not in the scope of the contract.

The design has been defined by IO. The solution developed in collaboration of TECHNETICS is a double Helicoflex HN229 mounted on a limiter or seat ring. The solution consists of a

double circular metallic seals with a number of bolts associated defined to permit a full efficiency of the sealing.

5.5.3.1.2 Bellows

- The definition of the double wall bellows definition is not in the scope of this contract.

The design has been defined by IO. The analysis of the Bellows against the RCC-MRX code have been carried out by WITZEMANN and analysis report can be available in the link ITER_D_WD7R44 - DD BELLOWS ANALYSIS REPORT - CONTRACT NUMBER – IO/18/CT/4300001639 [23].

5.5.3.1.3 Bolts

The DD flanges will be bolted with 120 M 20 bolts for a total tightening load of 5 322 109 N to ensure the efficiency of the metallic seals.

The bolts are listed in HNB1_DRIFT_DUCT_B_o_M. ITER_D_SN2CUG [25]; they are defined in the IS [24].

R-25	The bolts arrangement shall comply with the RCC-MRX code [3]

R-26	The bolts system shall be analysed according to section RB 3200 of RCC-MRX code [3]

Design rules for bolting rules are covered in RB 3280 and in Appendix A6 of [2]. RB3280 identifies the stress limits applicable to bolted assemblies, with Appendix A6 added to indicate how to calculate the effort and stress of the bolts and the assembled components and in particular for the various types of flanges.

The material of the bolts shall be 1.6580+QT taken from EN10269. The suggested alloy has an allowable stress slightly smaller (-8 %) than SA540-B21Class 1, but remains the strongest alloy detailed in EN10269 for bolting materials.

5.5.3.1.4 Flanges

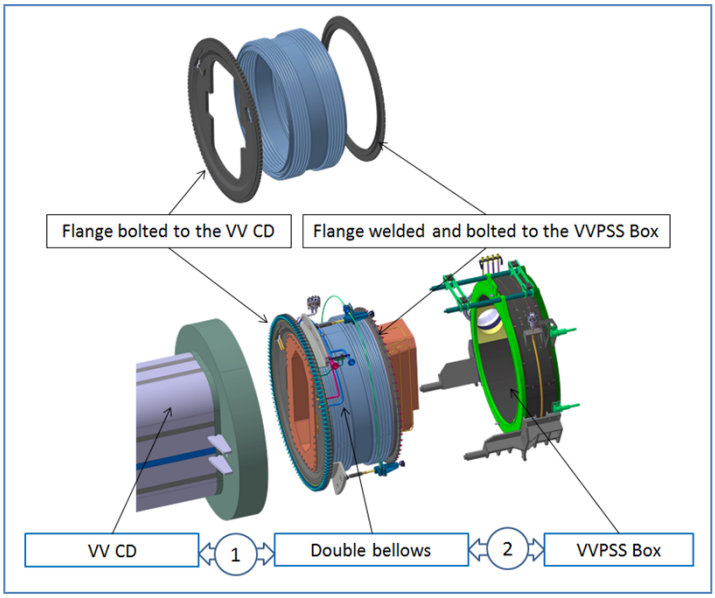

Figure 10: Interfacing flange of DD bellows

The DD flange interfacing the VV Connecting Duct shall be bolted with 120 M 20 bolts for a total tightening load of 5 322 109 N to ensure the efficiency of the metallic seals.
The leak tightness of the first confinement barrier shall be ensured by a double metallic seal with a monitored interspace by the SVS.

The DD Flanges will be submitted to loads defined in the LS [2] like:

- Pressure
- Temperature
- Reaction forces coming from the Bellows
- Reactions forces coming from the DD liner
- Tightening loads imposed by the metallic seals.

R-13	The bolted flanges shall be analysed according to section RB 3200 of RCC-MRX code [3]

R-14	The welds connection between the flanges and the Bellows shall be analysed according to RCC-MRX section RB 3700 Bellows.

