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11 Oct 2024 / 1.2 / Approved
EXTERNAL REFERENCE / VERSION

Technical and Financial Quotation Documents

In-Cryostat TCWS Piping Installation Contract Technical Summary

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1 Purpose

The purpose of this document is to provide a high level summary of the scope of works, strategy, and required Contractor competences for the ITER In-Cryostat TCWS Piping Installation Contract, covering the pre manufacturing, assembly and installation works inside the Tokamak Pit in Building 11 (WS1) of the ITER project based in Saint Paul Lez Durance, France.

2 Abbreviations

The following table lists and defines the abbreviations used in this document.

Abbreviation	Definition
ASN	Autorité de Sûreté Nucléaire
BM	Blanket Modules
CCWS	Component Cooling Water System
CHWS	Chilled Water System (CHWS)
CMA	Construction Management as Agent
CWP	Construction Work Package
DA	Domestic Agency
DR	Draining and Refilling
EWP	Engineering Work Package
ESPN	Équipements Sous Pression Nucléaires
FW	First Wall
IBED	Integrated Blanket, ELM-VS, and Divertor (Loop)
INB	Installation Nucléaire de Base (Basic Nuclear Installation)
IO	ITER Organization
IWP	Installation Work Package
LPC	Lower Pipe Chase
NDE	Non Destructive Examination
OHC	Overhead cranes
PHTS	Primary Heat Transfer System
PIA	Protection Important Activities
PIC	Protection Important Component
SB	Shield Block
SQEP	Suitably Qualified and Experienced Personnel
TCWS	Tokamak Cooling Water System
UPC	Upper Pipe Chase
VV	Vacuum Vessel
WS	Worksite

Table 2.1 Abbreviations and Acronyms

3 Technical Description

3.1 The ITER Project

For a complete description of the ITER Project, covering both organizational and technical aspects of the Project, visit www.iter.org.

3.2 Tokamak Cooling Water System

The Tokamak Cooling Water System (TCWS) removes the heat from the in-vessel components and VV, and transfers it to the Component Cooling Water System (CCWS-1) and Chilled Water System (CHWS); it comprises three sub-systems:

- The VV-Primary Heat Transfer System (PHTS) - total capacity 32 MW – provides cooling for the VV.
- The Integrated loop of Blanket, ELM-VS, and Divertor (IBED)-PHTS – total capacity 880 MW - provides cooling for the following main clients:
  - Blanket Modules (FW panels and SBs)
  - Divertor Cassettes
  - In-vessel coils (VS and ELM coils)
  - Diagnostic systems
- The Draining and Refilling (DR) system provides the VV safety draining function in addition to normal TCWS draining.

All the in-cryostat pipework is constructed in low cobalt (max. 0.05%) stainless steel 304L in accordance with ASME B31.3 Edition 2010 Fluid Category M. The pipe runs are either double walled, or part of a bundle with a common containment that is subject to the same categorisation. All support structures are stainless steel 304L. The intermedium plates between pipes and steel structures are Aluminium Bronze ASTM C63200.

The in-cryostat TCWS can be divided geographically into a lower part, an upper part, and an intermediate portion of the IBED-PHTS serving mainly the divertor cassettes, as shown in Figure 3.1.

