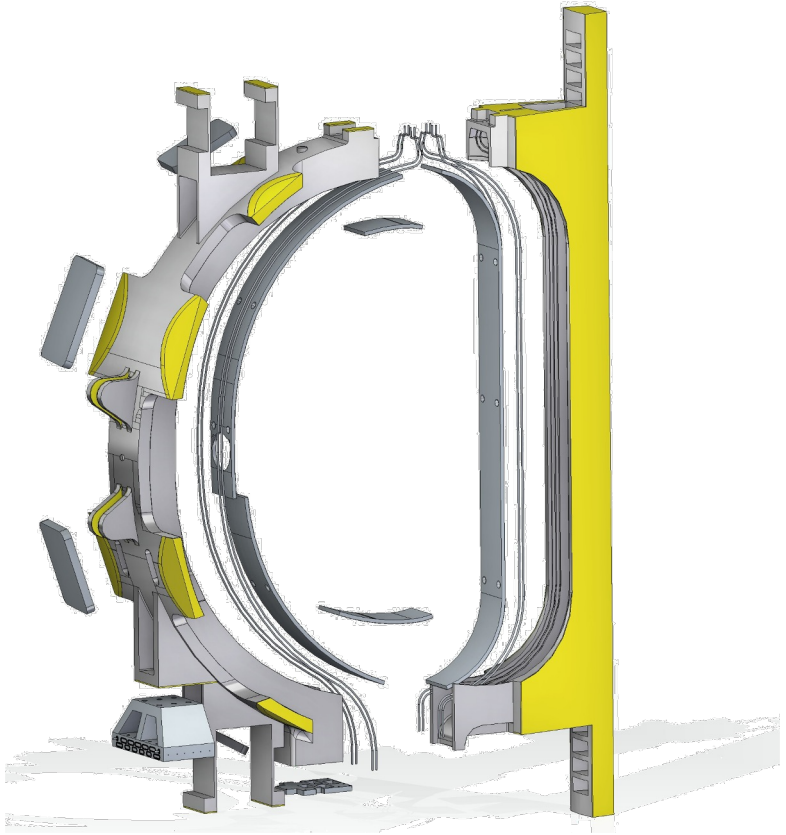
Call for tender for DTT TFC casing components: technical info.



Web event: 12/02/2024 14:30 CET (via zoom)

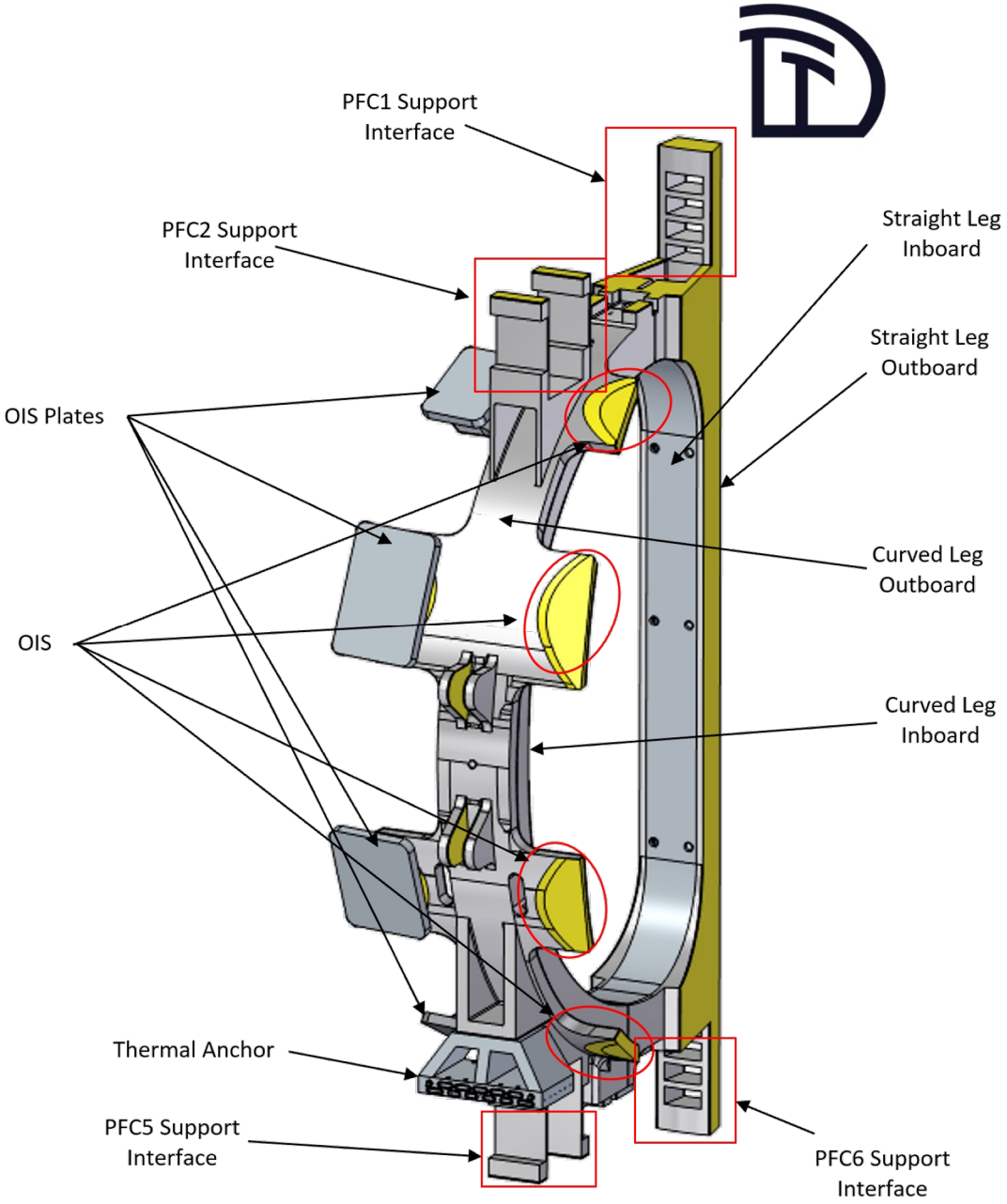
Call for tender for DTT TFC casing components

