



Final design of the Connection Pipes for the Test Blanket Systems

Call For Nomination (CFN)

Purpose

The purpose of this contract is to develop, starting from the existing conceptual design, the final design of the Test Blanket System (TBS) Connection Pipes system and deliver to the ITER Organization all required analyses and reports including results and outcomes of all necessary studies.

Background

A tritium Breeding Blanket (BB) ensuring tritium breeding self-sufficiency is a compulsory component for the DEMO fusion reactor although is not present in the ITER fusion machine. Mock-ups of DEMO BB, called Test Blanket Modules (TBMs), inserted and tested in ITER in three dedicated equatorial ports directly facing the plasma, are the principal means by which ITER will provide the first experimental answers on the correct performance of the breeding blankets, still an open issue on the path to commercial fusion power.

A TBM testing strategy has been developed in the last decades to obtain relevant DEMO data from tests in ITER and a proposal of a test plan for the first ten years of ITER operation including the objectives and the rationale of these tests has been elaborated by all the ITER Members. In fact, mock-ups of complete DEMO breeding blanket systems will be tested in ITER, which means that the TBMs are connected with several ancillary systems (such as cooling systems, tritium extraction systems, coolant purification systems, maintenance systems, and measuring and control systems). TBMs and associated systems are called Test Blanket Systems (TBSs). The activities concerning the TBS testing in ITER are part of the so-called "TBM Program".

The conceptual designs of the six TBSs to be tested in ITER have been developed from 2008 until 2015 and are now available and their further integration in the ITER facility is on-going. For each TBS and associated infrastructures, the most important next step is the elaboration and the achievement of the preliminary design and the performance of all the associated analyses and feasibility assessments while addressing the identified challenges. Then later on the final design shall be developed prior to the starting of the fabrication of all components and delivery at ITER Site.

The Test Blanket System (TBS) Connection Pipes (i.e. pipes connecting elements of the TBS in different rooms of the Tokamak Complex) must be delivered several years earlier than the other TBS components: the Connection Pipes for all the six TBSs have to be delivered simultaneously just after the completion of the nuclear buildings, in a few years from now. Indeed, there are many advantages to install them at the same time as all other neighbouring components of other ITER plant systems.

Scope of work

D) Systems, Structures, Components for which design has to be developed

The conceptual design of the TBS Connection Pipes, including the interfaces with the concrete buildings, has been developed over the last few years and the ITER Conceptual Design Review meeting was organized in September 2015.

The configuration of the system at conceptual design stage features the following pipe lines, which can be gather in the following four groups:

Group A) 18 pipings for the Coolant Systems (CSs) of the six TBSs including pipes and fittings (straight conduits, elbows and bends), piping mechanical supports, advanced thermal insulation material, metallic supports (I and H steel beams), protective grid (I and H steel beams), see Figure 1 and Figure 2.

Group B) Several pipings for the Tritium Extraction Systems (TESs), the Tritium Removal System (TRS) and the Neutron Activation Systems (NASs) for the six TBSs including pipes and fittings (straight conduits, elbows and bends), piping mechanical supports, metallic supports (I and H steel beams), see Figure 3.

Group C) Several pipings for the CCWS-1 Distribution System for the six TBSs including pipes and fittings (straight conduits, elbows and bends), piping mechanical supports, metallic supports (I and H steel beams), see Figure 4.

Group D) Several pipings for the Tritium Accountancy Systems (TASs) for the six TBSs including pipes and fittings (straight conduits, elbows and bends), piping mechanical supports, metallic supports (I and H steel beams), see Figure 5.

The Conceptual Design of all these pipes lines features a quantity of 1,189 stainless steel pipes fittings for a calculated mass of 2,082 kg, a total length of 3,790 m seamless pipes for a calculated mass of 43,018 kg. In addition, in a few locations where pipes are crossing either floor or wall or ceiling, the design of closure systems or simpler system such as steel gratings in between the two rooms shall be performed with for some of them some requirements in terms of tightness, fire resistance in normal and abnormal situations and so on, see Figure 6.

The Conceptual Design configuration is being currently modified quite significantly in terms of routing of the TBS Connection Pipes for Coolant Systems (CSs), the 18 pipings of group A), to accommodate changes in the ITER Cooling Water System layout. This will lead to an increased length of about 20%. It is going to have also an impact, normally limited, on the pipings of groups C) and D). The routings of the pipes is changed but the specifications in terms of, for instance, material properties, pressure and temperature, are not impacted.