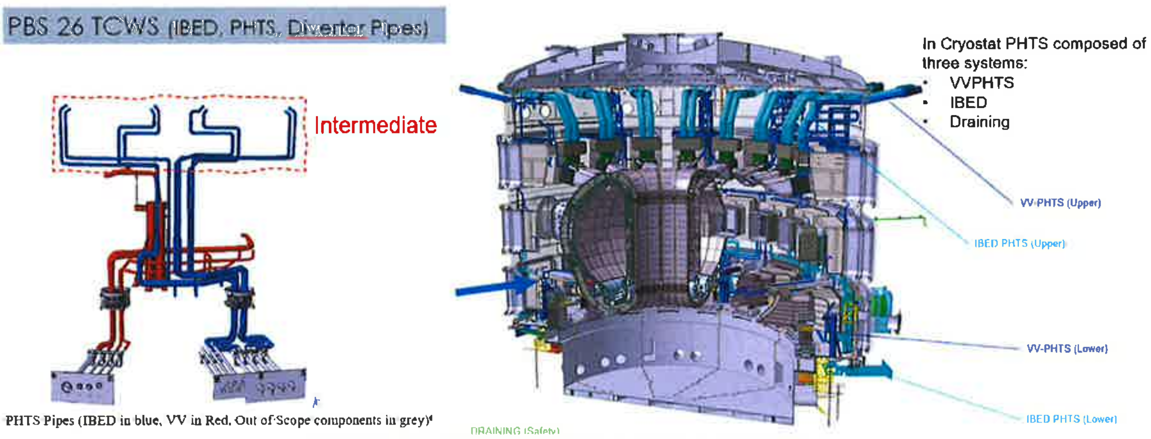

Figure 3.1 In-Bioshield Tokamak Cooling Water System

All three sub-systems are routed in the lower part, and extend radially from the Lower Pipe Chase (LPC) at building level B2M through penetrations in the Bioshield, and vertically via feedthroughs into the cryostat, with an eighteen-fold segmentation. The IBED-PHTS in this part includes the inlet and return lines serving the equatorial ports, while only the inlet lines to the VV are routed for the VV-PHTS. The DR system follows a similar routing from the LPC to VV, but with a nine-fold segmentation (one drain line per VV sector).

In the upper part both the VV-PHTS and IBED-PHTS subsystems are routed. The VV-PHTS in this part includes the return lines from the VV components; these lines are routed radially from the cryostat to the Upper Pipe Chase (UPC) at building level L3 in nine sets of double-walled, groups via feedthroughs in the cryostat wall and penetrations in the Bioshield. The IBED-PHTS inlet and return lines serving the BMs (FW/SB), and the ELM and VS coils are routed between the UPC and cryostat in the upper part, with the thirty-six bundles (process pipelines and guard pipe) routed via the Bioshield and cryostat to the upper VV ports.

The inlet and return lines of the intermediate portion of the IBED-PHTS are routed from the LPC to building level B1, where it serves the divertor cassettes, lower VS coil, and other clients, via eighteen vertical shafts. This portion of the IBED-PHTS is routed through the cryostat to the VV via dedicated penetrations adjacent to or integrated into the port structures.

3.3 Assembly Sequence Approach

Assembly of the ITER Tokamak Machine phase I in B11 Pit is separated into Eight distinct periods.

- A0 Lower Cryostat early works
- A1 Lower Cryostat activities
- A2 Sector Sub-Assembly (Assembly Hall)
- A3 Sector Assembly (In-Pit)
- A4 Align VV and Magnets Establish Tokamak Assembly Datum
- A5 Ex-Vessel Side Region Assembly activities (starts after the removal of the Radial beams in A4)
- A6-I In-Vessel Assembly works
- A7 Components Pre-Assembly in Assembly Hall (CS/LCTS/UCTS/Ports Pre-Assembly)

The works of this Contract scope to be performed during A5 period.

3.4 Construction Areas

The works in the scope of the Contract are located on the ITER Platform currently under construction in Cadarache, Southern France. Central to the facility is the Tokamak Complex, a nuclear rated structure in reinforced concrete that comprises three integrated buildings as shown in Figure 3.2 Site Overview – Future Final ConfigurationFigure 3.2. The Complex has a footprint of 118 x 81 m, extends vertically from -15 m to +40 m relative to ground level, and contains the plant systems that service (power, heat, cool, condition, fuel, monitor and control) the Tokamak machine.

To support the assembly of the Tokamak machine there is a steel-framed Assembly Building and Cleaning Facility, arranged to form a continuous working space.