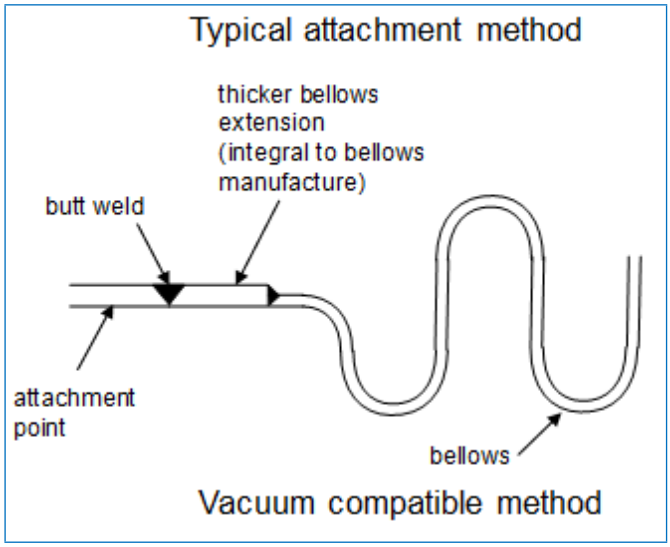

Figure 11: Welded connection between the flanges and the Bellows

The Drift Duct is connected to the VVPSS Box permanently. They are welded together and in addition bolts and rings are used to compensate the stresses induced by the Bellows displacements. The design of the interface was defined to get accessibility for the checking of the welding using a radiographic film.

R-15	The interface DD flange to the VVPSS Box Flange shall be analysed according to section RB 3200 of RCC-MRX code [3]

5.5.3.2 The DD liner

Preliminary analysis of the DD liner can be found in the documents:

- [26] Drift Duct Liner Structural Analysis - ITER_D_R78YLV
- [27] ITER_D_RRHU8J - Drift Duct Liner flange optimization

R-16	The contractor shall finalize the full thermo-mechanical analysis of the DD liner.
R-17	Some analysis performed at the Preliminary design stage shall be updated if needed.
R-18	The contractor shall justify the need to update Preliminary analyses or confirm the relevance of the preliminary results regarding the Final design.
R-19	The design of the DD Liner shall pass the SDC-IC [22] rules for M-type and C-type damage.
R-20	The SDCI-IC low temperature rules shall been used regarding the results of the Preliminary design – see section 4.1 of Drift Duct Liner Structural Analysis [26]

5.5.3.3 The Actuation System

R-21	The actuation system shall be designed following the European harmonized standards.

R-22	The contractor shall ensure the mechanical integrity of the actuation system regarding the load combinations defined in the LS [2].

5.6 Task D – 3D design work (Feedback task C)

The Detail Design 3D model may be impacted by the results of task C above.

R-27	CAD models of the Drift Duct shall be finalized taking into account comments, recommendations and improvements if required by task C.

R-28	Requirements R-13 and R-14 shall be applicable for task B.

Those deliverables will be approved by IO only and only if the CATIA models are compliant with the IO CAD manual. The IO approval will be done as soon as the models will be drafted in IO ENOVIA data base. It is important to mention that all extra work to be done to re-integrate the models in the IO data base due to non-compliance of the IO procedure or all extra work that would come from clashes or non-conformance with the NB cell environment shall be endorsed by the customer itself.

5.7 Task E – Second loop of analysis

The task E depends of the outcomes of the task A, B, C and D.
Basically, the task E shall be an update of the task C regarding the changes and improvements on the 3D models required at the conclusion of task C.
To be crystal clear the second loop of analysis shall be driven by, for examples, an increase of plate thickness, an increase of welds thickness, addition of ribs or any reinforcements, etc.

R-29	The contractor shall provide an analysis report of the latest updated model of the component.

R-30	The contractor shall assess and justify the need or not to re-launch the analysis on the models resulting from task C and D.

R-31	A statement report shall be produced – Requirement R-03 shall be applicable4

R-32	If required, the updated analysis shall be done according to the requirements already defined in task B [R-07, R-08, R-09, R-10]

5.8 Task F – Final Design Review

R-33	The contractor shall present their results (tasks A, B, C, and D &E) during a Design Review called Final Design Review according to the procedure ITER_D_2832CF - Design Review Procedure [1].

R-34	Twelve (12) weeks before FDR, the contractor shall prepare the documentation for the assessment of the FDR readiness and submit it to IO for review.

