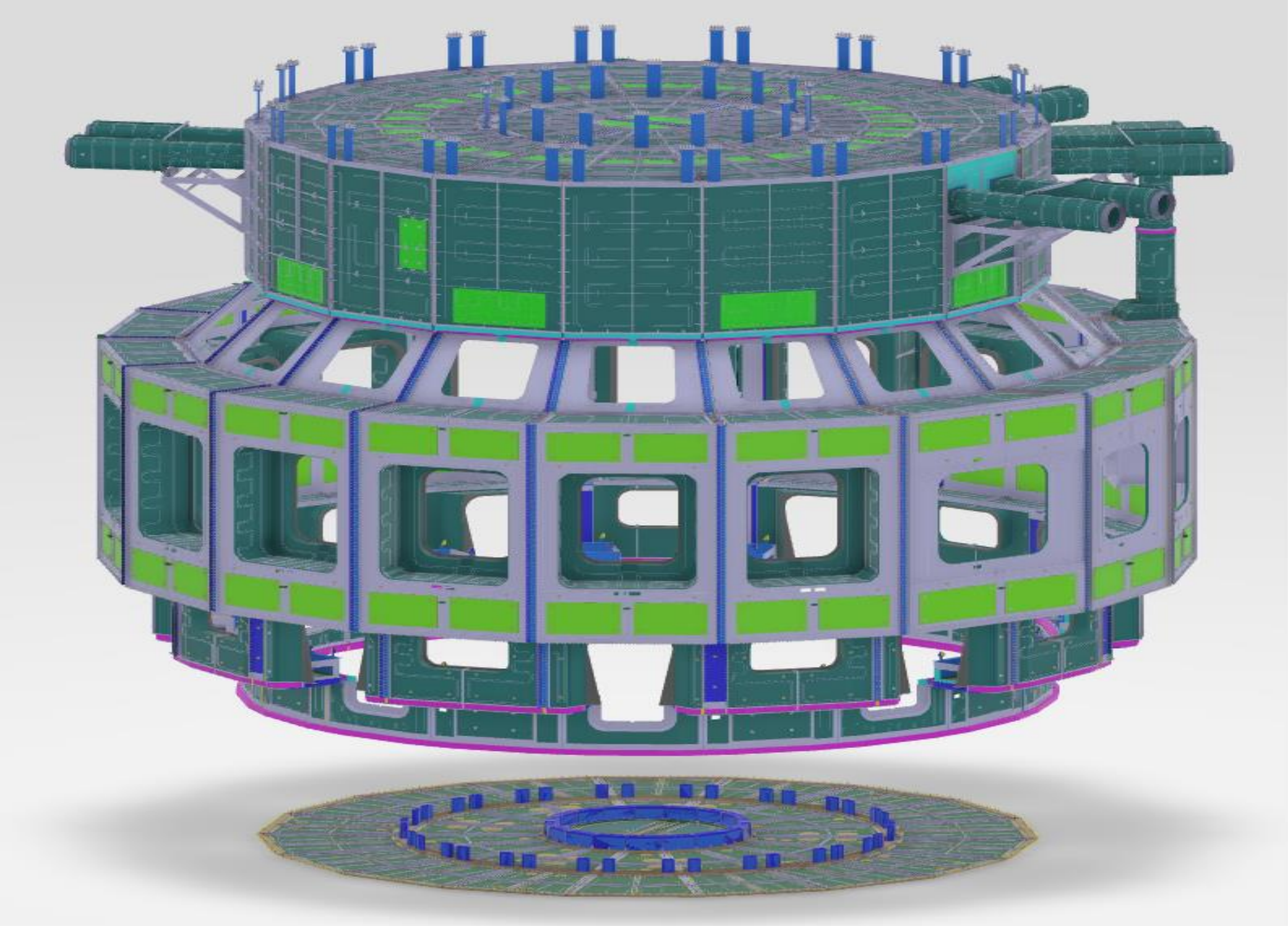

Cryostat Thermal Shield (CTS) Repair / Remanufacture Scope of Work

china eu india japan korea russia usa

Contents

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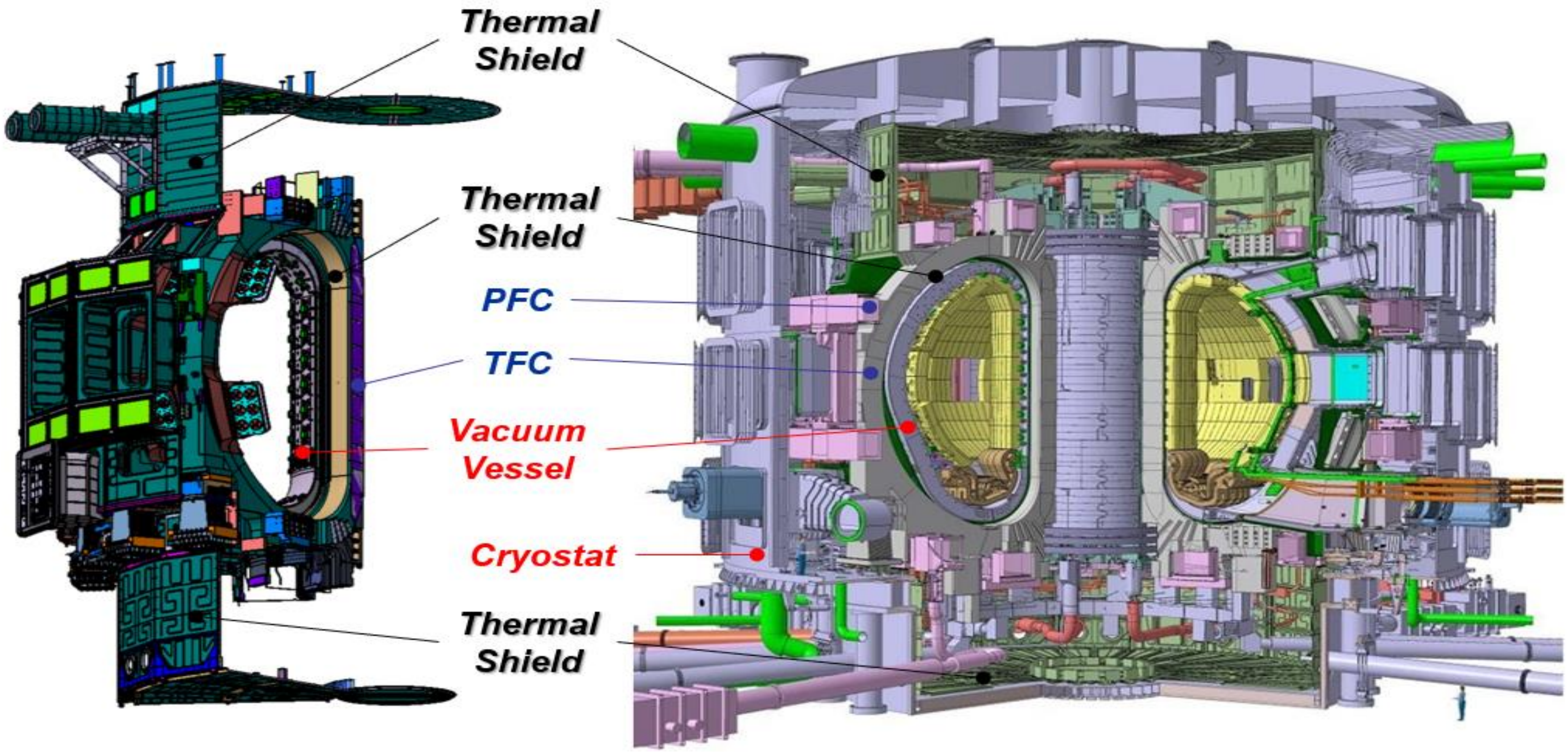
1. Cryostat Thermal Shield Components repair scope overview
2. Construction code, standard and personnel qualification
3. Cryostat Thermal Shield Components repair scope of work
4. Cryostat Thermal Shield Components technical data
5. Cryostat Thermal Shield Components remanufacture

ITER Thermal Shield

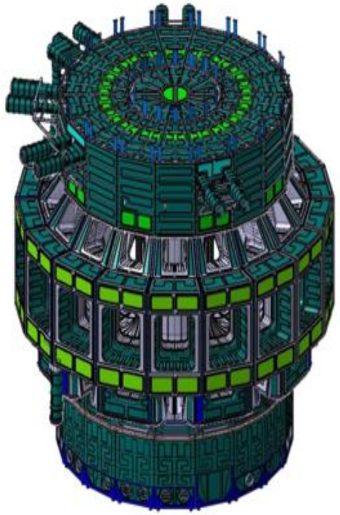


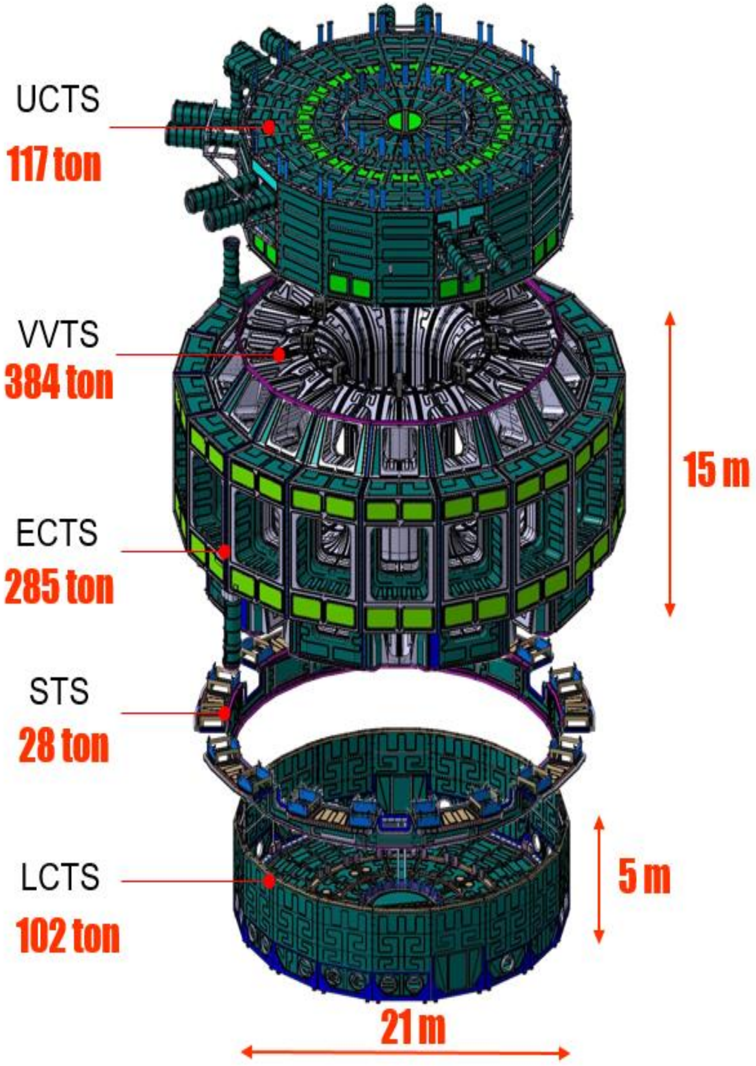
The **Thermal Shield** minimizes heat loads transferred by thermal radiation from the warm components to the superconducting magnet.