The material and information contained in this presentation are provided for information purposes only, and should not construed as basis for technical specifications of the call for tenders.

Scope of the Supply

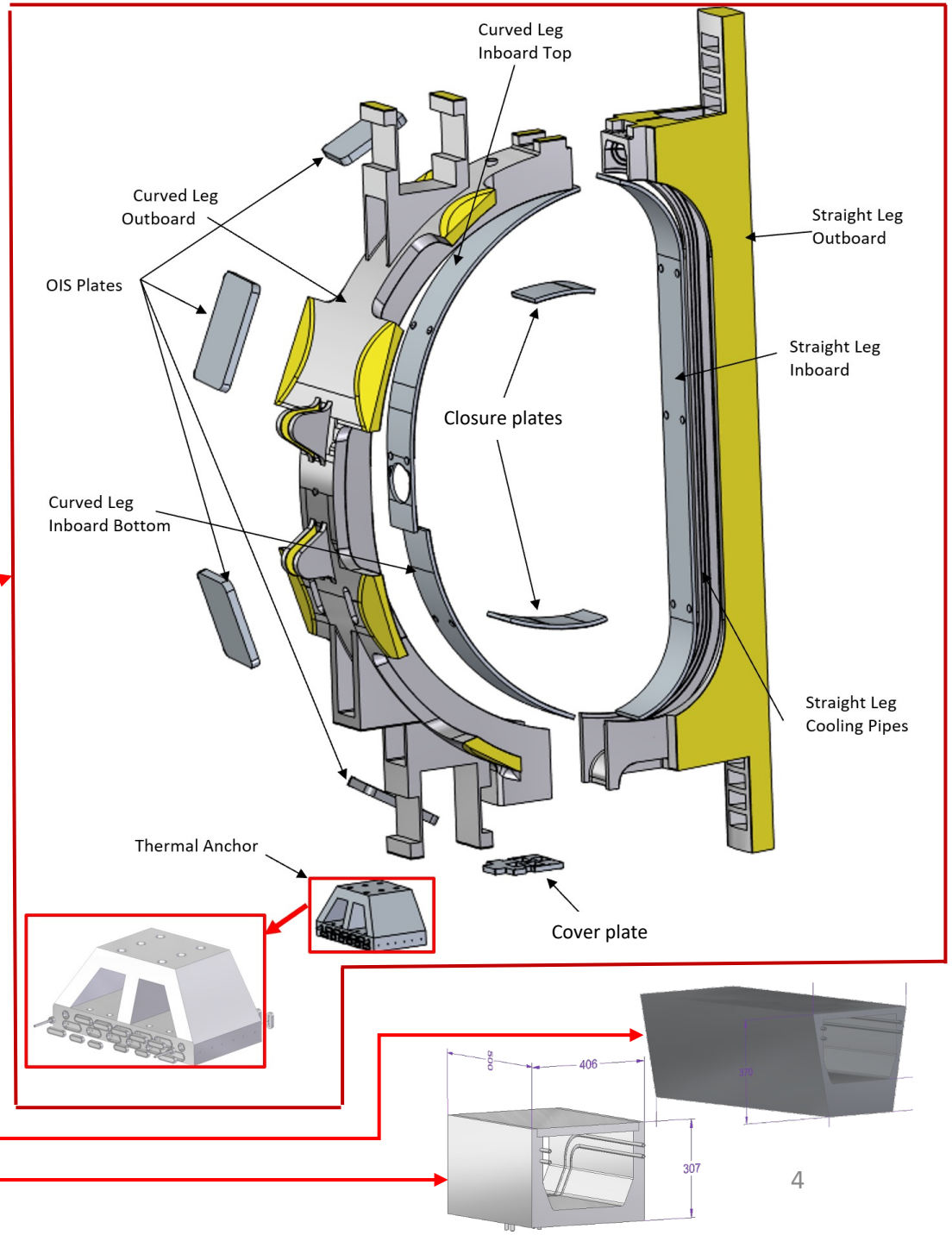
The Contractor is asked to supply and delivery to the destination sites the following items, including all relevant technical and quality documentation:

- 2 Mock-ups;
- 18 complete sets of TF Coil Casing Components (OIS plates and thermal anchor included in the scope of supply).