R-35	The contractor will support the Final Design Review meeting with a PowerPoint presentation (**PAR**) deliverables.

The supporting documentation consists mainly on reports which permit the complete finalization of the design:

- The Design Description Report (**DDR**) shall describe the complete solution in details developed along the tasks of the contract. This report permits to justify the solutions chosen; it shall demonstrate the compliance of the requirements defined in this Technical Specification
- The Final Analysis Report (**FAR**) shall content the loads combination defined in section

Supply of the deliverables shall be in electronic form. File formats are MS-Word for reports (and optionally PDF in addition).

6 CAD requirements

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 CAD Data (Schematics, Models and Drawings) delivered to IO comply with the "Procedure for the Usage of the ITER CAD Manual (2F6FTX)" [12], and with the "Procedure for CAD Management Plan (2DWU2M)" [13].
- 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 "Specification for CAD data production in ITER Contracts (GNJX6A)" [14]. This implies the usage of the CAD software versions as indicated in "CAD Manual 07 - CAD Fact Sheet (249WUL)" [15] 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

7 Licensing requirement for the DD

The **P**rotection **I**mportant **A**ctivities are identified by the Nuclear Operator. The list of the Protection Important Activities is based on the chapter 10 of the RPrS [Preliminary Safety Report (RPrS) ITER_D_3ZR2NC v3.0] [16] and the application of the INB Order which applies to all the lifecycle of a nuclear facility [Order dated 7 Feb 2012 relating to the general technical regulations applicable to INB. ITER_D_7M2YKF v1.6][17].

The PIAs for the NB Injector are defined in the Surveillance plan for PBS 53 ITER_D_U65RWF. During design phases, the safety demonstration is considered as PIA; the design study of the DD which are first confinement barrier is a safety demonstration.

IO shall manage this activity as follow:

PIA	Defined requirement	External interveners	Nature of the surveillance	Frequency of the surveillance	Actor of the surveillance	Formalization of the surveillance	Records management	Record location
Safety Demonstration related to safety demonstration	Compliance with the defined requirements for each PIC [(LAMFG2) Application of the procedure (LAMFG2)	All	Review of the document	For each document	TRO	Review in IDM	Standard IO rule (22K5JQ)	IDM folder 2N78DT

The Contractor shall provide a Quality plan at the kick off meeting. This QP shall remind the safety function of the Drift Duct.
The DD as a PIC must ensure the following nuclear safety function:

- Confinement : the DD belongs to the First confinement barrier
- Minimization of radiological exposure: the used Material that will be activated shall have a low concentration of Cobalt, Niobium and Tantalum.

Drift Duct items classified SIC are also classified PIC. The development of the Drift Duct shall comply with the Order dated 7 February 2012 relating to the general technical regulations applicable to INB [13].

The Suppliers and Subcontractors must be informed that:

- ITER is a nuclear facility identified in France by the number-INB-174;
- The Order 7th February 2012 title I and II replace Order 10th August 1984 since the 1st July 2013;
- The Order 7th February 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 in the chain of contractors and subcontractors.
- 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 (IO).

A specific management system has to be implemented by any Supplier and Subcontractor working on protection important activities, on the basis of activities defined and executed by the Supplier and Subcontractor.
The contractor shall refer mainly to the document ITER_D_SBSTBM - Provisions for Implementation of the Generic Safety Requirements by the External Interveners [19] which is a declination of the French order 2012 to IO.

Regarding the Nuclear safety function << confinement>>, the main PIAs for the DD are the following:

- All Analysis based on the LS [ITER_D_434UT4 - Load specification for Drift Duct] [2] ensuring the integrity of the confinement of the DD
- All Activities linked to the Welding data Book and the associated controls.