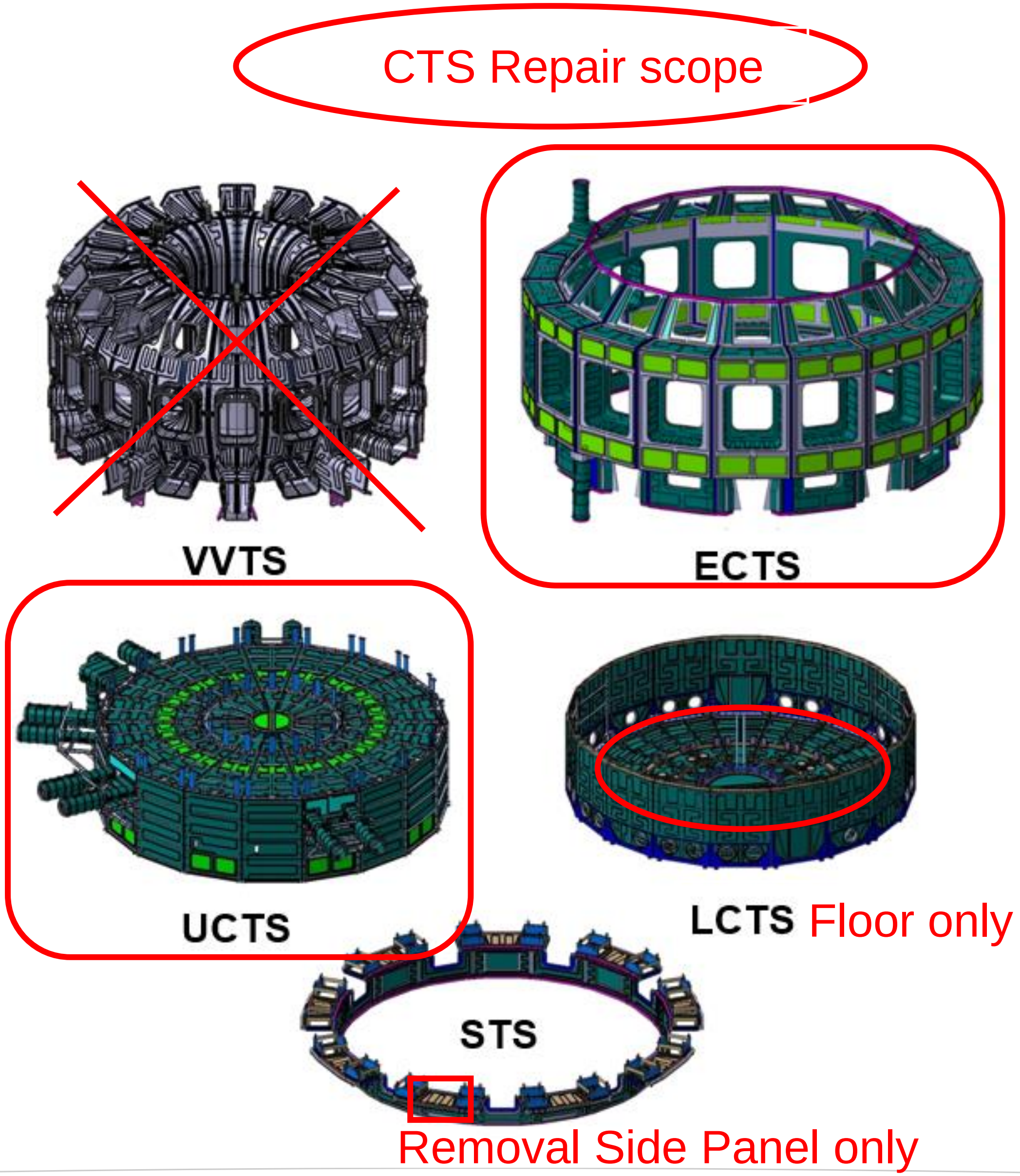
Thermal Shield (TS) Main Components

Main components;

- Upper Cryostat TS (UCTS)
- Equatorial TS (ETS)
  - Vacuum Vessel TS (VVTS)
  - Equatorial Cryostat TS (ECTS)
- Support TS (STS)
- Lower Cryostat TS (LCTS)