Scope of the Supply

TFC casing components BoM	Quantity			
Description	1 TFC	Gross weight [kg]	Envelope [mm]	18 TFC
Straight Leg Outboard	1	4850	6380x1153x615	18
Straight Leg Inboard	1	420	4126x346x30	18
Curved Leg Outboard	1	5360	5716x24371413	18
Curved Leg Inboard Bottom Side	1	170	1198x1593x346	18
Curved Leg Inboard Top Side	1	240	2442x1108x346	18
Bottom Closure Plate	1	70	835x346x30	18
Upper Closure Plate	1	45	524x346x30	18
Helium Cooling	1	30	-	18
Cover Plate	1	45	530x406x40	18
Plate OIS1	1	140	585x460x65	18
Plate OIS2	1	260	840x600x65	18
Plate OIS3	1	220	700x600x65	18
Plate OIS4	1	150	630x450x65	18
Toroidal Coil Thermal Anchor	1	700	853x452x394	18
Mock-up Straight Leg Sample	1			
Mock-up Curved Leg Sample	1			



Contractor Responsibilities (summary)

A. shall develop & provide to DTT detailed design and as-built of the casing on the base of the design made by DTT;

B. shall prepare a complete set of CATIA® V5 models and the associated CATIA® drawings for the complete Casing Component Set. These models are to be provided prior to manufacture;

C. to allow TFC Integrator to perform acceptance metrology verification, TFC Manufacturer Contractor shall prepare a metrology plan including a set of drawing with support frame and measurement/reference points utilized for final dimensional verification to be agreed with TFC Integrator and approved by DTT;

D. shall inspect the incoming material and guarantee that it fulfills the requirements of the Contract;

E. shall supply and provide all the Casing Components as required for the fulfillment of the Contract;

F. shall be responsible to provide the supply with the proper packaging in order to deliver it perfectly;

G. shall ensure that all the Quality requirements are fulfilled and all the Quality Documentation are drawn, filled and signed.

Workshop Personnel

All personnel involved in any manufacturing operations shall be informed of the special requirements of the work associated with the TF Coil Casing Components manufacture. In particular:

A. It is essential that workshop personnel do not deviate in any way from the design, or make repairs to resolve any manufacturing issue, without DTT involvement. As such, there must be an open channel of communication between workshop personnel and DTT;

B. All personnel entering the area of the TF Coil Casing Components manufacture shall be formally informed of the importance of the points as noted in Cleanliness Section;

C. All welders must be qualified for the welding technique chosen. A copy of the welder's license shall be provided.

D. Personnel performing NDT has to be qualified according to reference codes;

E. All NDT (with the exception of the visual examination) can be carried out by Level 1 or 2 qualified personnel as per ISO 9712 but the coordination and reports shall be responsibility of a Level 3 NDT expert;

F. Personnel performing welding inspection has to be qualified according to reference codes;

G. The use of sulphur and chlorinate-bearing fluids and materials shall be strictly controlled to minimize the risk of corrosion in stainless steel and nickel-based alloys;

In relation to the above points, DTT shall be present while workshop personnel are informed of these requirements.

Cleanliness Requirements

All manufacturing operations shall be performed under clean conditions.

It has to be pointed out that, any contamination with ferromagnetic materials (including debris, chips and dust) can jeopardize the functionality of the reactor and potentially generate hazards for the operators.

Particular care must be taken to ensure the following:

A. Any other non-related process which may be carried out in the vicinity of manufacture of the TF Coil Casing Components will not adversely affect the manufacture of the TF Coil Casing Components;

B. No painted or unpainted ferromagnetic materials shall be allowed to be in contact with the TF Coil Casing Components. No ferromagnetic materials dust or debris should be allowed in the manufacturing area of the TF Coil Casing Components;

C. All the tools used for the manufacturing of the TF Coil Casing Components, including: cutting tools, clamps, hammers, brushes, welding tools, support, handlers, lifting and moving tools, must be suitable for Stainless austenitic steel.

At the end of each manufacturing steps the TF Coil Casing Components shall be carefully cleaned/degreased and stowed in a dedicated and (dust/moisture) protected area.

All the details about the cleanliness management shall be described in the Production Process Description.

Material Chemical & Mechanical Properties

The coil casings shall be made from 316LN austenitic stainless steel.

The manufacturer shall purchase the 316LN base material according to ASTM A-480 & ASTM A-240 for plate form and ASTM A-484 and A473-01 for forgings, the composition of the AISI 316 LN may differ slightly from the reference one in order to fulfill the following requirements:

A. The structure after solution annealing should aim to be fully austenitic and homogeneous, (DTT in some cases may ask to assess that the δ-ferrite is ≤ FN 0.8, as per ISO 13520 or ASTM E562 if previously agreed with DTT);

B. relative magnetic permeability ≤1.05 at ~500 Oe at RT;

C. forging grain size index ≥2 (as per ASTM E112-88);

D. Manufacturer shall assess the chemical composition for each batch of raw material and list the results in a dedicated report, furthermore a witness from each batch shall be sent to DTT.