Regarding the Nuclear safety function << minimization of radiological exposure>>, the main PIAs for the DD are the following:

- The chemical composition of the material
- Material certificate deliverables

For the Nuclear Safety, it is important to remind the importance to refer to the following AD:

- Provisions for Implementation of the Generic Safety Requirements by the External Interveners
- *ITER Policy on Safety, Security and Environment Protection Management)*
- Overall Surveillance Plan of External Interveners Chain for Protection Important Components, Structures and Systems and Protection Important Activities
- Guideline for Identification of the Protection Important Activities (PIA)
- Safety Important Functions and Components Classification Criteria and Methodology
-

The DD liner is classified PED category 0, it shall therefore comply with the Sound Engineering Practice (SEP) as defined by [*Radioprotection guide for ESPN application* - ITER_D_2LTQ96 v1.1]. The use of the standards for the design and the manufacturing is considered to fulfil this requirement.

The DD liner is classified ESPN level N3, the "Radioprotection guide for ESPN application" [Radioprotection guide for ESPN application - ITER_D_2LTQ96 v1.1] requirements shall therefore be used.

8 Estimated Duration

The duration of this contract has been estimated as follow:

- FDR: T0 + 8 (height) months + 3 (three) months for the closure of the FDR (solutions to potential chits).

The FDR is planned on April 2019; the closure of the FDR is planned on July 2019 according to PCR 809 (PCR-809 - Transfer of design activities for the HNB components from F4E to IO for 53 P4 EU 01 & 53 P5 EU 01).

9 Responsibilities (including customs and other logistics)

ITER Organization:

ITER Organization will provide the needed information and access to the adequate ITER files for executing this work when needed following the implementation plan.

In particular ITER Organization will make available any technical information, for example layout of the NB plant, drawings, references needed for contractor to perform the work. The documents containing this information must be returned to ITER Organization on completion of the contract.

Contractor:

The Contractor appoints a responsible person, the Contractor's Responsible (C-R), who shall represent the Contractor for all matters related to the implementation of this Contract.

The contractor will provide results according to the scope of the work outlined above and will fulfil the implementation plan and conditions of present contract.

10 List of deliverables and due dates (proposed or required by ITER)

All deliverables (technical documents, drawings and CAD models, etc.) detailed here after produced shall be made available to the IO upon request. The transfer of documentation may be for information only for work in progress.

10.1 Deliverables

10.1.1 D/QP = Quality Plan of the contract

The Project Manager of the contractor will issue the Quality Plan of the Contract which will be submitted to IO for approval.

A first draft will be circulated to IO one month after the signature of the Contract. The draft Quality Plan will be discussed in the kick-off meeting and accordingly modified in a new and agreed version.
The Project Plan summarizes the tasks content by means of a detailed work breakdown structure, a time plan scheduling how the activities will be carried out, and details of the personnel resources to be employed in each subtask.

10.1.2 Deliverables of the Tasks

The scope of the tasks has been defined in section 4; it can be summarized as defined in the table below:

Deliverables	***Description***
Task A - TA	*Welds table / RCC-MR justification report*
Task B - TB	*3D CAD models reflecting the design maturity of the FDR with an assembly 2D drawing of the components which shall demonstrate the compliance of the design with the appropriate gaps, tolerances and RH access with a bill of material.*
Task C - TC	*These FEA models will correspond to the geometry of the parts (CATIA Model).* *Analysis Report*
Task D - TD	*3D CAD models reflecting the design maturity of the FDR with an assembly 2D drawing of the Components which shall demonstrate the compliance of the design with the appropriate gaps, tolerances and RH access with a bill of material.*
Task E - TE	*Analysis Report updated and Design report* *Final FEA models stored in IO database.*
Task F - TF	*The contractor will support the Final Design Review meeting with a PowerPoint presentation deliverables*

10.2 Milestones

Abbreviation:

DP: (Decision Point) - This is an hold point, a decision (or approval) has to be taken before going to the next phase or step

Name	Description	Comments	Hold Point
Coordination of the Contract			
M/QP	Quality Plan of the Contract	QA Document	
M/KOM	Kick-off meeting	IO site	
M/TA	Progress Meeting – status task A	TBD	DP
M/TC	Progress Meeting – status task C	TBD	
M/TE	Progress Meeting – status task E	TBD	
M/TF1	Final Design Review Meeting (task F)	FDR- IO site	
M/TF2	**FDR Chit closure meeting** (task F)	**TBD**	**DP**

ITER will approve or reject the deliverables and will authorize or not authorize the execution of the next sub-project of the project:

- **M/TF2:** This milestone will be considered as achieved as soon as all potential chit category 1& 2 will be solved and approved by IO panel member (according to the applicable design review procedure is ITER_D_2832CF - Design Review Procedure (V3.1))

The ITER Organization shall have 30 days from receipt of reports to approve them. The ITER Organization reserves the right to reject the report. The IO shall submit reasonable grounds for rejection. The Contractor shall have 30 days in which to submit additional information or a new report.