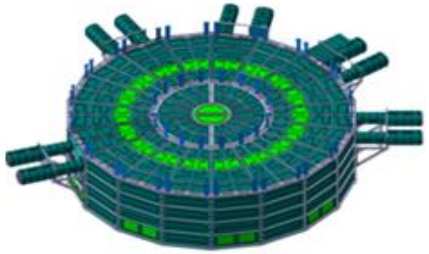


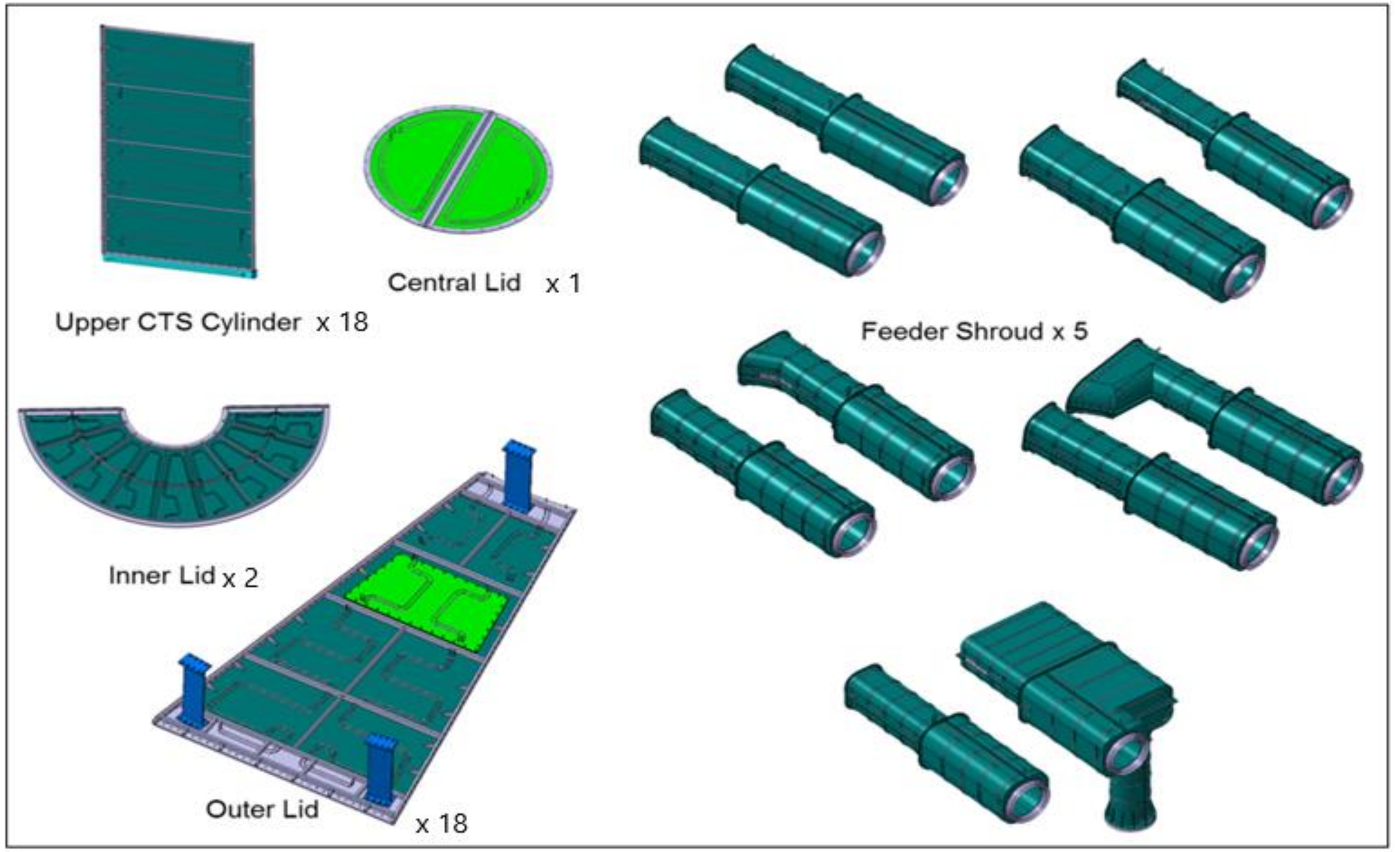




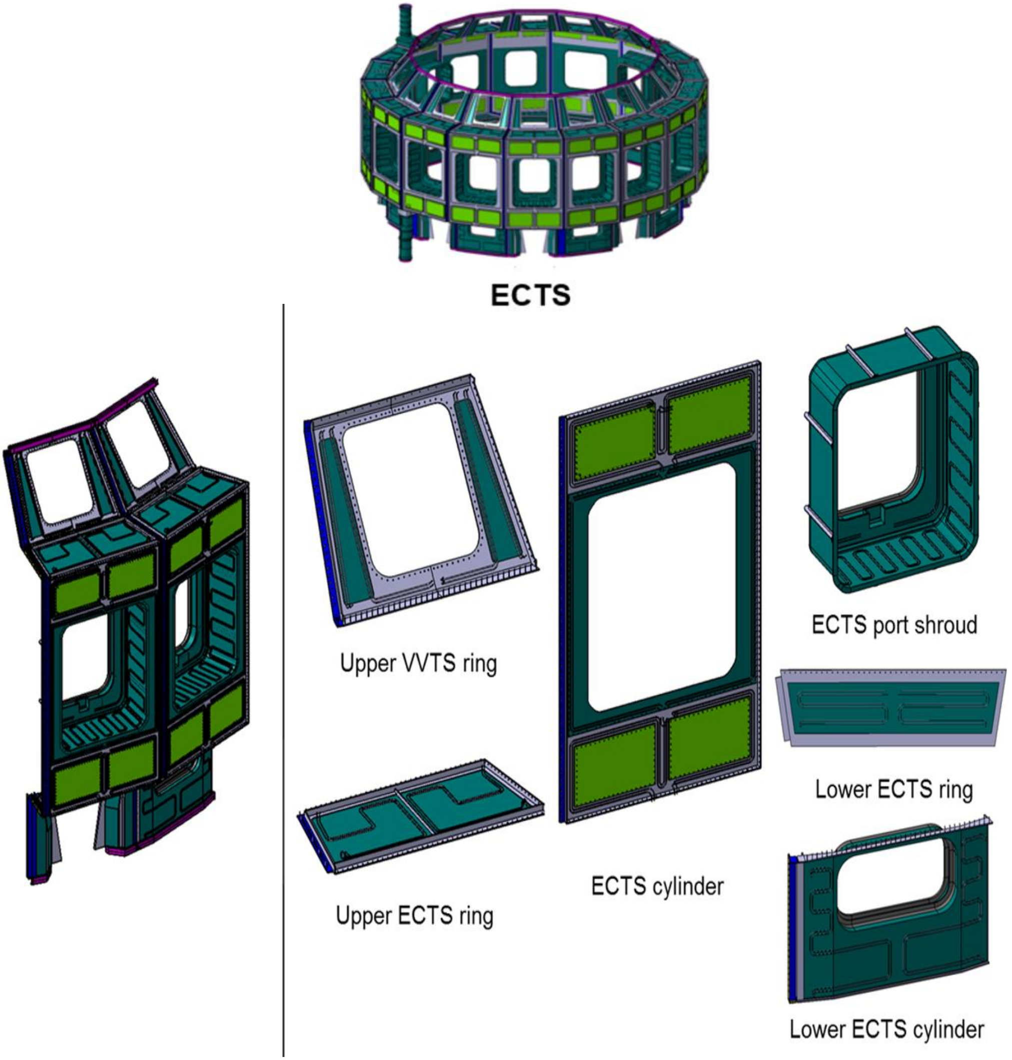
UCTS Overview

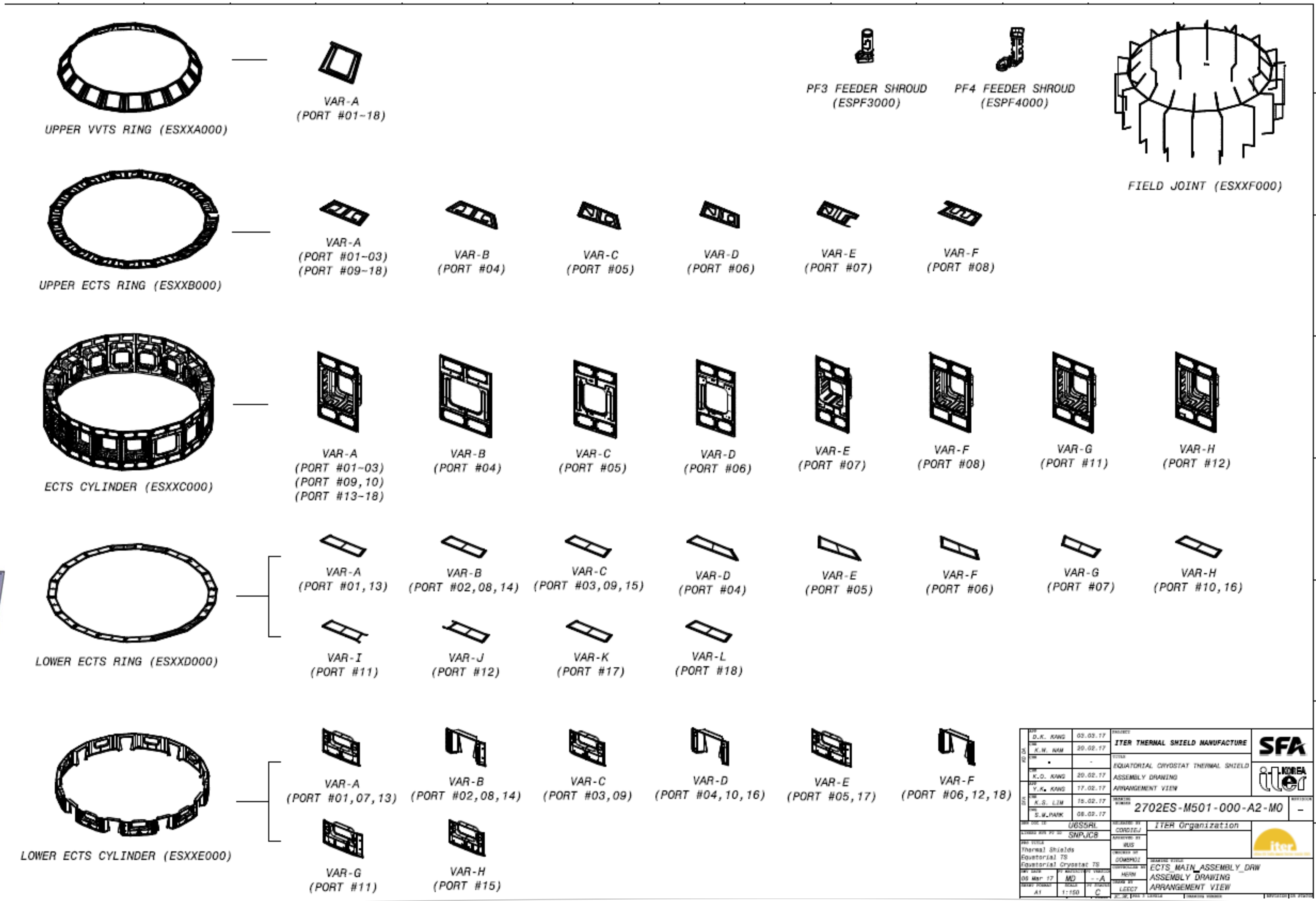
- **UCTS segmentation**



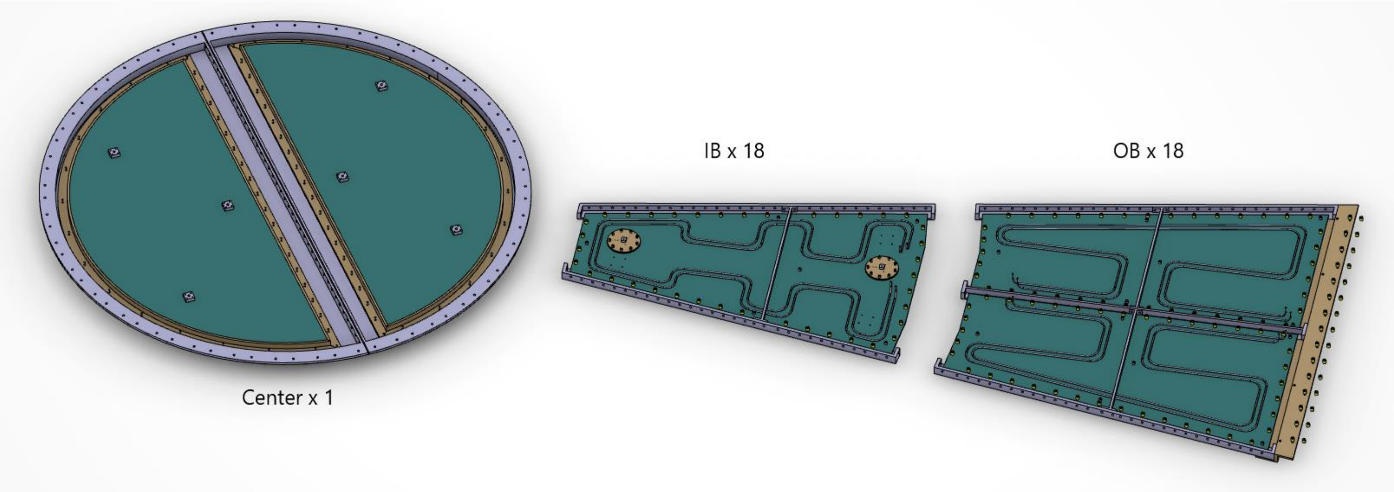


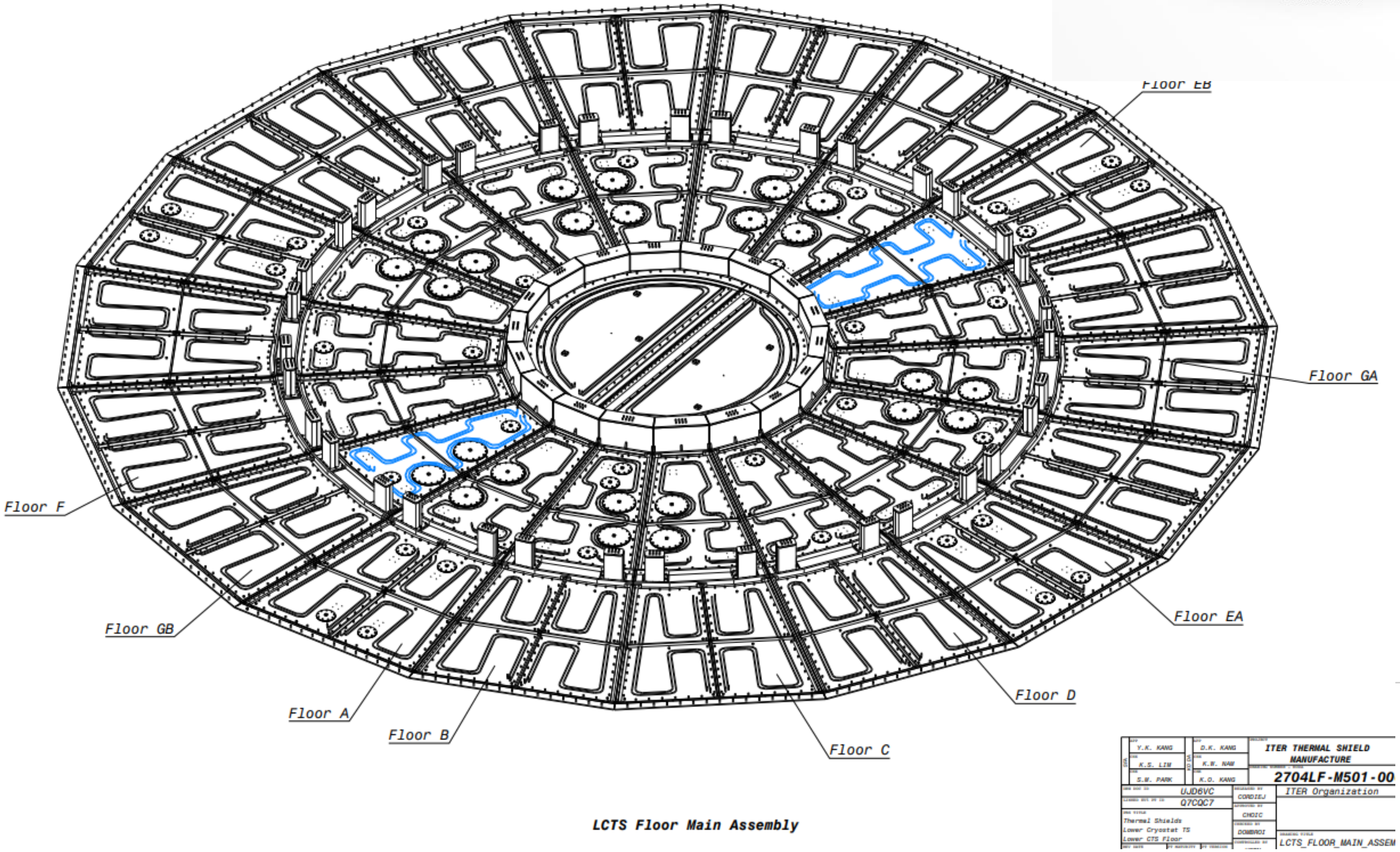
ECTS Overview



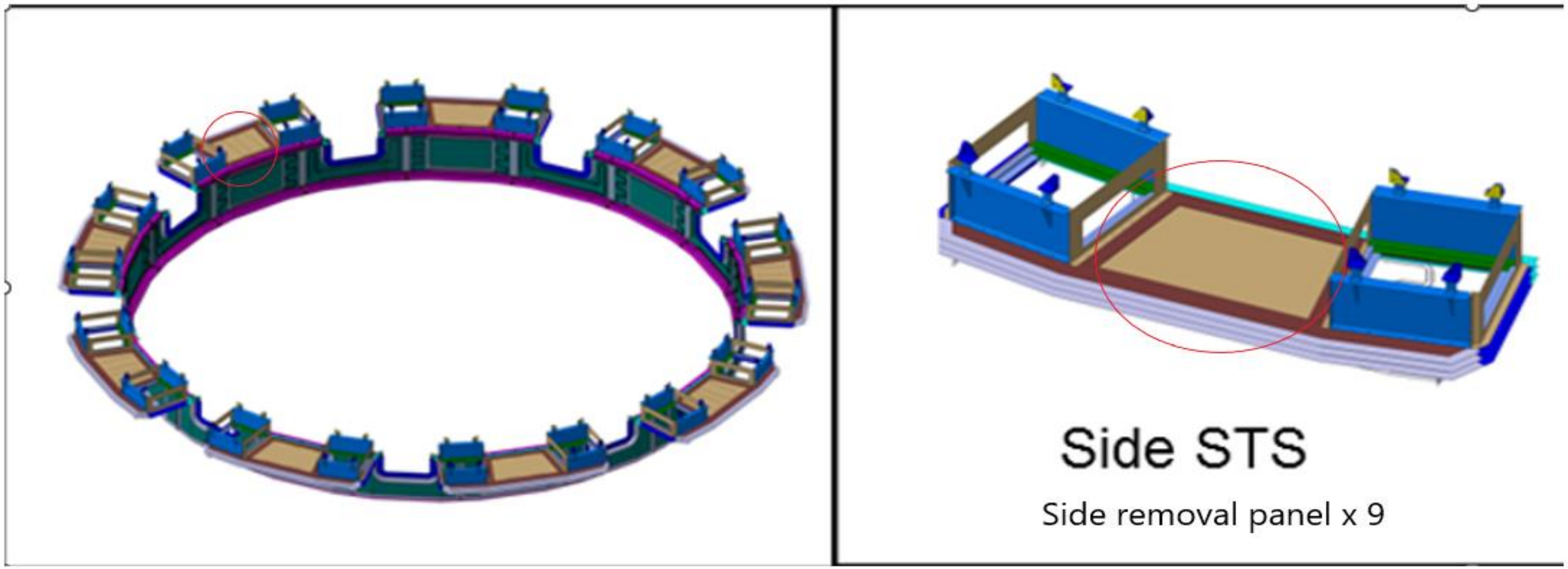


LCTS Floor Overview





STS Side Panel Overview



CTS Material

	Original	Repair
A. Panel Material	304LN	304LN
B. Panel Thickness	10mm, 20 mm	Partially 8mm, 18 mm (cooling pipe removed area)
C. Panel Surface	Silver coated (Min. 5 μm)	Silver coating removal
D. Pipe Material	TP304L	1.4435
E. Pipe to Pipe Joint		Orbital welding
F. Pipe to panel Welding Filler Wire	ER308L	ER317L Mn Modified* Or Inconel 625**
G. Stud bolts	SS304	SS316

ER317L Mn Modified* : less ferrite contents, good fracture toughness
Inconel625 :** good resistance to the SCC but required strong qualification for use at the cryogenic temperature.