   The elements listed below shall be limited as follow:

   - Co: 0.05% weight;
   - Nb: 0.1% weight;

E. The N content shall be tune by the manufacturer in order to achieve the required yield and ultimate strength while keep a good weldability as well as fracture toughness;

F. Mechanical properties shall fulfill the ones in technical specification (summarized in the next slide);

G. The melting of the base material shall include an AOD or VOD process, the forgings shall be multi-directionally forged;

H. The hot rolled plates and forgings shall be solution annealed and descaled. The descale process shall achieve a smooth finish. Imperfections that may be present shall be of such a nature or degree for the type and quality ordered that they will not adversely affect the machining of finished parts.

Material Chemical & Mechanical Properties

- Material mech. properties @ room T

Position ID	Young's Modulus [GPa]	Yield strength [MPa]	Ultimate strength [MPa]	K_{IC} Fracture Toughness [MPa $m^{1/2}$]
All	>=200	>= 280	>= 580	N/A

- Material Charpy @ 80 K

Position ID	Charpy [J]
All	>=200

- Material mech. properties @ 4,5 K

Position ID	Young's Modulus [GPa]	Yield strength [MPa]	Ultimate strength [MPa]	K_{IC} Fracture Toughness [MPa $m^{1/2}$]
All except OIS plate	>=205	>= 900	>= 1430	>=200
OIS plate	>= 205	>= 1000	>= 1500	>=200

Samples definition is summarized in the next slide

Raw Material Requirements

The following samples shall be obtained in three locations from the 10% of each thickness of plates and 10% of each type of the forging:

A. three samples prepared according to EN UNI 10002 (tensile at room temp.) one in the long direction, one in the long transverse and the last in the short transverse direction shall be **tensile tested at room temperature** (short transverse direction test for plates is not required);

B. three samples prepared according to ISO 6892 (tensile at low temp. or ASTM E1450-09) one in the long direction, one in the long transverse and the last in the short transverse direction shall be **tensile tested at 4.5K** (short transverse direction test for the plates are not required);

C. two samples prepared according to JIS Z 2284, **fracture toughness at low temp. (4.5K)** shall be tested;

D. two sample for **impact test at 80K** shall be carried out according to specifications to be agreed with DTT, samples position to be agreed with DTT;

Furthermore, as many samples as the above mentioned must be provided to DTT for independent testing, such samples shall be marked to allow full traceability from batch to samples.

Each batch shall be UT tested according to the requirement in the technical specification summarized below:

- ASTM A578 S1 (Inclusion measurement according to ASTM E45 Method A) for rolled steel plates;
- Other relevant standard to be agreed with DTT for ingots/forging or other raw material forms.

Welded Joint Requirements

Weld quality shall be assured by EN applicable standards (or the general provisions of the ASME Boiler and Pressure Vessel Code “the ASME Code”). The following requirements apply to all welds:

A. **All welding procedures must be qualified before welding commences** according to EN ISO 15607 ;

B. The number of sample tests and different destructive and non-destructive tests to be carried out for the welding process qualification is defined in ISO 15614-1;

C. A procedure shall be written for each weld to be performed, sample welds must then be performed with the as-supplied base material and filler material and subjected to tests to determine the chemical composition and mechanical properties of the joint. Both the procedure and the qualification of the procedure must be documented as described in the same article of the reference code. The coil cases will operate at 4.5K and all materials must comply with the toughness requirements in technical specification.

D. All welding personnel (welders and welding operators) must be qualified;

E. Every weld must be subject to 100% visual inspection;

F. Every weld must be subject to 100% surface inspection for cracks using a dye penetrant technique;

G. Every weld must be subject to 100% volumetric inspection by radiography and by ultrasonic inspection.

H. The acceptance criteria to be applied are those given in technical specification. Indication characterized as crack, lack of fusion, or incomplete penetration are unacceptable regardless of length/dimension.

I. Filler material: the δ-ferrite content of the weld metal shall be between 0 FN and 5 FN measured by magnetic method, coupons shall be prepared during the welding qualification.

J. Welded joints shall meet the magnetic permeability of ≤1.1 at ~500 Oe at RT. A samples of each joint shall be tested to assess this requirement.

K. **The supplier shall define the WPS and all the workshop/machining operations to limit the expected distortions induced by the welding process** (description of these processes is preliminary requested for the tender phase as a specific evaluation criteria).