10.3 Work monitoring / Schedules deliverables

This concerns Kick-off meetings, Progress Review meeting and Final Review meetings A schedule is proposed for the frequency of the Progress Review meetings. The final decision of these meetings will be agreed during the kick-off meeting.

The Technical Review meetings will be held at the end of the following tasks:

- A
- D
- E
- G which is the Final Design Review

Meetings or video-conferences for the purpose of reviewing the results before the delivery of each report are planned during the course of this contract. The details of the discussion, including date, premise and method shall be determined by mutual agreement between the IO and the contractor at least one month prior to each planned meeting. The cost and expenses for the meetings, including travel expenses for the participant(s), shall be borne by each party.

The meetings will be held for this contract, according to the following tentative schedule:

Name	Description	Due date* (months)	Acceptance criteria**
	Coordination of the Contract		
M/QP	Quality Plan of the Contract	1	A
M/KOM	Kick-off meeting	T0	**B**

M/TA	Progress Meeting – status task A	T0 + 1 = T1	**B**
M/TB	-	T1 + 1 = T2	**B**
M/TC	Progress Meeting – status task C	T2 + 4 = T3	
M/TD	-	T3 + 1= T4	**B**
M/TE	Progress Meeting – status task E	T3 + 1 = T5	**B**
M/TF1	Final Design Review Meeting (task G)	T0 + 8= T6	**B**
M/TF2	**FDR Chit closure meeting** (task G)	T6 + 3	

** Duration after the signature of the Contract*
*** A: Plan accepted by IO*
B: Minutes accepted by IO

The reports shall be prepared and submitted to the IO by the dates outlined in the tables below. It is understood that the report is expected to be prepared in Microsoft Word format, however; an alternative format may be used subject to the prior written approval of the IO.

Deliverables	***Due date* (months)***	***Acceptance criteria*****
Task A	1	**A**
Task B	2	**B**
Task C	6	**C**
Task D	7	**B**
Task E	8	**C**
Task F1	8	**C**
Task F2 *(Closure of FDR)*	11	**C**

** Duration after the signature of the Contract*
*** A: Documents compiled*
B: Model accepted by IO
C: Report accepted by IO
D: Drawings accepted by IO

The acceptance of the deliverables is based on the following procedure:

- The IO TRO will download the deliverables on ITER IDM
- The documents will be reviewed by an IO panel board within 5 weeks. It is a technical review.
- As soon as the document is approved on IO IDM, the deliverable of the contract is considered as approved.

11 Acceptance Criteria (including rules and criteria)

These criteria shall be the basis of acceptance by IO following the successful completion of the services. These will be in the form of monthly progress reports as indicated in section 6, table of deliverables and further detailed below:
Report and Document Review criteria
Reports as deliverables shall be stored in the ITER Organization's document management system, IDM by the Contractor for acceptance. A named ITER Organization's Contract Technical Responsible Officer is the Approver of the delivered documents.
The Approver can name one or more Reviewers(s) in the area of the report's expertise.
The Reviewer(s) can ask modifications to the report in which case the Contractor must submit a new version.
The acceptance of the document by the Approver is the acceptance criterion.