CTS Quantity

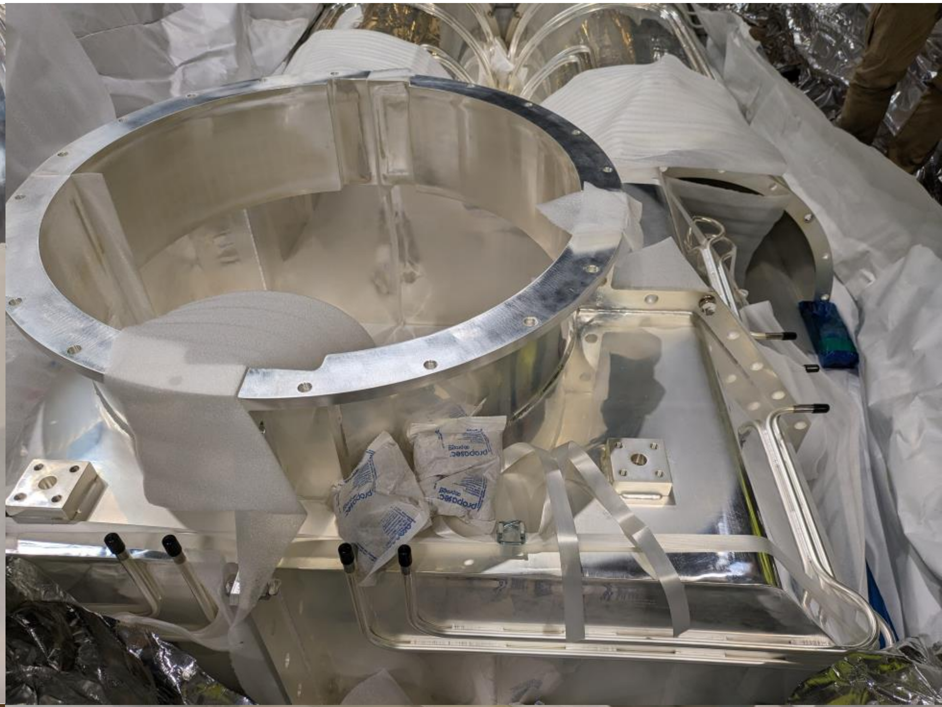
	Pipe length (m)	Bends (no.)	Panels (no.)	Surface Machining Area (m2)	Surface Polishing Area (m2)	Stud bolts M16x35L~90L) Replacement (no.)
LCTS Floor	986	1420	58	50	420	Type A = 450
Side STS	153	198	9	10	80	Type A = 950
ECTS	4962	6364	144	250	2200	Type A = 7000 Type B = 7500
UCTS	2817	4586	86	140	1320	Type A = 950
Total	8918	12568	297	450	4020	Type A = 9350 Type B = 7500

- Components are QC-1 classified and VQC-2A/2B
- No PIC nor specific PIA
- PED: Sound Engineering Practice (SEP) pipes.
- Metrology Classification - 1

Pipe size DN8 (OD13.72 x 2.24mm) 1.4435
Standard Bend Radius R=100mm
Panels size, weight and configuration are different

CTS Pictures as example





Contents

Applicable Codes and Standards

ASME Section VIII Division 2 for design and manufacturing of TS main components

ASME Section IX for welder or welding operator and welding procedure qualifications

ASME B31.3, Category M for cooling pipe

ASME Section V, VIII and B31.3 for non-destructive examination

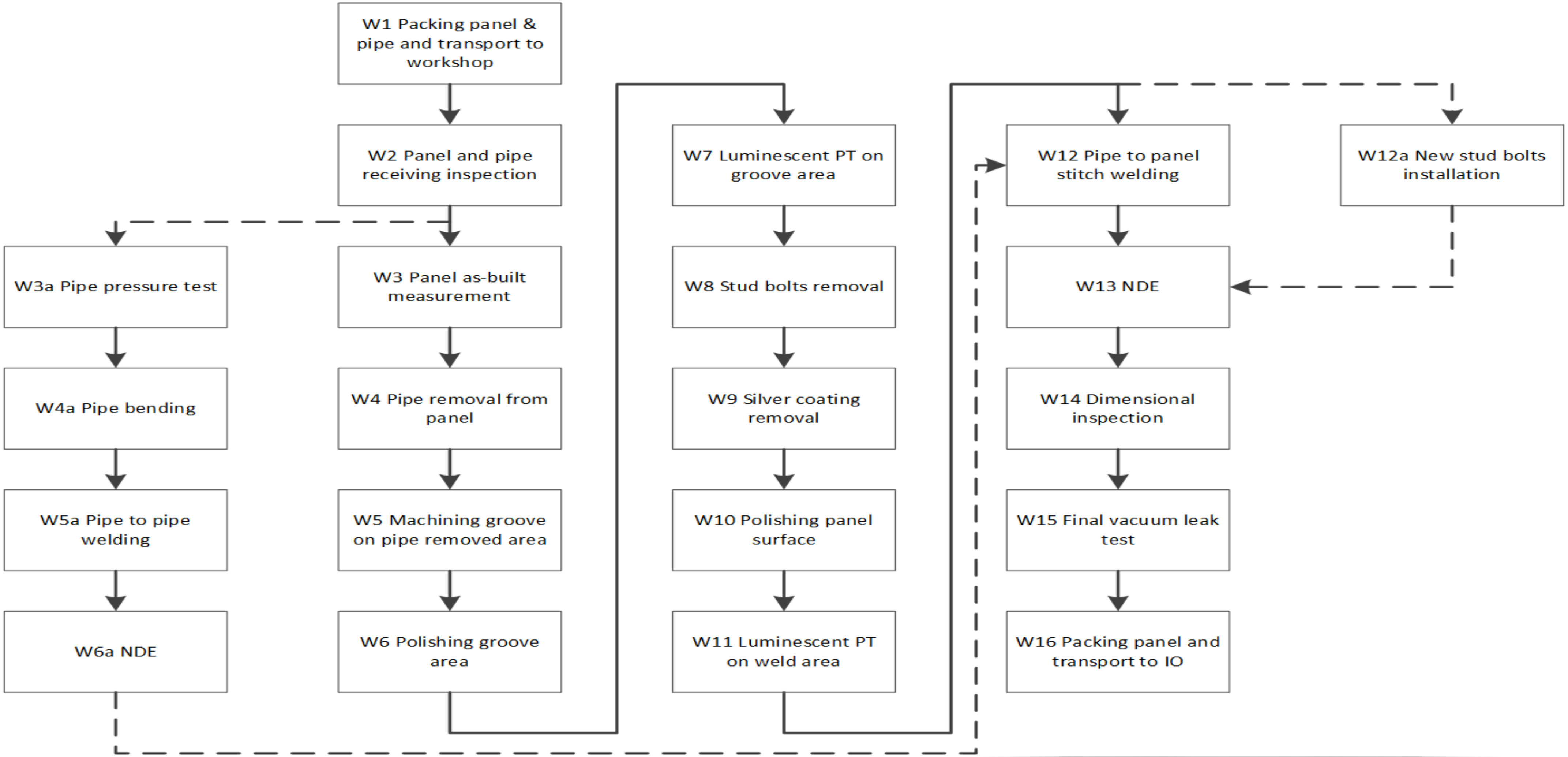
ANSI/ASNT-CP-189 for qualification and certification of non-destructive testing personnel

ASME B31.3 and PED/ESP for pressure test of piping

Contents

CTS repair sequence of work

Note: Dot line is for parallel activity



CTS repair sequence of work – W1 Packing panel & pipe and transport to workshop

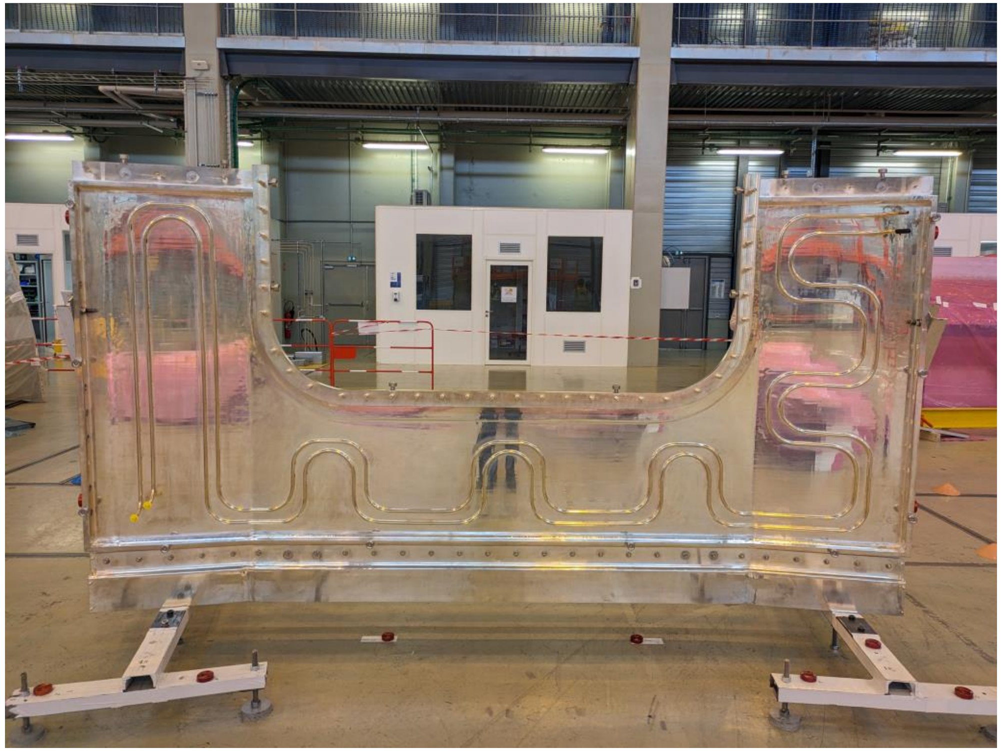
- Transport 70 wood boxes from IO warehouse (Located in Port saint-Louis-du-Rhône and IO worksite) to Contractor's workshop.
- Around 15 wooden boxes were already opened. Contractor to provide the new packages for transportation. Shock and tilt watches to be attached to the packages.
- The largest box overall dimension is 7800x3000x5000mm (LxWxH) and the weight is 40000Kg.
- Package storage condition – Temperature control (5 – 60 degree C at all time) before open package.
- Panel storage condition after package opened – Temperature control 5 °C to 28 °C. Humidity control 10% - 70%
- Contractor to provide all the machine and tools for the CTS repair works.

CTS repair sequence of work – W2 Panel and pipe receiving inspection

- Workshop condition – Temperature control 5 °C to 28 °C. Humidity control 10% - 70%.
- Workshop general area cleanliness shall meet IO requirement for Vacuum classification VQC-2 component.
- Manufacture the supporting frame for panel inspection.
- Perform visual inspection on panel and pipe surface. The visual inspection of the pipe outside shall also be performed with the naked eye or using a magnifying glass with a maximum magnification of 6.
- Perform endoscope inspection on the inner surface of the pipe. The inspection shall be recorded as digital movie data or photos with an indication of the endoscope position.
- The cooling pipe shall be buffed and the outer surface roughness shall be no more than Ra 0.8 μm. The pipe shall not have scratch, dent or pinhole.
- Clean the pipe as required in order to meet the acceptance criteria.