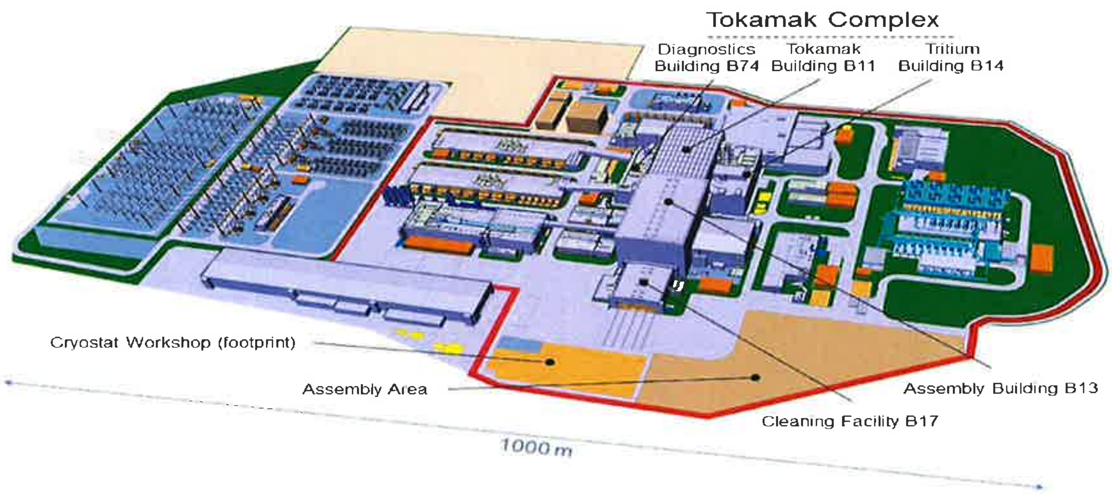

Figure 3.2 Site Overview – Future Final Configuration

The ITER site has been divided into 5 independent main worksites (WS). The worksites are defined to collect together groups of buildings and areas by major discipline, in order to better allocate works Contractors and suitably qualified persons. As presented in the Figure 3.3 below, the breakdown of the site and works is the following:

- WS1 - Tokamak Basic Machine (including Assembly and Cleaning Facility buildings)
- WS2 - Tokamak Complex buildings (excluding Tokamak Pit)
- WS3 - Other nuclear buildings and Control building
- WS4 - Cryogenic plant and Site Services buildings
- WS5 - Electrical Areas and Power Supplies Buildings

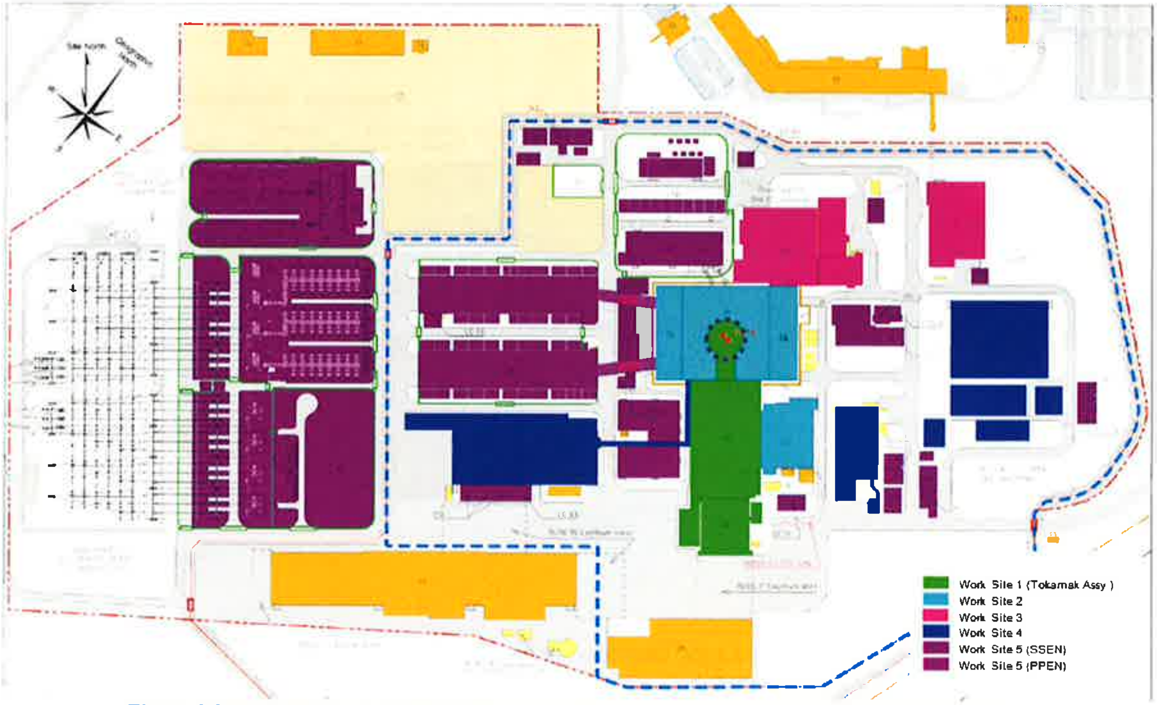

Figure 3.3 Breakdown of the ITER Site and buildings to independent Construction Worksites

The works in the scope of the Contract will take place in the WS1 B11 Pit in the buildings indicated with dashed black line in the Figure 3.3.