Welded Joint Requirements

In addition to the requirements above, for qualification purposes the following destructive mandatory tests shall be performed (at least) on each weld type (chamfer type) on the first TFC casing component set manufactured, additional welded joints to be tested will be agreed with DTT:

A. Tensile test at room temperature, 2 specimens (plus a sample as witness);

B. Impact test at room temperature, 2 specimens (plus a sample as witness);

C. Tensile test at 4.5K, 4 specimens: 2 specimens shall be **mandatorily tested @ 4.5K** by the manufacturer, the others 2 specimens shall be delivered to DTT that will carry out the tensile test independently;

D. Metallographic test: 1 macroexamination, 1 microexamination;

E. Welded joints shall feature the same mechanical properties as the base material.

For all welded parts the Contractor shall:

A. Prepare detailed drawings of the assembly and of the parts to be welded including chamfers;

B. Define a pWPS, qualify the process (also drawing a WPQR) and finalize the WPS to be approved by DTT. The manufacture shall take care to design the welding paths and select the welding techniques to limit as much as possible the thermal distortions on the items;

C. Prepare a WPQR. The Welding Procedure Qualification Record (WPQR) shall comprise all variables as well as the specified ranges of qualification given in the appropriate standard;

A. Prepare a WPS. The Welding Procedure Specification (WPS) shall give details of how the welding operation is to be performed and shall contain all relevant information about the welding work.

Construction

The raw materials may be in form of plates, bars, tubes, ingots and the like (preliminary description is requested for the tender phase as a specific evaluation criteria). The Contractor remains responsible for choosing the construction technology, either forging, automatic welding, machining or similar, which best suits their manufacturing processes. However, for all processes, the Contractor shall submit a Construction Detailed Procedure and detailed Manufacturing Plan for endorsement by DTT.

The construction of the casing components will include (at least) the following steps:

A. Receipt of the raw materials (plates, ingots, tubes);
B. Incoming inspection of all material certificates;
C. Acceptance tests on raw material, sampling the needed specimens;
D. Forging of the ingots into formed parts, if required bending/rolling of plates;
E. Machining, milling, drilling cutting, of parts/assemblies;
F. Acceptance tests on forged parts and/or plates, sampling the needed specimens;
G. Welding of plates/formed parts into components ;
H. Stress relieving, where needed;
I. Performing of NDT on 100% of the welded joints (see tech. spec.);
J. Cleaning and degreasing of the constructed components, sandblasting if required.

Manufacturer shall provide solutions (to be agreed with DTT) to avoid trapped volume in blind holes; such holes must be connected to the external environment to fulfill vacuum requirements.

Machining

A. The Contractor shall organize a design review with the presence of DTT to approve the detailed design;

B. The Contractor shall verify, after receipt of each batch of raw materials, that the material certificates are duly filled and complete, and that the requirements in technical specification are met;

C. The Contractor shall provide the information related the facilities, either internal or by sub-Contractors, needed for the successful construction of the casing components, such facilities include, but are not limited to:

- Welding stations and equipment (for the welding processes chosen by the Contractor);
- Drop or press forging equipment (where forged parts will be manufactured by the Contractor);
- Suitable milling machine and/or suitable gantry milling machine;

D. The Contractor must prepare detailed drawings of the assembly and of the parts to be welded including chamfers, such drawings shall be sent to DTT for approval. Should any concern arise from these drawings DTT reserves the right to ask clarifications and/or modifications to the Contractor, anyway this does not relieve the Contractor from his responsibilities on the detailed design.

Tooling Requirements: To satisfactorily construct the casing components, the following is required:

E. Suitable lifting equipment to handle the components;

F. Suitable supports for storage and preparation of the raw materials;

G. Suitable jigs and fixtures to allow a controlled welding process and to limit distortions to a minimum;

H. Suitable tooling needed to manufacture and transport the sub-assembly of the casings.

Dimensional Tolerances

Mandatory tolerances for construction:

1. General tolerances for machined products: class mK of ISO 2768-1 and ISO 2768-2

Table 1 — Permissible deviations for linear dimensions except for broken edges
(external radii and chamfer heights, see Table 2)

Values in millimetres

Tolerance class		Permissible deviations for basic size range							
Designation	Description	0,5[a] up to 3	over 3 up to 6	over 6 up to 30	over 30 up to 120	over 120 up to 400	over 400 up to 1 000	over 1 000 up to 2 000	over 2 000 up to 4 000
f	fine	± 0,05	± 0,05	± 0,1	± 0,15	± 0,2	± 0,3	± 0,5	—
m	medium	± 0,1	± 0,1	± 0,2	± 0,3	± 0,5	± 0,8	± 1,2	± 2
c	coarse	± 0,2	± 0,3	± 0,5	± 0,8	± 1,2	± 2	± 3	± 4
v	very coarse	—	± 0,5	± 1	± 1,5	± 2,5	± 4	± 6	± 8
[a] For nominal sizes below 0,5 mm, the deviations shall be indicated adjacent to the relevant nominal size(s).									