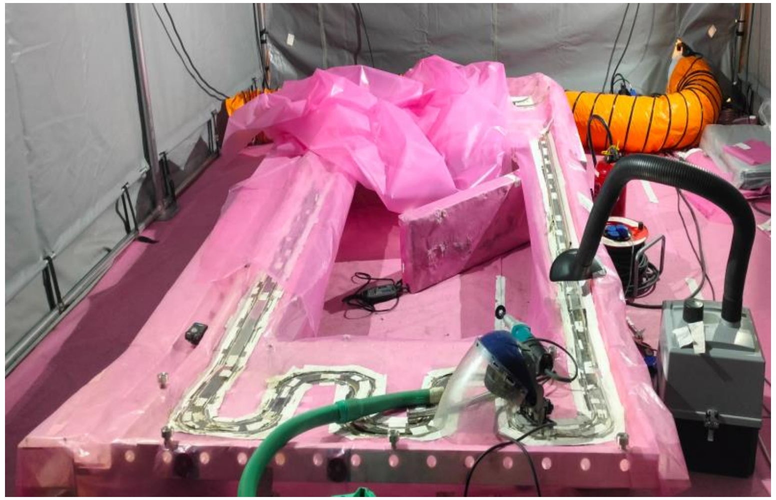
CTS repair sequence of work – W3 Panel as-built measurement

- Design and manufacture the supporting tool to fix the panel in free and unrestrained condition.
- Tack weld the target nests on the panels for metrology.
- Perform dimensional inspections on each panel with 3D dimensional survey method.
- This measurement will be compared with data after repair.



CTS repair sequence of work – W4 Pipe removal from panel

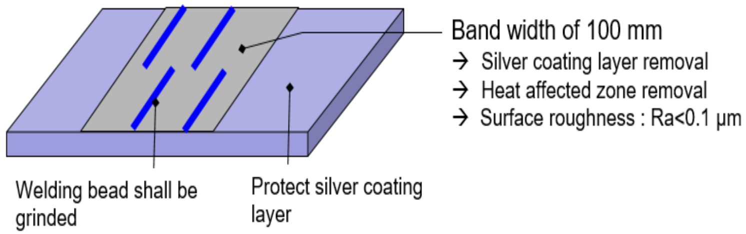
- Fix panel to the repair jig/fixture.
- Protection of panel adjacent area to avoid contamination during pipe removal.
- Remove the pipe from the panel. Machining shall be privileged if deemed reliable option.
- Remove weld bead.

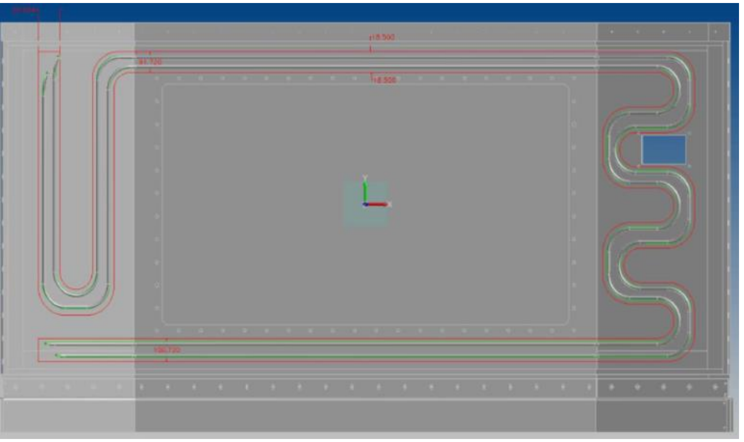


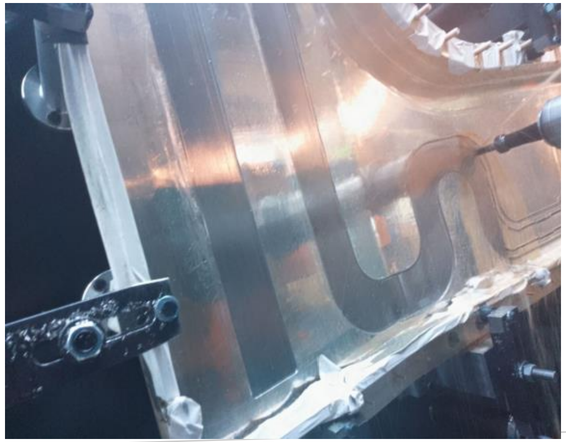
CTS repair sequence of work – W5 Machining groove on pipe removed area

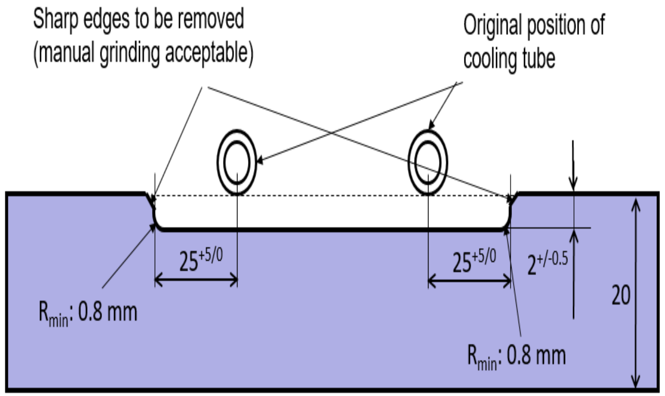
- A dedicated tool to be realized to hold and clamp the panel for the machining operation.
- 3D machining shall be implemented with 3D survey for CNC machine programming for each panel to respect the deformation of the panel.
- The surface on pipe removed area should be machined with dimension100 mm in with width and 2.0 mm +/- 0.5 mm in depth.
- Sharp edge shall be removed/rounded as described in Requirements.
- Thickness of panel shall be measured and recorded before and after machining.
- Dimensional control before machining and after final machining operation for each panel.

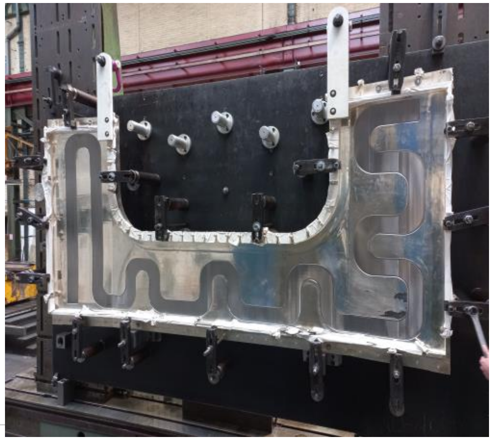
	Original	Repair
A. Panel Thickness	10mm or 20 mm	Partially 8mm or 18 mm (cooling tube removed area)
B. Surface	Silver coated	Partially removed (cooling tube removed area)











CTS repair sequence of work – W6 Polishing groove area

- Polishing the surface of removed area to ensure the surface roughness Ra < 0.1 μm and mirror glass Gloss Value ≥ 70%.

CTS repair sequence of work – W7 Luminescent PT on groove area

- Perform Luminescent PT on the machined surface to check presence of Stress Corrosion Cracking.
- Grinding if SCC is found.
- Protection of the polished groove to avoid any damage of the polished area during the next activities.

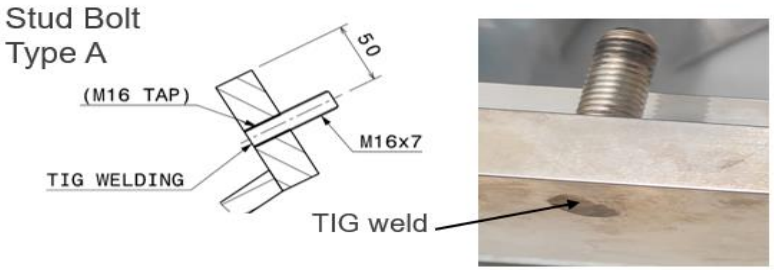
CTS repair sequence of work – W8 Stud bolts removal

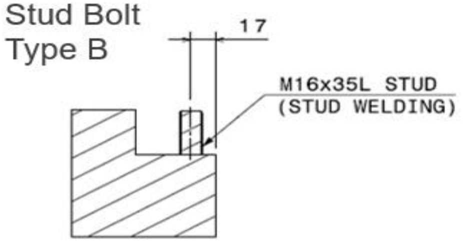
Replace all existing type B stud bolt by type A.

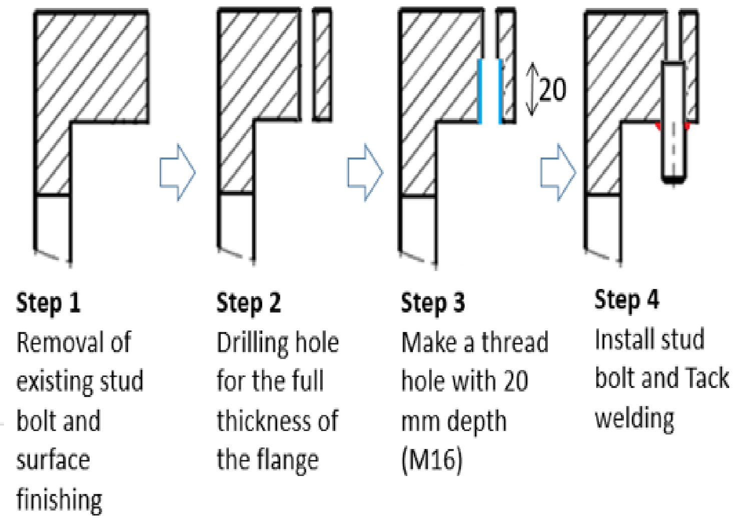
- Remove all existing type B stud bolt and clean the surface.
- Drill holes and tap thread holes on the flange.
- Clean an protect the thread holes before new type A stud bolt installation.

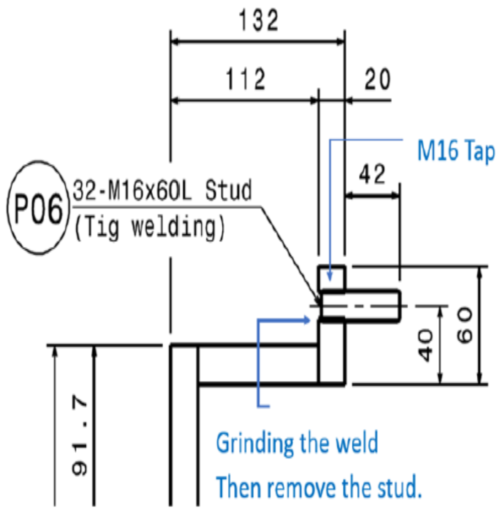
Replace all existing type A stud bolt by new type A bolt.

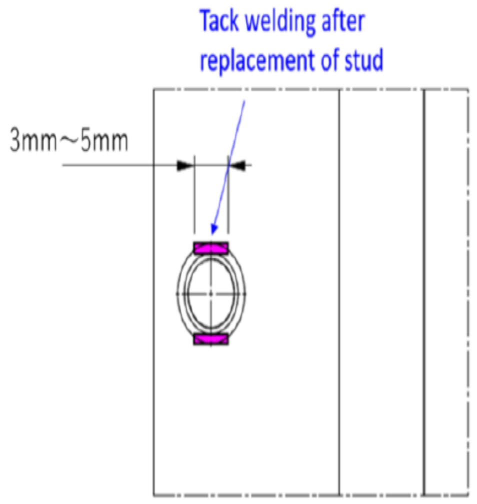
- Remove all existing type A stud bolt by mechanically removing the weld performed on the back side of the bolts.
- Re-tap the thread holes.
- Clean the threaded holes.
- Visual inspection of the threaded hole.
- Protect the threaded hole before new type A stud bolt installation.