In addition to the pipes lines, the design of two decay tanks (or surge tanks or delay tanks) up to the final stage is also to be studied as part of this contract. The size will depend on the needed delay time of the coolant water and of the design and associated technology and. The design shall account also in particular for the available space constrain. There could be the two items of another group called Group E), see Figure 7. Their final design should be studied. The most promising design solutions, which are available to date in the industry, shall be assessed. The preferred ones considering all constrains and requirements shall be proposed

to the ITER Organization (IO) and its final design delivered. The design shall include the attachment to the cast-in-plates embedded into the building concrete floor through a frame, the design of the shielding structure (with specifications given by IO in terms of material and thickness if any) and its attachment to the floor.

For all items of Group A) to Group E), the verification of the loads induced onto the various embedded plates compared to the allowable loads shall be performed. The list, position and size of all embedded plates are input data provided by IO. One supplementary requirement in the design development of all items is to comply also with the embedded plates made available to anchor all items based on the conceptual design. It is expected that a sufficient design margin has been considered in the embedded plates sizing so that it also gives sufficient flexibility to succeed in finding an acceptable final design.

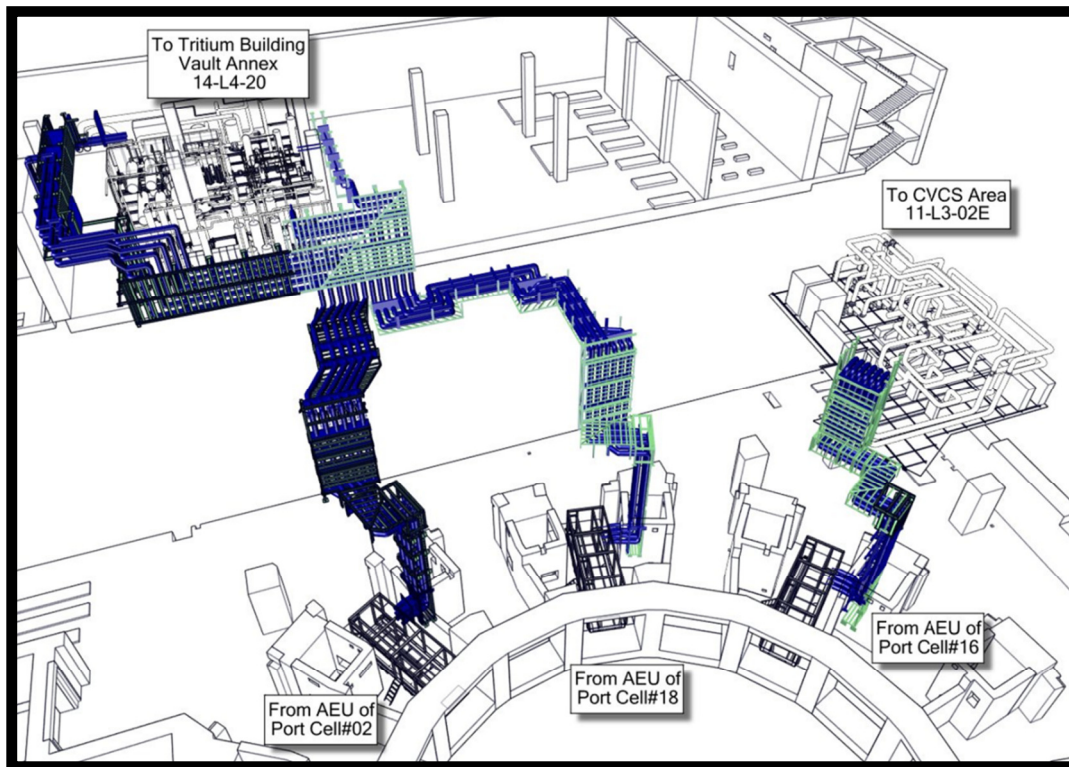


Figure 1: Overview of the TBS Connection Pipes for the Coolant Systems

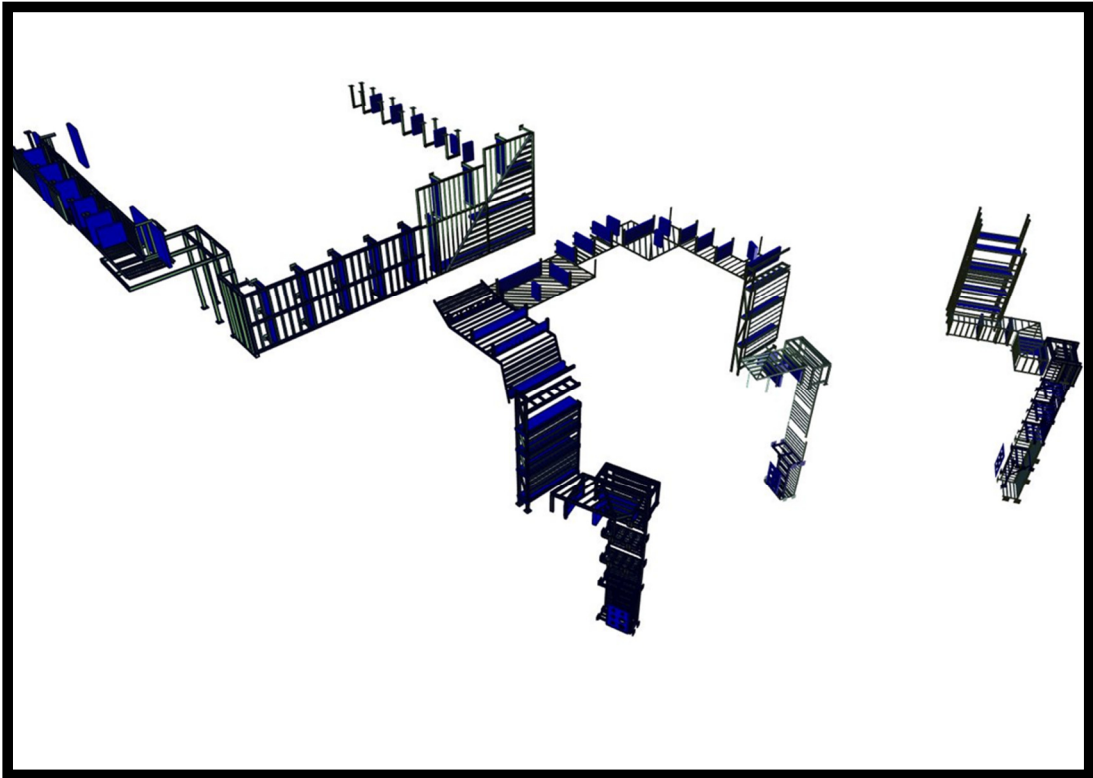


Figure 2: Overview of the H-beam & I-beam metallic supports and protective grids for the TBS Connection Pipes of the coolant systems