12 Specific requirements and conditions

Contractor to carry out the work described in this document must have proven experience, as appropriate

- Expertise in performing ANSYS analysis on ITER components
- Expertise in the RCC-MR code
- Expertise in ENOVIA / CATIA ITER requirements
- Technical document generation
- System requirements management

13 Quality Assurance (QA) requirement

The organisation conducting these activities should have an ITER approved QA Program or an ISO 9001 accredited quality system.
The general requirements are detailed in ITER document ITER Procurement Quality Requirements (22MFG4)
Prior to commencement of the task, a Quality Plan Quality Plan (22MFMW) must be submitted for IO approval giving evidence of the above and describing the organisation for this task; the skill of workers involved in the study; any anticipated sub-contractors; and giving details of who will be the independent checker of the activities.
Prior to commencement of any manufacturing, a Manufacturing & Inspection Plan Manufacturing and Inspection Plan (22MDZD) must be approved by ITER who will mark up any planned interventions.
Deviations and Non-conformities will follow the procedure detailed in IO document MQP Deviations and Non Conformities (22F53X)
Prior to delivery of any manufactured items to the IO Site, a Release Note must be signed MQP Contractors Release Note (22F52F).
Documentation developed as the result of this task shall be retained by the performer of the task or the DA organization for a minimum of 5 years and then may be discarded at the direction of the IO. The use of computer software to perform a safety basis task activity such as analysis and/or modelling, etc. shall be reviewed and approved by the IO prior to its use, it should fulfil IO document on Quality Assurance for ITER Safety Codes Quality Assurance for ITER Safety Codes (258LKL).

14 References / Terminology and Acronyms

[AD]	IDM link
1	ITER_D_2832CF - Design Review Procedure
2	ITER_D_434UT4 - Load specification for Drift Duct
3	RCC-MRX code, 2015 edition. Design and construction rules for mechanical components of nuclear installations
4	SRD-53-01, -02, -03 (NBH&CD) - ITER_D_28B37M

5	ITER_D_35BVV3 - Instructions for Structural Analyses
6	ITER_D_VQVTQW - Template for Structural Analysis Reports
7	ITER CAD manuals ITER_D_249WHA v5.0.
8	CAD Manual 09 - Drawing Best Practices (24SNC9)
9	CAD Data Promotion Checklist (2FBLRJ)
10	Template for Technical Specification to Supply Contract (HPNCA2)
11	Template for Technical Specifications for Services (2N926R)
12	Procedure for the Usage of the ITER CAD Manual (2F6FTX)
13	Procedure for CAD Management Plan (2DWU2M)
14	Specification for CAD data production in ITER Contracts (GNJX6A)
15	CAD Manual 07 - CAD Fact Sheet (249WUL)
16	ITER_D_3ZR2NC - Preliminary Safety Report (RPrS) – section I-9.5 Magnetic zoning
17	Order dated 7 Feb 2012 relating to the general technical regulations applicable to INB. ITER_D_7M2YKF v1.6
18	ITER_D_PA9RDK - BINDING REQUIREMENTS DERIVEING FROM INB ORDER APPLICATION
19	TER_D_SBSTBM - Provisions for Implementation of the Generic Safety Requirements by the External Interveners
20	ITER_D_T3BK4M - ANNEX B DRIFT DUCT
21	Quality Classification Determination, ITER_D_24VQES
22	In-vessel Components, SDC-IC - ITER_D_222RHC
23	ITER_D_WD7R44 - DD BELLOWS ANALYSIS REPORT - CONTRACT NUMBER – IO/18/CT/4300001639
24	Interface Sheet 15-53 - ITER_D_BFACWG - IS-15-53-002_VV_Connecting_Duct-NB_Drift_Duct
25	HNB1_DRIFT_DUCT_B_o_M. ITER_D_SN2CUG v1.0