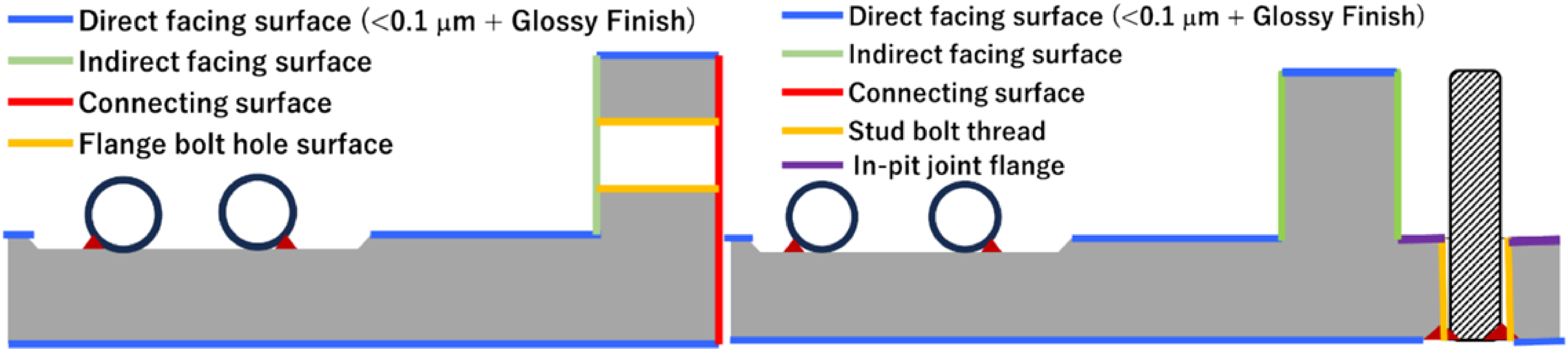


CTS repair sequence of work – W9 Silver coating removal

- Remove silver coating layer (Min. 5 µm up to 10 µm), chlorine, and/or cavities under the silver coating layer on all the panel surface (Both sides of each panel).
- Only mechanical removal is permitted. Chemical removal is not allowed.
- Develop and qualify the method to ensure the silver coating completely removed in all the surface. Justification showing that silver coating will be completed removed shall be part of the qualification process. No Chlorine or cavities remain on panel surface including the threaded holes where the stud bolts were removed in W8. No contamination or damage on stainless steel surface during repair process.
- Perform visual inspection to check any chlorine or cavities on full panel surface including the threaded holes after cleaning. If chlorine or cavities were found on base material, all of them should be removed. If cavities are deep and difficult to remove only by buffing method, then grinding can be applied locally. However, that area shall be smoothened after grinding.
- After removal of all silver layer, chlorine or cavities, the surface shall be tested to ensure no residue of silver coating and/or chlorine.
- All panels come with 3 identifications engraved: Serial#, PNI# and FR# (TAG #). If the original marking is removed during silver coating removal, Contractor shall mark the same identifications corresponding to the individual panel following IO requirement.

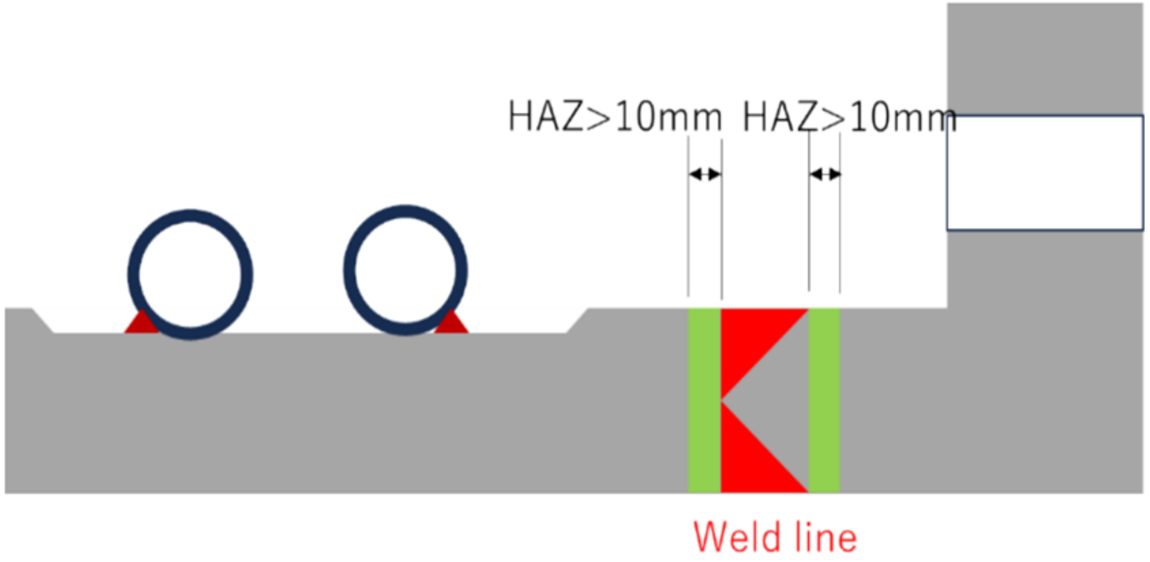
CTS repair sequence of work – W10 Polishing panel surface

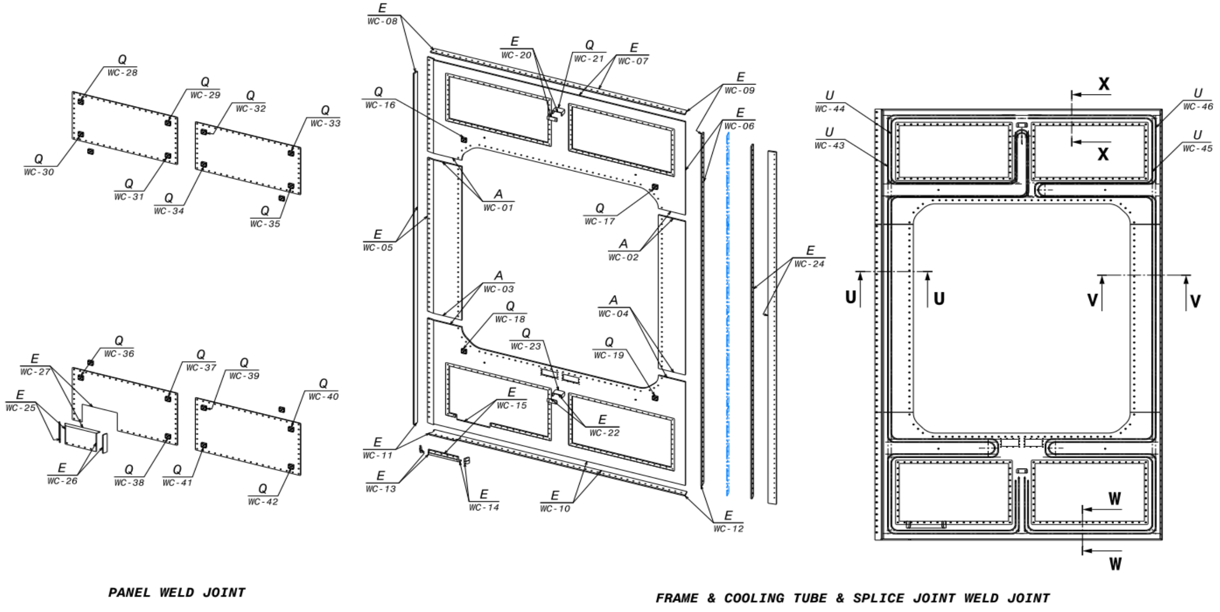
- Polishing the full panel surface with a mechanical method to achieve the requirement in below.
- Surface roughness requirement. Each definition of surface should be referred to below Figure Definition of panel surface for surface roughness requirements.
- Surface facing to adjacent components directly: Ra < 0.1 μm and mirror glass Gloss Value ≥ 70%.
- Surface facing to adjacent components indirectly: Silver removal and polishing
- Connecting surface: Only polishing.
- Inside flange bolt hole: Only silver coat removal.
- Inner side of lateral flange (in-pit joint flange): Only silver coat removal.



CTS repair sequence of work – W11 Luminescent PT on weld area

- Perform Luminescent PT, to check presence of Stress Corrosion Cracking, on the joint to panel welding area including HAZ (more than 10.0 mm from fusion lines) according to ASME BPVC Section V Article 6. Refer below Flange to Panel welding area.
- If indications are detected, all of them shall be removed by mechanical method such as grinding (Maximum removal depth is 2.0 mm from surface). After removal of indications, luminescent penetration inspection shall be applied again to confirm no indications.
- If indication is found by PT after 2.0 mm depth removal, remove additional 0.50 mm depth maximum and apply PT to confirm SCC possibility.



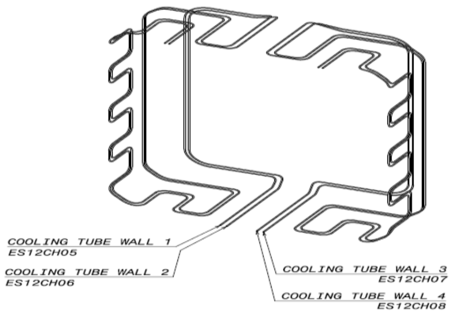


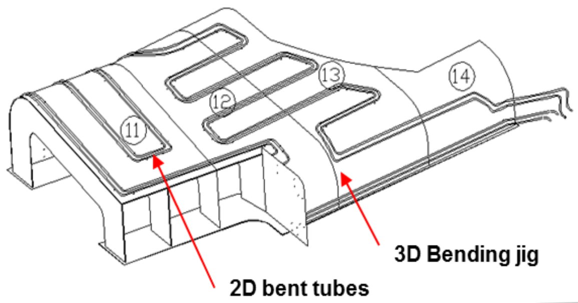
CTS repair sequence of work – W3a Pipe pressure test

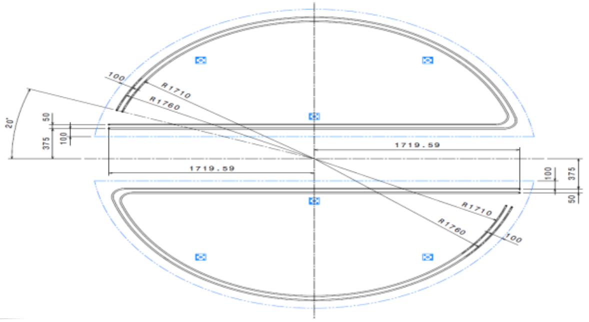
- Perform pressure test (5 MPa) for all the pipes purchased by IO after receiving visual inspection.
- Test fluid with Nitrogen gas.
- No actual drop of initial charging pressure after 30 minutes of holding time. Pressure drop measured by the pressure gauge shall not be greater than the gauge sensitivity. Actual pressure drop greater than the gauge sensitivity shall be reported as a major non-conformity.
- The Contractor is responsible for the supply of all testing equipment, vacuum components, all testing jigs, flange closure plates (welded or otherwise) and fittings to allow an acceptance helium leak test to be carried out.

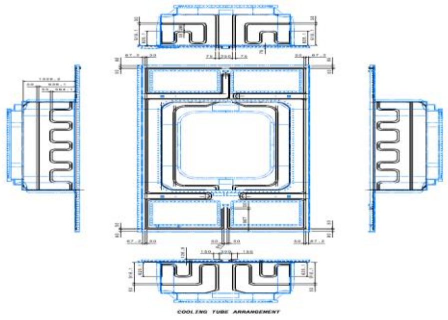
CTS repair sequence of work – W4a Pipe bending

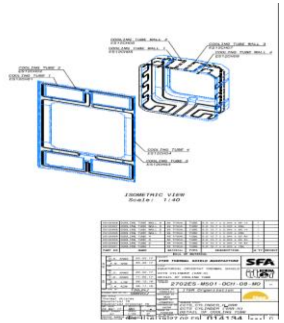
- Perform Pipe 2D bending and 3D bending according to the drawings. Refer below figure for 2D and 3D concept.
- Standard bend radius is R=100mm. But many different bend radius (e.g. R=50mm, R=1800mm etc.) to be performed according to the drawings.
- Pipe bending shall be performed by a pipe bending tool or machine to prevent mechanical damage to the pipe material.
- The wall thinning ratio of pipe shall not exceed 10% of nominal wall thickness.
- The flattening ratio of the pipe shall not exceed 8% of the nominal outside diameter.
- Perform visual inspection after pipe bending. Endoscope shall be carried out to check the inner surface of the pipe. The inspection shall be recorded as digital movie data or photos with an indication of the endoscope position. The visual inspection of the pipe outside shall also be performed with the naked eye or using a magnifying glass with a maximum magnification of 6. No scratch, dent, or deformation of the pipe. No damage or corrosion caused by the contact with bending tools. debris, grease, oil, oxides, and other materials liable to impair the next manufacturing process
- Perform pressure test (3 MPa) after pipe bending with Nitrogen gas.
- Perform Vacuum Leak Test. The bent pipe is inserted into the plastic bag. The pipe is evacuated by a vacuum pump in the leak detector. Then the plastic bag is filled with helium gas and the pipe is leak-tested. The vacuum leak test is performed at room temperature. The leak rate is continuously recorded using the manufacturer’s program. A standard leak shall be fitted to the tube under test and the leak detection system calibration be performed utilizing the standard leak.