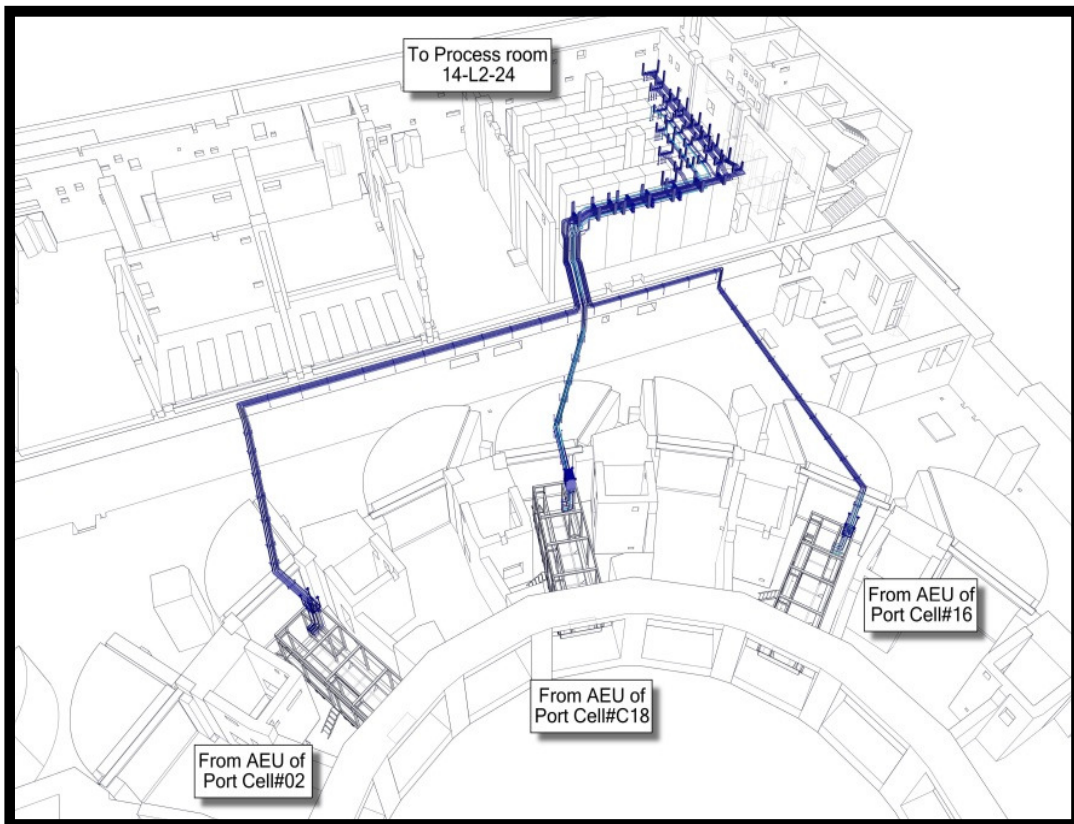


Figure 3: Overview of the TBS Connection Pipes for TESs, TRS and NASs

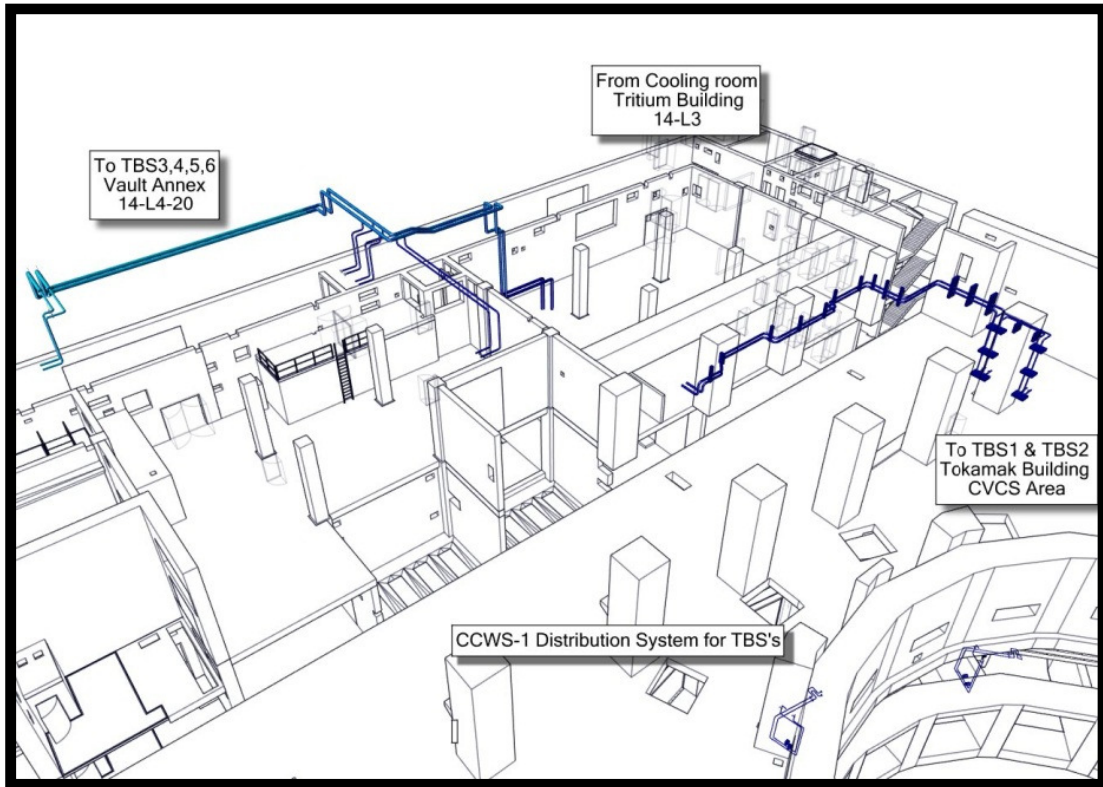


Figure 4: Overview of TBS Connection Pipes for the CCWS-1 Distribution System

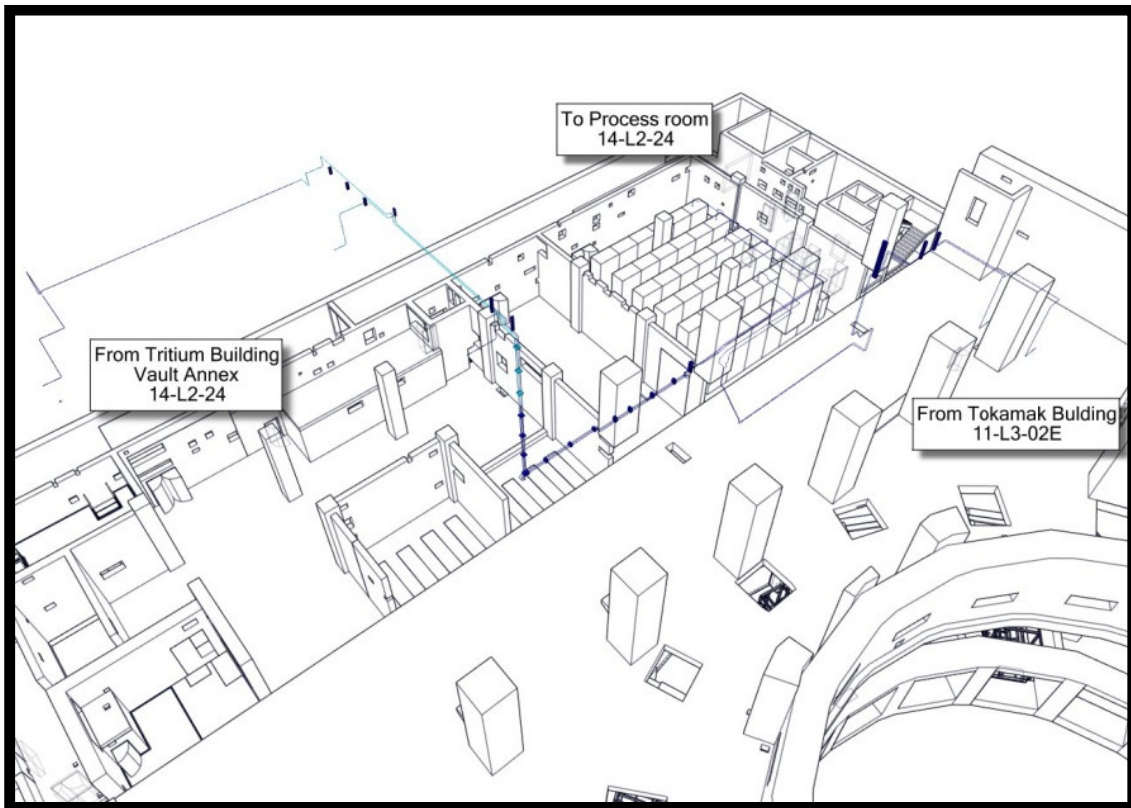


Figure 5: Overview of the TBS Connection Pipes for the TASs

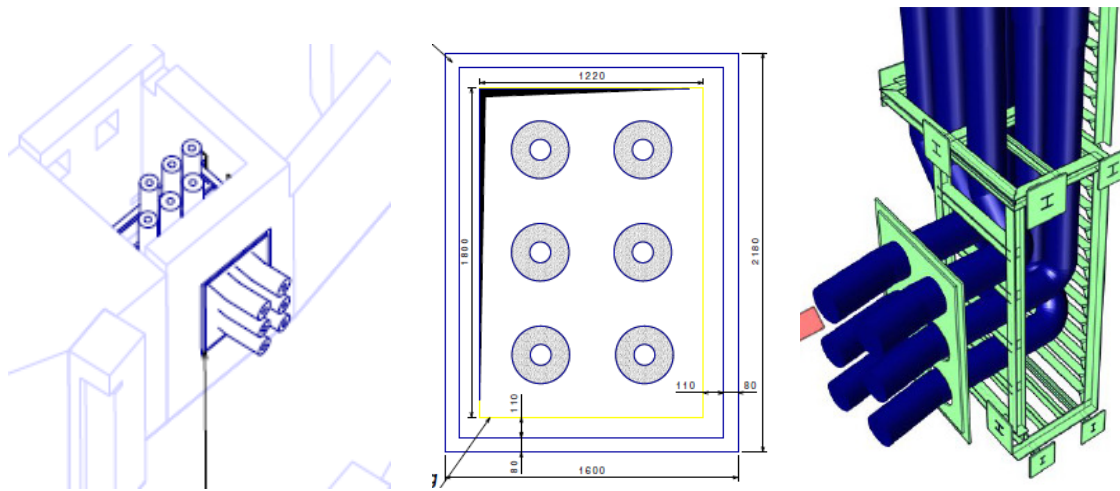


Figure 6: Closure plate between vertical shaft and TBM port cell

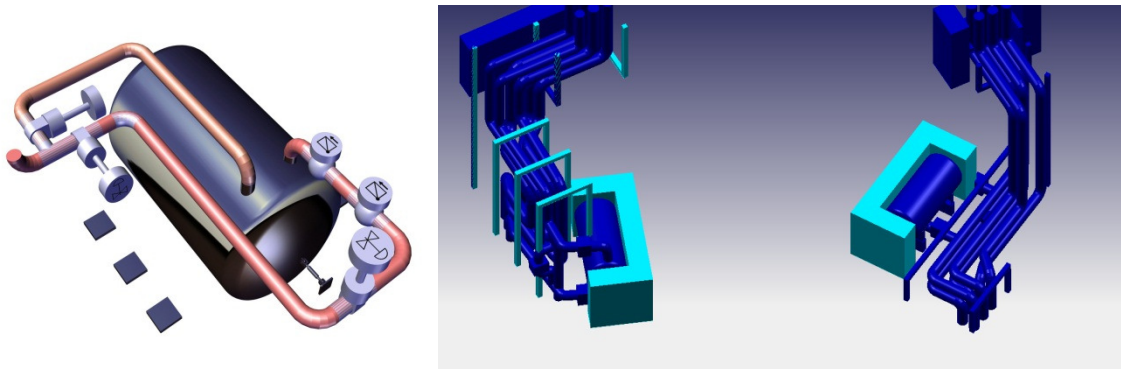


Figure 7: Pre-Conceptual Design of Delay Tanks and Configuration

II) Main Specifications and Requirements

The main specifications and requirements for the design of the straight pipes, the fittings and the delay tanks are given in respectively Table 1, Table 2 and Table 3. The design and manufacturing reference Code, which was used to develop the conceptual design of the pipings and fittings, is the ASME B31.3, see ref [2] . However, there is still an uncertainty whether it is the best choice in between using ASME B31.3 or RCC-MR, see ref [3] The selection of the reference Code (either ASME