3.5 Construction Instruction Process

The IO, assisted by the Momentum - Construction Manager as-Agent (CMA), will define the assembly process through Construction Work Packages (CWPs). Each CWP will define a package of works prepared and instructed to the Contractor by the CMA and performed by the Contractor as a unit, with a defined start and completion point and a required cost based upon the tendered unit rates for each type of work.

3.6 Scope of Activities

The contract will include TCWS piping systems inside Cryostat, in crown area at B2, and in Cryostat space room at L3.

Refer Appendix - In Cryostat TCWS Piping Installation Overview of Scope of Work for further details.

In terms of Scope of Work, the scope will generally consist of the preparation, execution, control and documentation of the permanent works, plus any temporary works required to achieve the permanent works.

The scope of this contract includes various activities such as:

- Issue all necessary documentation for the works, such as Quality Plan, Health and Safety plan, Workforce planning (Installation sequence and Level 4 Schedule) and the Installation Work Packages (IWPs) for the execution of the works.
- Identification, definition and provision of any required temporary works required to complete the permanent works, such as HVAC, lighting, protection, temporary access, safety equipment, standard tooling, etc..

- Develop mock-up and qualification method.
- Execute mock-ups and qualification process and develop detailed fabrication and installation procedures.
- Site metrology and reverse engineering during all installation activities.
- Protect the surrounding components installed by the others.
- Design, procurement and maintenance of purpose-built tooling.
- Provide the consumables and accessories required to complete the works.
- Issue all the necessary documentation required to follow-up installation activities and to record all activities.
- Packing and transport raw materials (procured by the IO like pipes, fittings, steels, and inline components) from the IO warehouse to the Contractor's fabrication workshops.
- Pre-fabrication of support structure and pipework spools include pipe bending.
- Polishing outer surface of guard pipes with a finish roughness less than 0.2μm.
- Assembly of pipework spools as bundles in fabrication workshop.
- Assembly of thermal insulation parts on the inner surface of guard pipe for bundles.
- Assembly of spools or bundles with inline components like vacuum flanges, bellows, spacers, bushings, etc. in fabrication workshop.
- Pre-assemble pipework spools with supports as modules configuration if required.
- Pickling and passivation of stainless steel weld and piping surface.
- Packing and transport pre-manufactured spools, support structures, modules from Contractor's fabrication workshops to the IO warehouse.
- Design, procurement and installation of temporary supports.
- Installation of pre-manufactured pipework spools, bundles, and support structures.
- Technical cleaning (foreign material exclusion, dust control, flushing and drying or others).
- Thermal insulation works.
- Preservation works.
- Installation inspection and tests (e.g. NDE, hydraulic pressure test, helium leak test).
- Preparation and issue of detailed as-built drawings, specifying dimensions achieved.
- Issue mechanical completion dossiers.

All above mentioned works (except the pre-fabrication activities) shall be performed by the Contractor within ITER premises at Saint Paul-lez-Durance in France.

4 Interfaces and Resources

4.1 Boundary between Worksite 1 and Worksite 2

The physical boundary of the Tokamak is, for the purpose of assembly and installation works, defined by the outer surface of the Bioshield. In general terms, this surface demarcates the Tokamak Assembly Works to be executed by the WS1 Contractors from the Tokamak Complex works to be executed by WS2 TCC Contractors as shown in Figure 4.1.