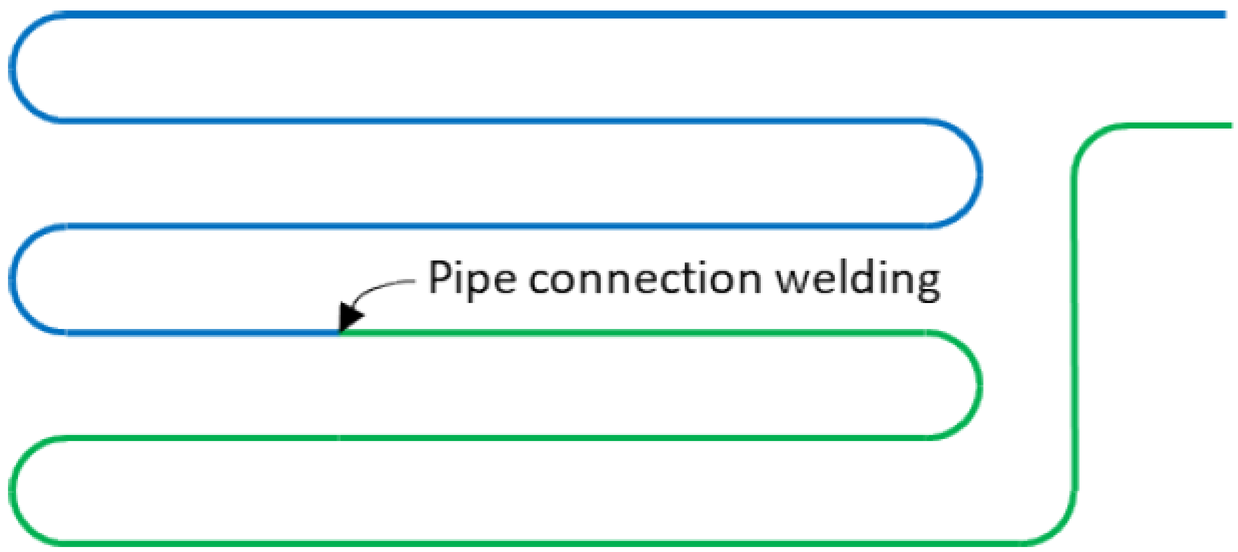






CTS repair sequence of work – W5a Pipe to pipe welding

- Perform pipe to pipe welding for the long cooling circuit. Pipe length provided by IO is around 6m.
- Only orbital welding is allowed for cooling pipe connection welding.
- After pipe top pipe welding, a visual inspection inside the pipe with an endoscope shall be carried out to check the inner surface of the pipe to pipe weld. The inspection shall be recorded as digital movie data or photos with an indication of the endoscope position.
- The visual inspection of the pipe outside shall also be performed with the naked eye or using a magnifying glass with a maximum magnification of 6.
- PNI and Piece No. of material or items shall be marked permanently with dot pin marker The piece number shall be visible after assembly and shall not affect the interpretation of the results of the non-destructive examination.



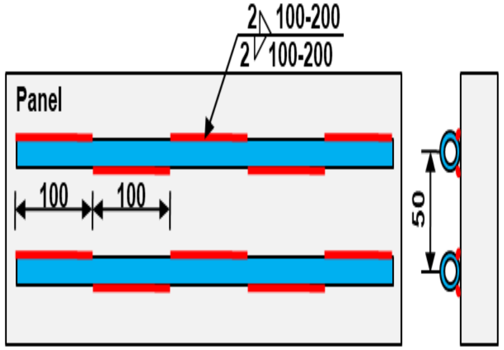
CTS repair sequence of work – W6a NDE

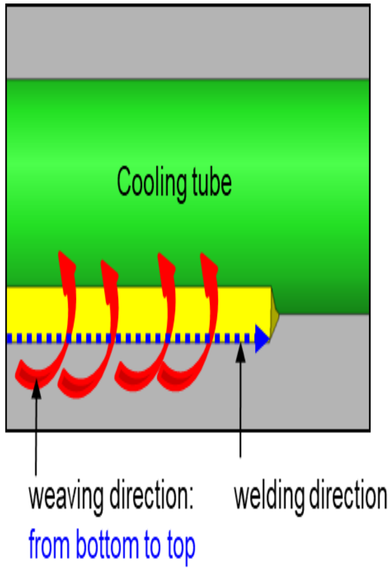
NDE after pipe to pipe welding

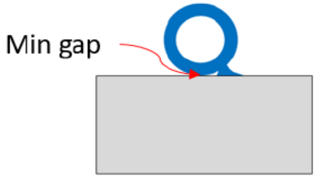
- All cooling pipe connection welds shall be inspected/examined prior to pipe to panel welding.
- Pipe to pipe is a full penetration weld joint and is therefore subject to the 100% volumetric examination like **Radiographic test** and other NDE requirements like **Cold-Shock test**, **Pressure test** & **He Leak test**.
- Pipe-to-pipe weld joints shall be subject to a cold shock test with liquid nitrogen prior to performing the volumetric examination. *Method:* The weld joints are locally immersed in a liquid nitrogen container. After the joint reaches a steady state in the container, it is warmed up to room temperature by exposing it to ambient air. Then the volumetric examination of the welded joint shall be performed according to the NDE inspection procedures.
- Perform pressure test (3 MPa) with Nitrogen gas after pipe to pipe welding.
- Perform Helium Leak Test on all welds at room temperature. The leak rate is continuously recorded using the manufacturer's program. The measured leak rate shall be lower than the allowable leak rate 1E-10 Pa-m^3/s.

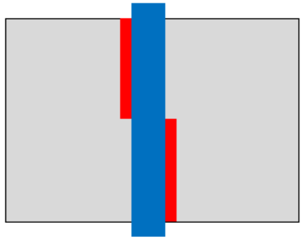
CTS repair sequence of work – W12 Pipe to panel stitch welding

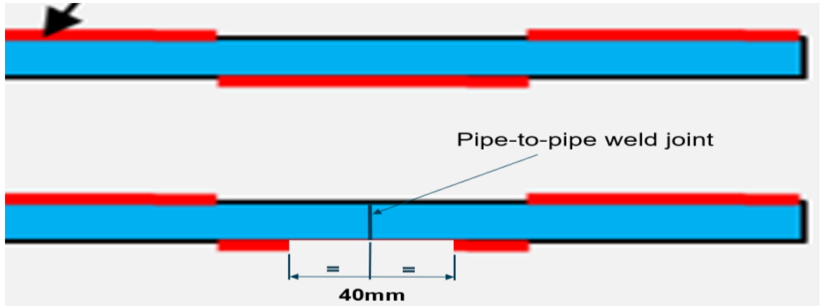
- Qualify and procure the filler material (ER317L Mn Modified Or Inconel 625) according to requirement.
- Pipe stitch welding joint has to qualify for WPS, WPQR & welder qualification according to ASME Section IX. In addition, stitch welding qualification is required for the gap between penal to pipe.
- Pipe to panel stitch welding shall be performed using an equivalent sized fillet weld per ASME IX.
- Position the pipe on the machined groove area.
- Tack welding the pipe on the panel.
- Stitch welding the pipe on the panel.
- Stitch welding should not overlap on pipe-to-pipe weld joint, it shall 20mm far from the joint on both side.
- Weld throat thickness is minimum 2mm, maximum 4mm and has an even thickness (+/-12.5 %).
- Weld penetration to the pipe shall be max 1 mm.
- Piece No. stamping by a handy dot pin marker on the plate surface where the cooling pipes are welded.

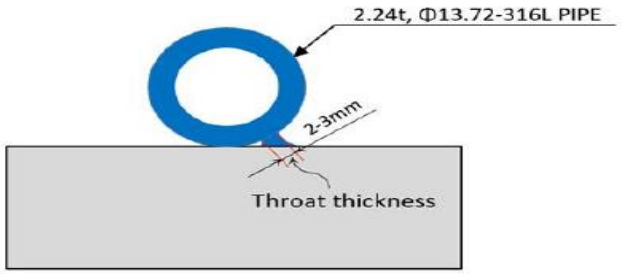


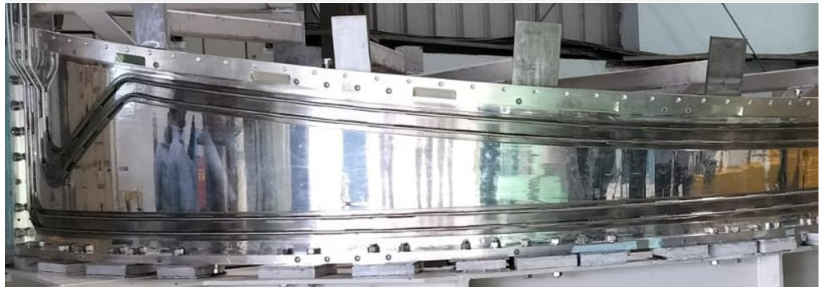












CTS repair sequence of work – W12a New stud bolts installation

- New stud bolts (provided by IO) will be screwed into the threaded holes.
- The extremity of the bolts (that will be tack welded later) shall remain at a target distance between 0 and 2mm from the global surface of the flange.
- Position of the bolts before tack welding.
- Once inserted, the bolts will be blocked in rotation by adding 2 tack welds on the backside of the bolt.
- Perform visual inspection of the weld.
- Perform final cleaning (including adjacent areas) by swabbing the area to be cleaned with a lint free cloth soaked in Isopropyl Alcohol.

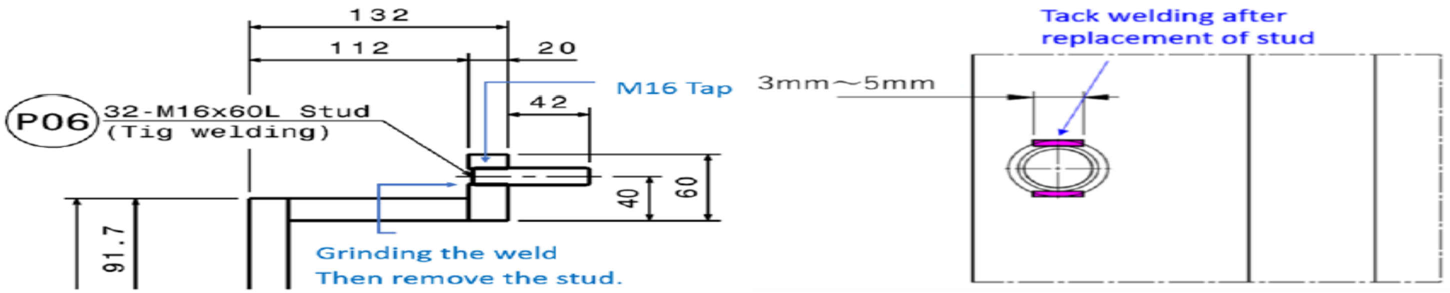
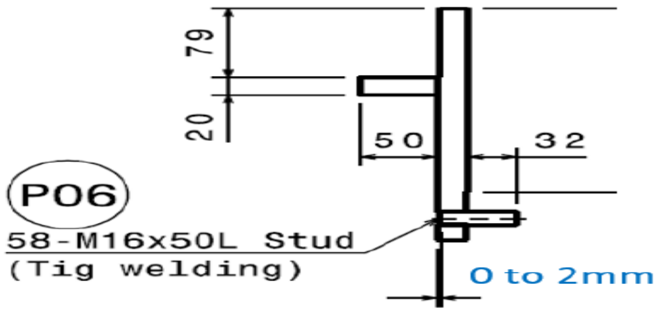