B31.1 or RCC-MR) will be part of the outcomes of a first step in the execution of the contract for which the supplier shall provide its recommendation to the ITER Organization (IO), based on its own expert assessment of the use of both. The IO shall take the final decision at some time during the execution of the contract based on the comparison made by the supplier with pros and cons. That explains why, in the Tables 1 to 3, there are these two options which are kept opened for the time being.

Code	ASME B31.3 [2]	RCC-MR [3]
Material	Austenitic stainless steel	
Material Grade	grade 316L (UNS 31603)	grade 1.4404
Specifications (general requirements, material)	ASME B31.3 (Category M- fluid) ASTM A312	Section 1, subsection C, chapter RC 2000, Class 2 components Section 2, chapter RM 3342
Process	Seamless Pipes	
DN	from DN 15 to DN 250	
Schedule	from 5s to 160s	
Maximum allowable pressure	from 0.5 to 172 bar	
Maximum allowable temperature	from 35 to 550°C	
ESP [4] pressure category	SEP, I, II and III	
ESPN [5] nuclear level and pressure category	Nuclear level N2 and N3 Pressure category 0, I and II	
Other requirements	[1] [6] [7]	
ITER Particular requirements	Impurities level limitations for some elements (Co%, Ta%, Nb%)	

Table 1: Main Specifications for Straight Pipes

Code	ASME B31.3 [2]	RCC-MR [3]
Material	Austenitic stainless steel	
Material Grade	grade 316L (UNS 31603)	grade 1.4404
Specifications (general requirements, base material, filler material)	ASME B31.3, Category M- fluid and by cascade ASME B16.9 (fittings), ASME B16.5 (flanges), ASTM A403, ASTM A312, ASTM A182, ASTM A240 and others	Section 1, subsection C, chapter RC 2000, Class 2 component Section 2, chapter RM 3347
Process	Base material : Seamless tubular or flat products Manufacturing: forging /welding / forming	
DN	from DN 15 to DN 250	
Schedule	from 5s to 160s	
Maximum allowable pressure	from 0.5 to 172 bar	
Maximum allowable temperature	from 35 to 550°C	
ESP [4] pressure category	SEP, I, II and III	
ESPN [5] nuclear level and pressure category	Nuclear level N2 and N3 Pressure category 0, I and II	
Other requirements	[1] [6] [7]	
ITER Particular requirements	Impurities level limitations for some elements (Co%, Ta%, Nb%)	

Table 2: Main Specifications for Fittings (Elbows, Reducers, TEE junctions) and Flanges

Code	ASME BPVC [8]	RCC-MR [3]
Material	Austenitic stainless steel	
Material Grade	grade 316L (UNS 31603)	grade 1.4404
Specifications (general requirements, base material, filler material)	Section III or Section VIII, Section II and others	Section 1, subsection C, chapter RC 2000, Class 2 component, Section 2, chapter RM 3322 Section 2, chapter RM 3332
Process	Forging / welding / forming	
Volume	Up to 3m ³	
Dimensions	To be defined	
Maximum allowable pressure	172 bar	
Maximum allowable temperature	343°C	
ESPN [5] nuclear level and pressure category	Nuclear level N2 Pressure category IV	
Other requirements	[1] [6] [7]	
ITER Particular requirements	Impurities level limitations for some elements (Co%, Ta%, Nb%)	

Table 3: Main Specifications for Delay Tanks

The design of the two delay tanks shall comply with either the ASME BPVC (either section VIII or section III) or the RCC-MR. The material specification shall be decided at a later stage.