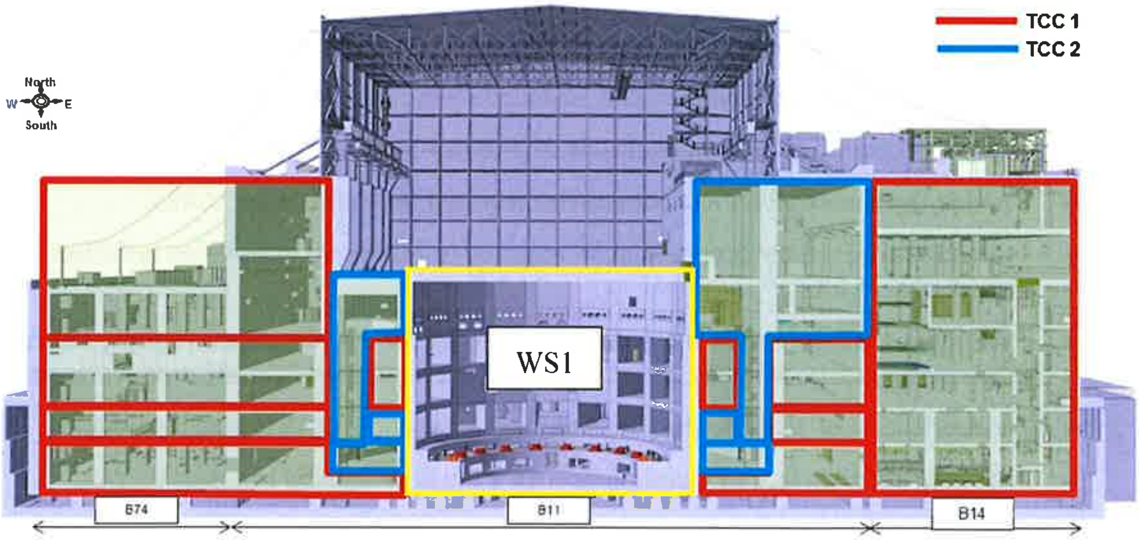

Figure 4.1 Physical boundary principle between WS1 and WS2 in the Building 11

4.2 Worksite 1 Coordination

It is expected some coactivity with other Contractors working in Worksite 1.

To manage the coactivity in worksite 1 and the installation schedule, the IO is currently managing all construction activities with the supporting from Construction Management-as Agent (CMA).

- Coordinate all construction activities
- Manage the construction activities
- Develop and maintain the workface planning
- Manage the WS1 facilities with the support of Building and Site Management Program, the cleanliness, preservation and Foreign Material exclusion.

4.3 Workshops

The IO will provide an area dedicated to the Contractor for the installation of his site facilities, possibly covering a workshop, local storage, and some pre-assembly activities on smaller components. These areas will be located on the ITER Worksite platform. The areas will be connected to the potable water, IT and electrical networks as well as to the industrial drainage network.

To support the pre assembly activities, the Contractor shall provide a general workshop facility within the area described above and as appropriate to volume and schedule an off-site locally workshop to enable the pre fabrication and modification of pipe spools, support structures, temporary meanings, etc. These workshops shall be staffed by competent technicians, and have an acceptable selection of hand tools, machine tools, control instrumentation and welding equipment.

The Contractor will be fully responsible for transport between the ITER site and these workshops, and for any ITER components while off-site.

On the site, ITER has available a number of buildings for component storage. In general IO special tools (if any) will be collected by the Contractor from these storage locations, and returned to them on completion of the corresponding CWP.

Due to the limited area available for the onsite workshop, not suitable for complete scope prefabrication, the contractor is responsible to provide his own workshop for main spools and support structures prefabrication activities outside of IO site.

4.4 Interfaces to Other Contracts

4.4.1 Interfaces to IO WS1 Contractors

The Contractor may:

- Execute a CWP where the preceding CWP was performed by another Contractor.
- Complete a CWP where the following CWP is performed by another Contractor.

At the start of a CWP the Contractor will have an opportunity to examine and accept the components/environmental conditions, and at the end of the works, the completion will be certified by the IO with the support of the CMA.

4.4.2 Scaffolding

The IO will put in place a framework contract for the lease of scaffolding (scaffolding contractor). This contract will be for the provision of scaffolding to the Contractor and other IO works contractors.

Due to the high level of interaction between different contractors, the use of this scaffolding contract will be obligatory for all work being carried out in WS1 as several works contractors may use the same scaffolding.

4.4.3 Lifting

The assembly hall overhead cranes (OHC, 2x50t and 2x750t) are largely used for the machine assembly.

The works executed in B13, B17 and B11 require regular support from an electric mobile crane which provided by IO service Contractor.

The installation Contractor is responsible for the Lifting and Handling operations include provide the lifting accessories.

5 Required Competences

The competence and experience of the Contractor, and the ability, experience, and training of his engineering and construction team will have a direct influence on quality, re-work, and schedule, and ultimately on the performance of the Tokamak during operation; the Contractor will be required to demonstrate competence and experience in a number of key areas as listed below.

Core competences are those areas of technical experience that must be provided by the Contractor. These are identified in Table 5.1. The remaining competencies may be obtained by sub-contracting subject to the limit specified in the Procurement Summary document, in which case the Contractor will be required to identify SQEP staff members for the area of competence subcontracted to guarantee adequate technical supervision.