Table 1 — General tolerances on straightness and flatness

Values in millimetres

Tolerance class	Straightness and flatness tolerances for ranges of nominal lengths					
	up to 10	over 10 up to 30	over 30 up to 100	over 100 up to 300	over 300 up to 1 000	over 1 000 up to 3 000
H	0,02	0,05	0,1	0,2	0,3	0,4
K	0,05	0,1	0,2	0,4	0,6	0,8
L	0,1	0,2	0,4	0,8	1,2	1,6

2. General tolerances for welded constructions, class AE in accordance with EN ISO 13920

Table 1 — Tolerances for linear dimensions

Tolerance class	Range of nominal sizes l in mm										
	2 to 30	Over 30 up to 120	Over 120 up to 400	Over 400 up to 1 000	Over 1 000 up to 2 000	Over 2 000 up to 4 000	Over 4 000 up to 8 000	Over 8 000 up to 12 000	Over 12 000 up to 16 000	Over 16 000 up to 20 000	Over 20 000
	Tolerances t in mm										
A	± 1	± 1	± 1	± 2	± 3	± 4	± 5	± 6	± 7	± 8	± 9
B		± 2	± 2	± 3	± 4	± 6	± 8	± 10	± 12	± 14	± 16
C		± 3	± 4	± 6	± 8	± 11	± 14	± 18	± 21	± 24	± 27
D		± 4	± 7	± 9	± 12	± 16	± 21	± 27	± 32	± 36	± 40

Table 3 — Straightness, flatness and parallelism tolerances

Tolerance class	Range of nominal sizes l in mm (relates to longer side of the surface)									
	Over 30 up to 120	Over 120 up to 400	Over 400 up to 1 000	Over 1 000 up to 2 000	Over 2 000 up to 4 000	Over 4 000 up to 8 000	Over 8 000 up to 12 000	Over 12 000 up to 16 000	Over 16 000 up to 20 000	Over 20 000
	Tolerances t in mm									
E	0,5	1	1,5	2	3	4	5	6	7	8
F	1	1,5	3	4,5	6	8	10	12	14	16
G	1,5	3	5,5	9	11	16	20	22	25	25
H	2,5	5	9	14	18	26	32	36	40	40

Handling

During the manufacture of the TF Coil Casing Components, many handling operations are required. In order to minimize the risk of damage to any components due to handling operations being carried out, it is expected that the Contractor will pay close attention to all expected handling operations prior to commencement of the operation.

With reference to and in order to meeting the requirements of the Quality Plan and Control Plan (see managing spec.), the Contractor shall submit a Handling Detailed Procedure for all of the handling operations which are expected to be carried out during the manufacturing process.

Handling Detailed Procedures, will consider:

A. avoid direct contact of non Austenitic metal equipment/items with TF Coil Casing Components and related raw materials;

B. attempt to carry out all manufacturing processes with a minimum number of intermediate handling operations;

C. design/manufacturing and install, suitable supports around the components to be handled to ensure that the components do not undergo plastic deformation;

D. ensure that all pipes are protected from mechanical damage;

E. ensure that pipes and the cooling channel ends are sealed and protected from the ingress of particulate or liquid material;

F. not weld any equipment to any component of the TF Coil Casing Components, e.g. lifting equipment;

G. ensure that there is no direct contact between painted or unpainted ferritic steel (including ferritic stainless steel) and any of the TF Coil Casing Components;

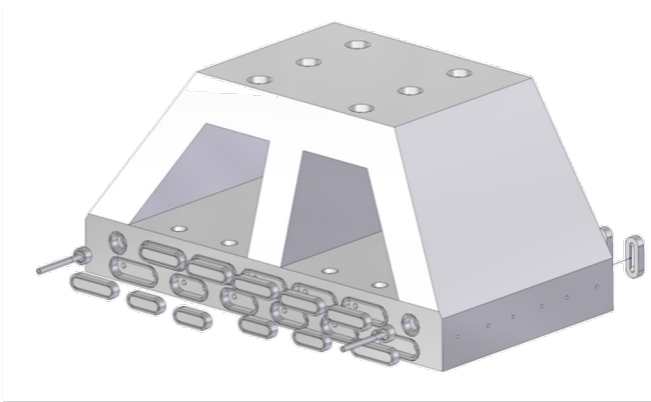
H. design and manufacture appropriate jigs and fixtures for all handling processes.