III) Expected work, outcomes, results

The contractor will have to deliver a full set of analyses and documentation that shall correspond to the final design of the whole system including all its equipment: pipes, fittings, pipes supports, thermal insulation material, steel supporting frames and structures, fire protection equipment or/and material, additional anti-whipping equipment if any, closing structures/frames/equipment for all piping penetrations through concrete slab/concrete wall / concrete ceiling. The expected main work can be summarized as below:

- Review and provide a critical assessment of the conceptual design developed by ITER Organization and subsequent changes performed since the conceptual design approval
- Provide possible options, with advantages and disadvantages and preferred one, in the strategy of the assembly or installation scheme according to Host State Country (France) regulations (ESP/ESPN)
- Perform a comparison on the two possible reference design and manufacturing Codes which can be selected for the design of the pipes lines with analysis of technical advantages and disadvantages; Perform a project risk analysis in view of licensing and procurement, cost and procurement schedule with respect to the two Codes.

- Review and propose any consolidation of the TBS Connection Pipes system load specification with respect to industrial codes and practices
- Provide an exhaustive detailed description of the design of all Systems, Structures and Components (SSCs).
- Provide all exhaustive engineering analysis reports and calculation notes and structural analyses (thermomechanical, seismic, mechanical and so on) and associated reports that are required before entering the fabrication stage of all SSCs. It shall take into account the type of welds and the coefficient for the calculations associated to each joints at manufacturing and assembly levels. The types of loads are internal pressure, temperature, weight of the pipings and its content plus the thermal insulation, dynamical effects due to movements of fluid, moves of floor and buildings, vibrations, seismic event, fire and so on. The structural integrity of the pipings and tanks shall be assessed regarding single and all relevant loads combinations. All normal situations and abnormal situations shall be part of the assessment. This set of data will be part of the input data provided by ITER Organization to the company
- Provide all mechanical engineering model and drawings (ex: at the level of each support, connection to the embedded plates and so on). The isometrics drawings are just an example.
- Provide a Bill of Material (BOM) with quantities, specifications and so on. Provide for each component its technical specifications
- Provide a factory qualification test plan on any item, which requires a specific qualification program
- Provide an on-site (ITER site) assembly plan
- Provide an on-site (ITER site) testing and commissioning plan (including regulatory proof tests and/or functional leak test)
- Provide an engineering detailed assessment of the cost (depending on the targeted ITER schedule until the completion of the assembly of all items) for all items covered by this contract
- Develop a full detailed In-Service Inspection (ISI) Plan. The needed inspection operations and solutions, the way to achieve the inspections and the rationales behind the listed inspections (ex. visual examination of highly stressed area) shall be detailed and justified
- Optimize the design following the ALARA (As Low As Reasonable) principle in order to mainly decrease the dose rate for workers during maintenance and minimize the amount of radwaste
- Design in detail the closure plates and grids at the locations pipes cross concrete floors, walls and ceilings
- Perform the relevant analyses (ex. fire analysis and seismic analysis) related to the credit of safety given to the pipings that are Hard Core Component (HCC), which means pipings and surrounding which have to maintain ITER in a safety state after an accident
- Perform an exhaustive review of the existing industrial approaches and solutions to mitigate the negative consequences of a pipe failure leading to a whipping effect.

Provide a detailed design of the protective grid or the chosen alternative system and provide the associated analyses for the selected solution.

- Defines the solution for maintaining pipings and vessels under idle conditions with respect to the French regulation [4] and perform the design of the needed additional equipment (ex. piping plugs) and perform the associated analyses and calculations
- Propose design solutions to protect the SSCs from fire events and implement into their detailed design the preferred and selected solution in agreement with the nuclear operator (IO)
- Perform a RAMI (Reliability, Availability, Maintainability and Inspectability) analysis based on industrial practices, record of experience (ROX), industrial knowledge, failure mode and effect analysis (FMEA)
- To provide the definition of the various tolerance to be considered at the different step of the design process and fabrication process: minimum required thickness without allowances and tolerances to withstand pressure, corrosion or erosion allowance, negative tolerance from the material standards, thinning allowance for possible thinning during manufacturing process and so on
- To define the situations of pipings presetting, cold start, washing (if needed) and cleaning

In complement of the listed expected achievements of work, it is expected that ITER specific requirements are also implemented into the design of the whole system. A few but non exhaustive list of additional requirements or repeated requirements are given hereafter as example:

- ALARA principle has to be applied
- Design and fabrication shall be targeted to have a lifetime of the system of about 30 years with as less maintenance operations as reasonably possible
- Optimization of the design is to be targeted in order to minimize the amount of maintenance operations (for regulatory In-Service Inspection, for routine maintenance, for repair)
- No halogen element or negligible amount into the thermal insulation material, into the fireproofed material (if any), any nonmetallic component of part of a component
- No oil or liquid can be part of the piping supports or any other equipment
- Specific material requirements such as for example low cobalt content steel, low roughness of steel surface, cleanness
- A target is to have all welds for connecting various parts of the pipings with the possibility to perform 100% visual, surface and volumetric inspections
- A target is to have as less welds as possible in order to minimize the risk of failure, the number of inspections needed for all the joints, to have less In-Service Inspections.
- To propose some alternative and advanced solutions for In-Service Inspections in case for example the limited access to a part of the system is challenging or need significant effort to access the part to be inspected
- To design the protective grid (if any) and the thermal insulation equipment as dismantlable components in order to access any part that needs to be inspected.