Section	Area of Competence	Core Competence
5.1	Codes and Standards	√
5.2	Occupational Safety	√
5.3	Nuclear Regulation	√
5.4	Clean Conditions Working	√

5.5	Precision Assembly of Multi-Process Piping System	√
5.6	Process Development and Qualification	√
5.7	Quality Assurance / Quality Control	√
5.8	Stainless Steel Welding and Brazing Process	√
5.9	Inspection and Non-Destructive Examination	√
5.10	Lifting and Handling	√
5.11	Metrology, Reverse Engineering, Customization and Precision Pipe Forming	√
5.12	Execution of Mock-ups and Development of Detailed Fabrication and Installation Procedures	
5.13	Management and Execution of Site Works in Highly Regulated, Complex, Industrial/Nuclear Projects	
5.14	Component and Tooling Maintenance, Storage and Preservation	
5.15	Polishing of Stainless Pipe Exterior	
5.16	Thermal Insulation	
5.17	Packing and Transportation	

Table 5.1 Required Competences

5.1 Codes and Standards

The systems that comprise the Tokamak have significantly varied functions, operating conditions, safety classifications, quality classifications, integrate a wide range of technologies, and the hardware is being sourced among all the ITER Parties. A number of Codes and Standards apply to the design and fabrication of the Tokamak systems, including RCC-MR and ASME Section III for the Vacuum Vessel, ASME Section VIII Division 2 for the Cryostat.

TCWS piping system will be connected to or attached to above systems by welding which applying the most stringent requirements.

ASME B31.3 Edition 2010 Fluid Category M apply to the design, fabrication, and installation of the TCWS piping systems.

ANSI/AISC N690 Edition 2012 apply to the design, fabrication, and installation of the TCWS support structures.

AWS D1.6 Edition 2007 and AWS A5.7 & ASME SFA 5-7 apply to support structural welding.

ASME B31.3 and ASME Section IX for welder or welding operator and welding procedure qualification.

ASME BVP Code Section V and B31.3 for Non-Destructive Examination.
Comply with Sections 342 and 343 of ASME B31.3 for qualification and certification of non-destructive testing personnel.

5.2 Occupational Safety

The working environment of the Tokamak presents numerous occupational safety risks, which includes heavy lifting and handling, confined spaces, suffocating gasses, working at heights, hot work, industrial radiography, pressure testing, and co-activity.
Maintaining safe working conditions in this environment shall be a key priority for IO and for the Contractor. The IO with the supporting by CMA shall operate a work permit system, and shall co-ordinate work between contractors, but the Contractor shall be responsible for

performing and documenting risk assessments for each work package, augmented by point-of work risk assessments.
A clear, uncompromising commitment to safety and excellent track record, demonstrating the practical and consistent application of best-practice principles to ensure a safe working culture is required.

5.3 Nuclear Regulation

Per French Order of 7th February 2012, the ITER Organization is the Nuclear Operator of the ITER nuclear fusion facility (INB 174).
In order for the IO to satisfy the INB Order, the Contractor shall comply with all the safety requirements in the Provisions for Implementation of the Generic Safety Requirements by the External Interveners.

Except the connections to VV which according to ESPN Order and RCC-MR requirements, TCWS pipework has received an exception from the ESPN (Équipements Sous Pression Nucléaires) however all components are considered PIC so all quality steps are mandatory. PIAs shall be defined as per ASN (Autorité de Súreté Nucléaire) requirements.
Where equipment falls under any other European Directive, it is the responsibility of the Contractor to ensure they all come with their certificate of compliance and bear the CE marking prior to use for installation purpose.

5.4 Clean Conditions Working

The WS1 is composed of the Cleaning Facility (B17), the Assembly Building (B13), the Tokamak pit and the Crane Hall (B11).
The highest cleanliness requirements apply to the whole volume of WS1 (B17, B13 and the Crane Hall) with the specificity of the Pit which requires to wear a hairnet.
Establishing and maintaining cleanliness and controlling debris and foreign objects is vital for machine performance and reliability. Strict control must be implemented throughout the assembly cycle to ensure contaminants do not accumulate, and the Tokamak and Assembly buildings will be operated under ISO Class 9 Cleanroom Standards.

During the assembly process, temporary access and supports will be required to all parts of the Tokamak. Because of the limited space, clean conditions, and abundance of high value, sensitive components, scaffolding is a specialist activity. All such scaffolding is to be supplied and erected by the Contractor.

Knowledge and experience in clean assembly works, and the demonstration of robust processes to manage operator skills, and the storage and control of clean conditions equipment is required.