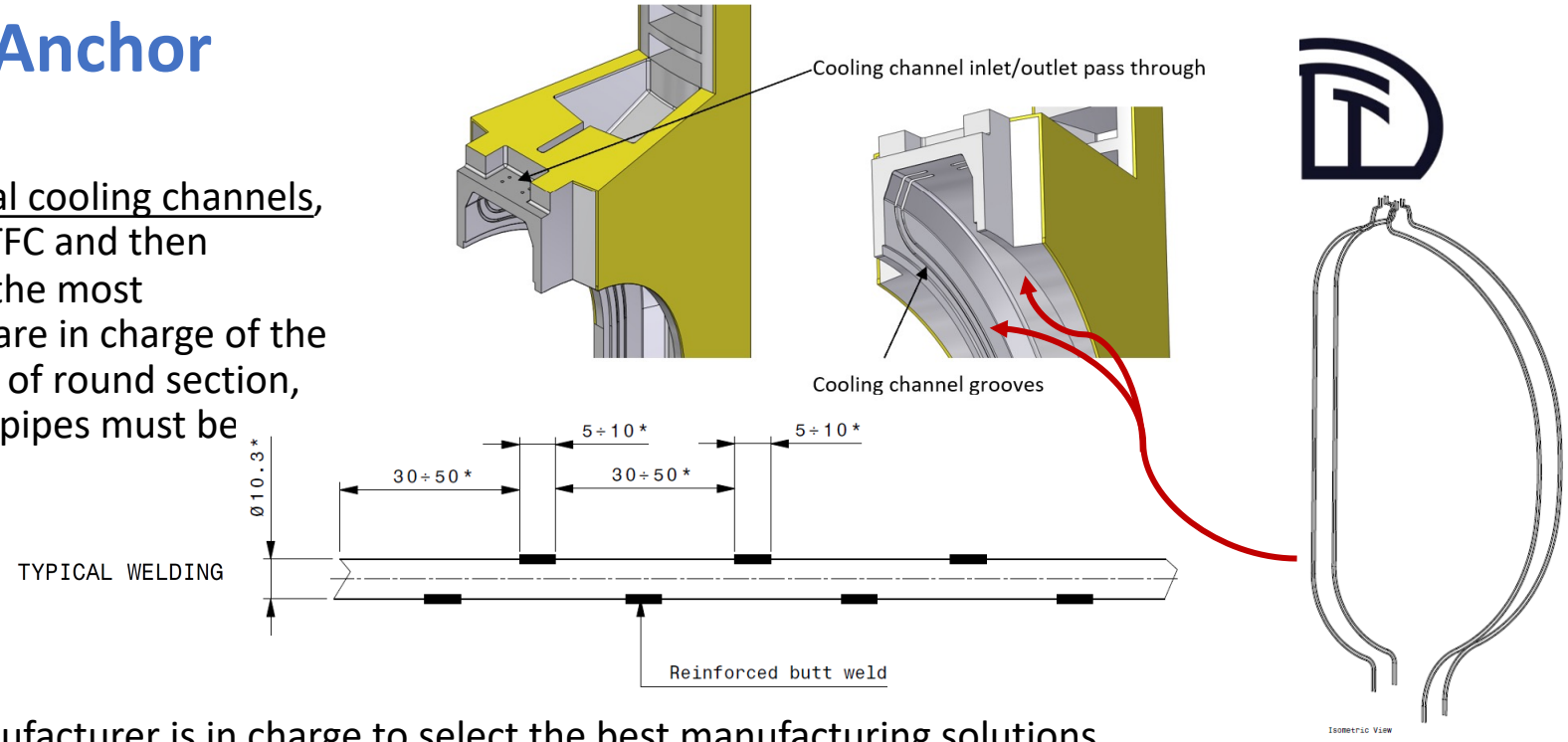
The list of Handling Detailed Procedures depends on the chosen manufacturing process(es), however, it is expected that a Handling Detailed Procedure will be submitted to DTT for all the handling procedures including:

- lifting of all casing components;
- handling/turning of all casing components;
- storage of all casing components;
- moving of the assembly during the preparation for the shipment.

Cooling Channels & Thermal Anchor

The casing components are equipped with internal cooling channels, which are first fitted in machined grooves of the TFC and then welded to the component itself. The selection of the most appropriate weld type/method and its execution are in charge of the supplier. Each channel has two termination pipes, of round section, which penetrate the component side wall, all the pipes must be tested, cleaned and sealed.





The manufacturer is in charge to select the best manufacturing solutions of the thermal anchor (requested preliminary for the tender phase as a specific evaluation criteria).

All the cooling channels must be tested, cleaned and sealed as per technical specification:

- Leak test of the cooling channel. The leak rate at 3.0 MPa must be less than 10^{-8} Pa·m^3 / s;
- Pressure test of each cooling channel using nitrogen or helium at 3.0 MPa, for one-hour time. The pressure sensor used for the test has an accuracy of ± 0.25% with a smallest interval of 0.2 bar;
- After testing, the helium pipes shall be flushed with Nitrogen (3 l/min for minimum 5 minutes) in order to completely clean and dry the pipes (procedure shall be agreed with Manufacturer);
- After Nitrogen purging, pipes shall be closed with dedicated dummy plugs and with a minimum extra length of 50mm and filled with 0.5 bar Nitrogen (delivery conditions i.e. fittings type etc. to be agreed with DTT).