Another expectation is that all the supplementary studies and reports and documentation related to the construction design, which shall be provided by the nuclear operator (ITER Organization) to the Agreed Notified Body for its review and then formal approval of the design before starting of the fabrication, shall be part of the deliverables of this contract.

IV) References:

- [1] French Order dated 7 February 2012 relating to the general technical regulations applicable to INB
- [2] ASME B31.3 (2010)
- [3] RCC-MR edition 2007
- [4] French Decree 99-1046 of 13 December 1999 on Pressure Equipment (ESP - Equipement Sous Pression)
- [5] French Order 2005 December 12th for nuclear pressurised equipment (ESPN - Equipement Sous Pression Nucleaire)
- [6] Order 21 December 1999 Classification and Evaluation of Conformity of Pressure Equipment
- [7] Order 2000 March 15, Operation of Pressure Equipment
- [8] ASME Boiler and Pressure Vessel Code (BPVC), 2015

Timetable

The tentative timetable is as follows:

Tender submission	December 2015 – January 2016
Tender Evaluation	February 2016
Contract placement	April 2016
Completion	December 2017

Experience

The companies shall have adequate experience in the following areas:

- Relevant experience and technical and engineering capability in the design of nuclear high temperature (about 500°C) and high pressure (about 15.5MPa for water fluid and about 8MPa for Helium gas) pipings (including the pipes, the associated pipe supports and an advanced thermal insulation material plus its casing if any) and fittings
- Relevant experience and technical and engineering capability in the design of pipes and fittings in compliance with ASME B31.3 (for Category M Fluid Services) and RCC-MR Codes (for Class 2 components at the highest)
- Relevant experience and technical and engineering capability in the design of pipings and fitting or/and the design of high temperature pressurized coolant system in the framework defined by French Regulations for pressure equipment and nuclear pressure equipment, see ref [4] [7]

- Relevant experience and technical and engineering capability in the design of high energy pipings taking into account risk of guillotine pipe break and possible induced missile effect. Demonstrated experience in some projects on the implementation of the best engineering solutions and systems to prevent or mitigate such kind of incident or accident and mitigate the associated risks
- Relevant experience and technical and engineering capability in the design of structural steel frames and structures supporting pressure equipment or pipings in a nuclear environment
- Experience and technical and engineering capability in the definition of In-Service Inspections according to regulations and/or Codes&Standards for nuclear high pressure and high temperature pipings or systems
- Experience and technical and engineering capability in the design of high pressure and high temperature coolant fluid circuits/systems/loops in nuclear environment would be an asset
- Experience and technical and administrative knowledge or expertise in the nuclear licensing of pressure equipment and nuclear pressure equipment to be operated in a nuclear power plant facility, in France or another country, would be an asset
- Experience and technical and administrative knowledge or expertise in the nuclear licensing of pressure equipment and nuclear pressure equipment to be operated in a nuclear facility, or even better a nuclear power plant, in France or another country, would be an asset
- Experience in the design of pipings or pressure equipment or pressurized system or mechanical equipment in accordance with ASME BPVC VIII or ASME BPVC Section II would be an asset
- Experience in the design of specific anti-whipping high energy piping or system (protective grid, shock absorber...) would be an asset
- Experience in the design of nuclear piping and vessels following a high standard of quality assurance
- The company shall possess ISO 9001 or equivalent.
- Capacity in Quality Assurance Management for manufacturing nuclear components in conformity with the French Order of 7th February 2012 establishing the general rules for basic nuclear installations.

Candidature

Participation is open to all legal persons participating either individually or in a grouping (consortium) which is established in an ITER Member State. A legal person cannot participate individually or as a consortium partner in more than one application or tender. A consortium may be a permanent, legally-established grouping or a grouping, which has been constituted

informally for a specific tender procedure. All members of a consortium (i.e. the leader and all other members) are jointly and severally liable to the ITER Organization.

The consortium groupings shall be presented at the pre-qualification stage. The tenderer's composition cannot be modified without the approval of the ITER Organization after the pre-qualification.

Legal entities belonging to the same legal grouping are allowed to participate separately if they are able to demonstrate independent technical and financial capacities. Candidates (individual or consortium) must comply with the selection criteria. The IO reserves the right to disregard duplicated reference projects and may exclude such legal entities from the pre-qualification procedure.