5.5 Precision Assembly of Multi-Process Piping System

The scope of the TCWS installation contract is the construction of multi-process piping and double wall piping systems with tight tolerances requirements. High precision work, rigorous and robust quality control are required for the scope of works.
A broad range of experience and skills is demanded, including precision fabrication, assembly, handling, placement and interconnection of the multi core pipes with a high degree of accuracy. Precise bending and fit-up for weldments. Lifting and positioning the large and heavy bundles within the very congested area which surrounded by many sensitive and high value components. Alignment and welding of complex multi-process spools within tight and confined space.
The workforce shall be qualified and experienced mechanical and piping craftsmen.

5.6 Process Development and Qualification

Assembly of the multi-process bundles will require tests and mock-ups to develop and successfully qualify the specific procedures and processes.
Experience in the development and qualification of detailed, specific assembly processes and procedures are required.

5.7 Quality Assurance / Quality Control

Quality Organizations consistent with achieving and guaranteeing compliance with the demands that nuclear regulation and regulator surveillance imposes; ISO 9001 accreditation of the Contractors' QA systems is required.
The Contractor is responsible for controlling the quality of his work, and that of his sub-contractors. All work will be subject to assessment by IO or IO representatives, and Protection Important Activities or Safety Relevant work will be subject to ASN audit.

5.8 Stainless Steel Welding and Brazing Process

Welding is a key activity, and the joining processes are a significant part of the TCWS piping installation work. Experience in the implementation of high-quality welding processes, supported by rigorous quality control standards and compliance with numerous construction codes is required. Piping and main support structures are made of stainless steels plus the limited Aluminium Bronze C63200 plates.
The main welding technologies envisaged for the works are:

- TIG/GTAW
  Manual, mechanized, and narrow gap techniques
- MIG/GMAW
  Manual and mechanized
- FCAW-G
  Mainly for support fabrication in workshop.
- Orbital Welding GTAW
  To include orbital lathes for weld preparation and rework
- Dissimilar Metal Welding
  To weld the Aluminum Bronze plates on stainless steel structure
- SMAW
  Limit to tight space only.

5.9 Inspection and Non-Destructive Examination

The Contractor is responsible for performing and documenting the specified inspections and tests necessary to guarantee the quality of their work, and for qualifying all such processes and the operators performing the work. Relevant experience in the implementation of a range of standard NDE techniques is required, including:

- System flushing
- Hydrostatic test
- Helium Leak Testing
- Visual Inspection
- Endoscopic inspection
- Ultrasonic Testing
- Radiographic Testing
- Dye-Penetrant Testing

Qualification of operators and techniques shall be in accordance with the relevant codes and harmonized standards and will be performed by the Contractor as required.

5.10 Lifting and Handling

The Contractor will be responsible for planning the lifting and handling operations required to complete TCWS piping installation from component point of delivery (B17). The scope includes the development of lifting plans for all the spools, support structure, Bundles and inline components during the long installation period.
The Contractor will supply riggers and banksmen experienced in heavy, complex lifting operations (IO will supply crane operators).

5.11 Metrology, Reverse Engineering, Customization and Precision Pipe Forming

Optical metrology system to be used for controlling the dimensions of the TCWS piping system to achieve the tight alignment tolerances. The system will have to be operated at the limit of its capabilities to deliver the required precision.
Survey work will comply with the ITER Metrology Handbook, and will be subject to verification and audit by IO.
Extensive experience of large volume optical metrology and knowledge of best practice techniques is required.
TCWS piping system will connect to numbers of components all around the Tokamak. Most of the client components already installed by the others. To accommodate assembly and manufacturing tolerances, particularly for the multi-process pipes with precise bending and alignment requirements, the Contractor will perform all the activities necessary for the customization process, including:

- Comply with IO CAD Data Management system requirement during the synchronous collaboration phase by using of Envoia and ideally Aveva, or software completable with Aveva to transfer data intelligently.
- Dimensional control and reverse engineering
- Analysis and presentation of data, provision of models and drawing to define the custom forming to be performed
- Producing spooling shop drawings
- Manufacturing spools and bundles
- Polishing of stainless pipe as required
- Cleaning of parts comply with the ITER Vacuum Handbook
- Packing and logistics.

Experience in reverse engineering and precision manufacturing of spools is required.

Appendix - In Cryostat TCWS Piping Installation Overview of Scope of Work