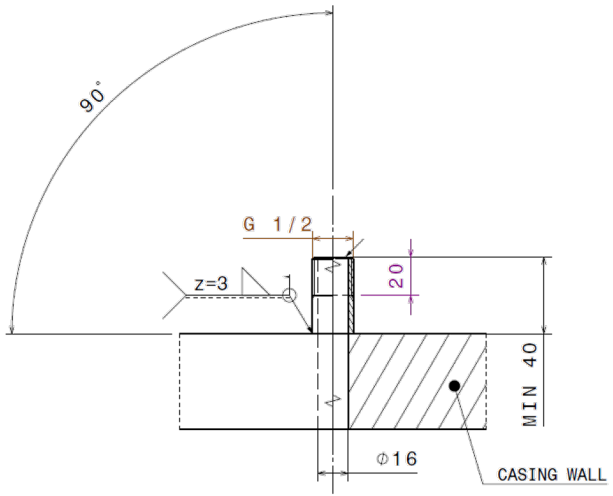
Impregnation/Pumping Port

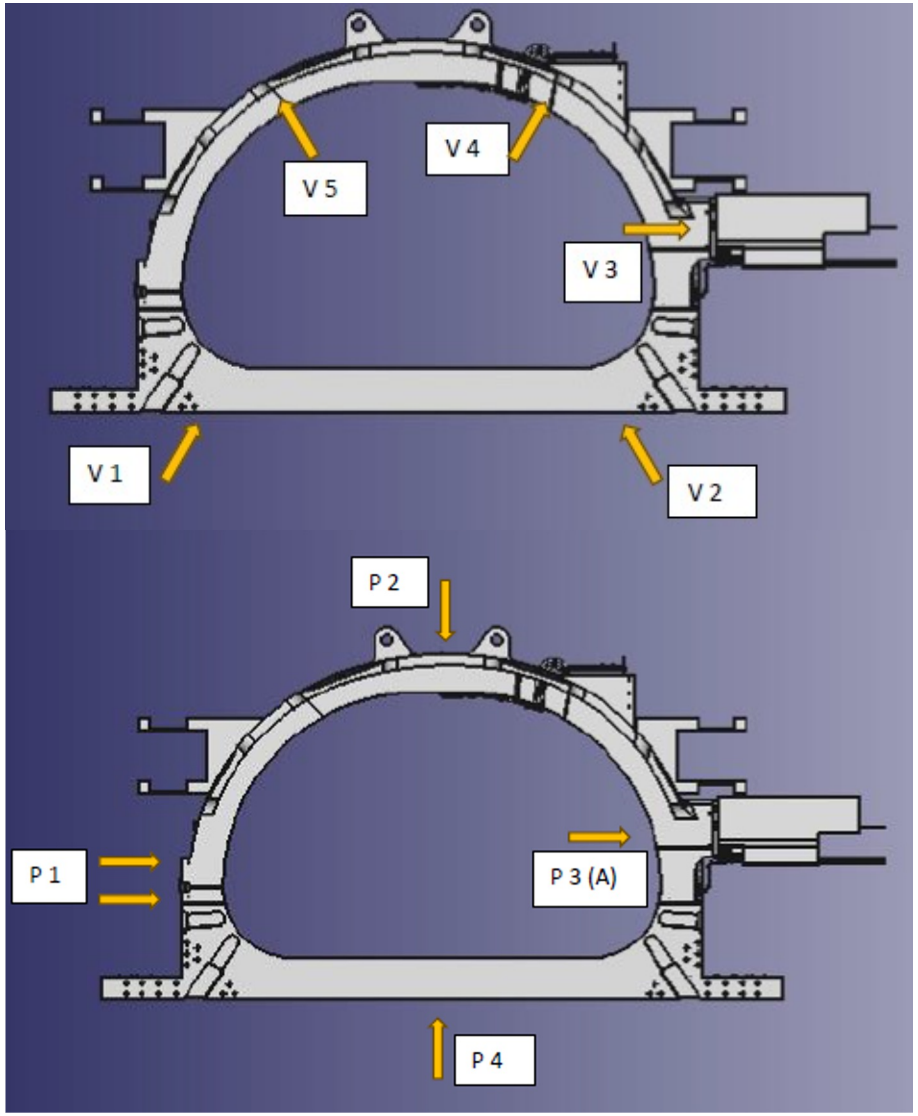
Impregnation port position, quantity and type will be agreed with TFC Integrator & DTT.

Ports details and layout has to be included in the scope of work and in dedicated drawings.

10 impregnation holes/plugs of diameter 16mm are preliminary foreseen.

- Typical ports layout is depicted in figures on the right.
- Typical geometry of impregnation port are in picture below,





Packaging

The Contractor is responsible for the design and manufacture of the packaging for the casing components.

The Contractor shall submit a Packaging Detailed document and drawing for DTT endorsement.

A. Each set of casing components must be packaged in a suitable fashion for road transport up to its specific coil manufacturing site;
B. Each set of casing components must be protected from moisture by usage of absorber bags and application of air-tight plastic wrap;
C. The casing components shall be fitted with suitably located (for all 3 directions) accelerometers to confirm that they have not undergone accelerations greater than 5 g (49 m/s^2) during transport;
D. The cooling channels inlet and outlet must be sealed and protected against impact and abrasions;
E. The packaging shall allow lifting of the components without plastic deformation or damaging;
F. The packaging shall seal & protect the casing components from: sun, rain, mist, mud and dust;
G. The lifting equipment used for transportation shall be connected solely to the packaging frame(s) and not to the TFC case items;
H. The packaging shall protect the components from the light shock generated by handling and transportation.

THANK YOU FOR YOU ATTENTION