26	Drift Duct Liner Structural Analysis - ITER_D_R78YLV
27	ITER_D_RRHU8J - Drift Duct Liner flange optimization
28	ITER_D_TWMSS6 - Final Deliverable - Technical Specification on RCCM Expertise - TO 37 - Drift Duct - NOVAE Deliverable
29	ITER_D_KTU8HH - Software Qualification Policy
30	ITER_D_35BVV3 - Instructions for Structural Analyses
31	ITER_D_VQVTQW - Template for Structural Analysis Reports
32	ITER_D_22MAL7 - Procedure for Analyses and Calculations
33	TER_D_VAET99 - Template for Seismic Analysis Reports
34	ITER_D_TL7H73 - Template for CFD analysis reports
35	ITER_D_VT29D6 - Instructions for Seismic Analyses
36	ITER_D_VUEEDB - Instructions for Computational Fluid Dynamics Analyses
37	ITER_D_U34WF3 - Instructions for the Storage of Analysis Models
	DOCUMENTS FOR INFORMATION
Ref 1	ITER Vacuum Handbook, ITER_D_2EZ9UM
Ref 3	Safety Important Functions and Components Classification Criteria and Methodology, ITER_D_347SF3
Ref 4	Accident Analysis Report (AAR) Volume I – Event Identification and Ref 1Selection, ITER_D_2DPVGT
Ref 5	Accident Analysis Report (AAR) Volume II - Reference Event Analysis, ITER_D_2DJFX3
Ref 6	Accident Analysis Report (AAR) Volume II – Figures, ITER_D_2EBGU5
Ref 7	Load Specifications, ITER_D_222QGL (v6.0)
Ref 8	Heat and Nuclear Load Specifications, ITER_D_2LULDH
Ref 9	Guideline for ITER System Load Specification, ITER D 33TTPJ

Ref 10	ITER_D_25EW4K - Codes and Standards for ITER Mechanical Components
Ref 11	ITER_D_2E95HD - Summary of Applicable Rules for Vacuum Vessel Structural Analysis with Regards to RCC-MR
Ref 12	PCR-558 - Implementation of double metallic seals with pumped interspace instead of lip seal for NB circular flanges
Ref 13	Safety requirement Roombook (KF63PB v2.11)
Ref 14	ITER Vacuum Handbook – Appendix 8 Flanges, ITER_D_2DJYQA
Ref 15	ITER_D_BER7ZT - DDD HNB Drift Duct
Ref 16	ITER_D_BERF89 - DJD HNB Drift Duct
Ref 18	ITER_D_222U38 - 316 L - Composition
Ref 19	SDC-IC- Appendix A, Materials Design Limit Data - 222RLN V3
Ref 20	SDC-IC- Appendix A, Materials Design Limit Data - 222RLN V3
Ref 21	AK02 Cu-Cr-Zr : https://user.iter.org/?uid=29DE9M
Ref 22	F4E_D_2BHY66 - Welds table (Beam Line Vessel)- RCC-MR expertise April 2018

Annex 1
Drift Duct Annex B
Annex 2

1. I NPUT DATA

CAD models	Format
NB cell	CATIA V5
HNB designed by IO	CATIA V5
Front components arrangement	CATIA V5
CAD model of the Drift Duct	CATIA V5
CAD model of the RH tool	CATIA V5
Drawings	
Drawing of HNB	PDF
Drawings of the HNB/DNB front components assembly sequence	PDF
Documents	
Seismic spectrum of the NB cell	PDF

- Template for ITER Built-To-Print 2D drawings
- QA & Rules for ITER Built-To-Print 2D drawings

Annex 3

Proposal of content that should be in the welded table:

ITEM WELDING EXPERTISE		Conception (drawing)							Inspection non destructive and destructive																	
		Accessibility		type of preparation		classification RCC.MR (level 2)			Inspection before alignment (parts to be welded) RS 7360			Inspection after alignment RS 7380		Before welding table RS7720-c1		During welding table RS7720-c2		after welding table RS7720-c3								
Weld N°	View / Detail	during production	geometry	Type of geometry	NF EN ISO 9692-1	RC 3833-3 category	RC 3833-3a type	RC 3851 weld coefficient 'n'	dimensional RS 7361 (Recommended)	visual RS 7362	Surfaces RS 7363 table RS 7720-c1	dimensional RS 7381	visual RS 7382	surface		surface		surface		Volumetric					
									criteria	method criteria	method Criteria	criteria	method Criteria	extent	method	extent	method	extent	method criteria	Extent as requested by RCC-MR	method criteria	method criteria			
									RMC 7100 and RMC 7200	Liquid Penetrant (LP) RMC 4000 table RS7363-a	method	RMC 7100 RS7382-d	%	RES ou MAG RS 7363 RMC 4000	%	RES RMC 4000 RS 7724.1	%	RES RMC 4000 RS 7724.1	%	RT RMC 3300 RS7724-3 Possible on the requested extent?	UT (only in case RT is not OK) RMC 2600 RS7724-4 Possible on the requested extent?			