Figure 2.3: Stud bolt removal and tack welding after replacement



CTS repair sequence of work – W13 NDE

NDE after pipe to panel stitch welding

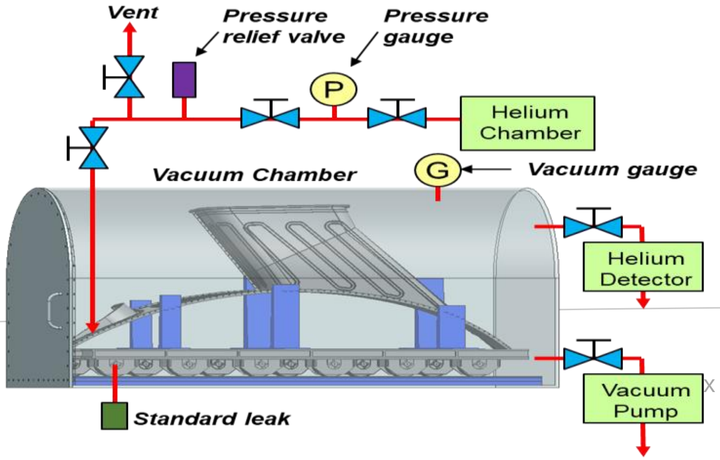
- All stitch welds between the panel and cooling pipes shall be visually inspected.
- Visual inspection shall be carried out on the pipe outside surface and weld bead with naked eye or using a magnifying glass with maximum magnification of 6.
- Tools, gauges, instruments and equipment used for testing shall be calibrated in accordance with ASME Section VIII Division 2 Part 8.
- Acceptance Criteria
  - Absence of burn-through at the pipe surface of welded pipe
  - Absence of crack, serious scratch which encroach on the specified minimum wall thickness of the pipe
  - Absence of dent or deformation of the pipe
  - Absence of debris, grease, oil, oxides, corrosion, and other materials liable to impair the next manufacturing process
- Inside the pipe, no oxidation or burn through on the pipe inner wall. This shall be confirmed by endoscopic examination of minimum 30% of each pipeline. Oxidation shall be inspected by means of discolouration acceptance criteria in accordance with DIN 25410.
- The endoscope shall be introduced at the both sides. All pipelines are to be examined and recorded.
- Perform pressure test (3 MPa) with Nitrogen gas after pipe to panel stitch welding.

CTS repair sequence of work – W14 Dimensional inspection

- Dimensional inspections should be carried out at all crucial stages of the manufacturing process to guarantee adherence to the final tolerances and to quickly implement corrective measures. The frequency and details of intermediate surveys is the responsibility of the Contractor in order to ensure full compliance during the final dimensional inspection approved by IO.
- All equipment used in dimensional inspection shall be calibrated by an accredited independent laboratory. The laser tracker used for dimensional inspection shall be specially calibrated on an annual basis by a certified supplier (e.g. Laser Tracker Manufacturer).
- The equipment selected by the Contractor shall be fit for the requirements of the measurement process. The selection process shall consider areas such as measurement uncertainty, speed of data acquisition, measurement geometry, local environmental conditions.
- The Contractor shall create a Metrology and Dimensional Inspection Procedure that includes all inputs to the measurement process (i.e., measurement instruments and software to be used and procedures to be followed).
- The Contractor shall produce “as built” drawings/electronic data that demonstrate compliance with the required tolerances and main interfacing parts.
- The temperature shall be measured and recorded every 1 hour by a thermometer. The temperature measuring points shall be well distributed and checked by direct measurement on the flanges (thickest part) at three different levels (top, middle and bottom). The accuracy of the measurements shall be better than $\pm 0.5\,^{o}C$.
- If the difference of average temperature per each hour is more than ±1°C, the latest average temperature shall be applied for the correction to 20°C. It means that if the measured average temperature is changed more than ±1°C per each hour, input data of actual temperature will be updated with latest average temperature so re-scaling will be applied by Spatial Analyzer software.
- Panel to be measured under unrestrained condition, a specific supporting tool shall be designed, manufactured and procured by the contractor. The supporting tool shall be used during the measurement surveys performed before and after panel repair, to ensure that the supporting conditions of the CTS panel are identical between both surveys.

CTS repair sequence of work – W15 Final vacuum leak test

- Perform FVLT (Final Vacuum leak test) after the completion of each panel repair.
- Tests shall be made with the pressure differential in the same direction as for operation of the component.
- A standard leak shall be fitted to the vacuum chamber and the leak detection system calibration shall be performed utilizing the standard leak.
- Panel is inserted in the vacuum chamber and connected
- With a roughing pump, the chamber is evacuated until its vacuum level reaches the requisite pressure for the operation of a turbo-molecular pump (TMP).
- The TMP is started, and the chamber is evacuated. When the background leak rate on the leak detector was stable in the 10^{-9} range with no fluctuation of the decimal (10^{-10}) digit for 5 minutes, then helium gas is charged into the cooling pipe up to 3 MPa, and the chamber is leak-tested.
- No increase in the leak detector background above the allowable leak rate defined for Cold Shock Test. This means no fluctuation of the decimal digit (10^{-10}) of the measured leak rate (10^{-9} range) on the detector after the helium pressurization in the cooling pipe.
- The Contractor is responsible for the supply of all FVLT testing equipment include vacuum chamber, instrumentation, and testing components to allow an acceptance of FVLT to be carried out.



CTS repair sequence of work – W16 Packing panel and transport to IO

- Prior to packing, CTS components shall be cleaned and free from paint, oil, rust, scale, slag, grease, marking materials, or other foreign materials.
- The inside of the surface of the cooling pipe is cleaned during fabrication. After cleaning the pipe's inside surface, the pipe shall be sealed with a blind cap to prevent contamination.
- The CTS shall be packed in polythene with desiccants enclosed within the shipping bag to absorb residual atmospheric moisture. Humidity indicators shall be attached to the bag to check the humidity during shipping. Silica gel bags shall be installed inside the shipping bag. The shipping bag containing components shall be evacuated to a low vacuum and backfilled with nitrogen gas. Filling pressure should be determined within the range that the shipping bag is able to expand without damage on sealing.
- The CTS shall be adequately protected against shock, impacts, and bad weather of all types and must be watertight, ensuring the protection of the CTS against ingress from seawater and air humidity.
- The use of adhesive tape for the protection and packaging of CTS components shall be restricted to prevent the risk of contamination from the tape. In particular, tape used on austenitic stainless steel shall meet leachable chloride and fluoride limits of 15 ppm and 10 ppm, respectively. Where used, tape shall be fully removable, leaving no residue, using isopropyl alcohol or acetone as the solvent to remove all traces of the adhesive.
- Handling instructions shall also be clearly marked on the outside of the packaging. All such marking shall be in English.
- Crates and packing cases shall be constructed to avoid the risk of damaging and tearing the shipping bag. Single parts to be supplied, such as bolts, etc., shall be packed and placed in separate containers adequately labelled with their name and quantity.
- Packing conditions shall meet the requirements of the ITER Vacuum Handbook.
- All components shall be packed in wooden cases for transit.
- Depending on the type of cargo, the Contractor shall attach the shock and tilt watches to the outside of the packaging.

General Requirements for Cleanliness

- A detailed Clean Work Plan shall be submitted for prior acceptance to the IO before any cleaning operations are undertaken.
- The cleaning fluids shall be used in accordance with the ITER Vacuum Handbook. "Only materials accepted by ITER for the relevant Vacuum Classification shall be used on ITER vacuum systems. All material for use in vacuum shall be clearly specified at the design stage and certified in accordance with EN 10204 2.2, 3.1 or 3.2, or equivalent, before being used in manufacturing."
- IO database for management of all Material, Fluid and Processing Materials approvals requests, rather than the form-based system. **Material approval request** –for materials that will remain in vacuum. **Fluid and Processing Material** used for the processing of the above. This includes solid materials that do not remain in vacuum but will be in contact with vacuum surfaces such as packaging or handling.
- The panels must be kept free from oil, grease, swarf, atmospheric dust, paint, and dirt.
- The area cleaned shall be assessed for cleanliness in compliance with the wipe test as specified in IO procedure 'Standard Wipe Test for Cleanliness'.
- General area cleanliness requirements pertaining to Vacuum Classifications are summarized in the below table.

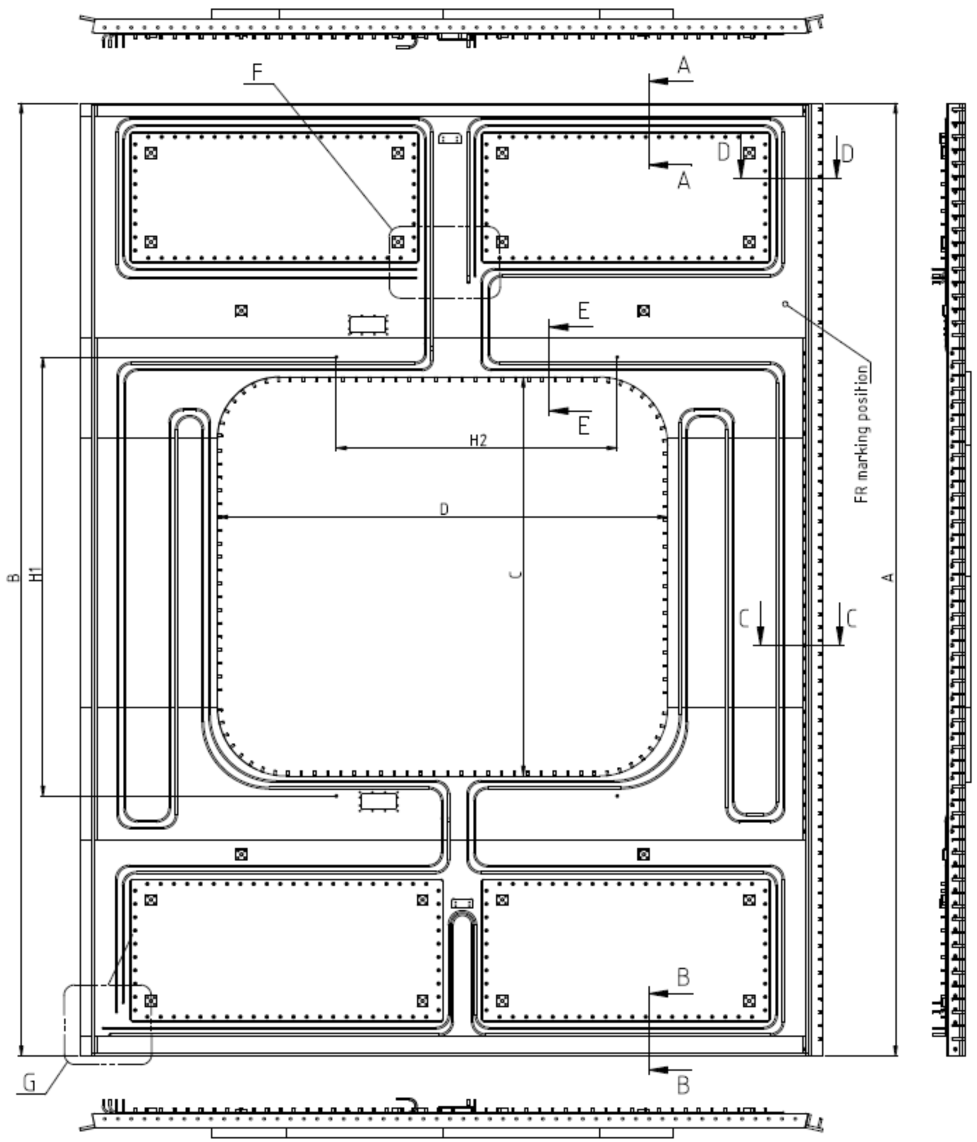
VQC	Cleanliness requirements	Personnel	Area Cleanliness
2	Authorized equipment operated to approved procedures. Management of equipment (e.g. no vacuum pumps or other machinery exhausting into clean area).	Trained personnel. Clean outer protective gloves for the handling of clean equipment.	Daily Cleaning of work area including floors and surfaces.

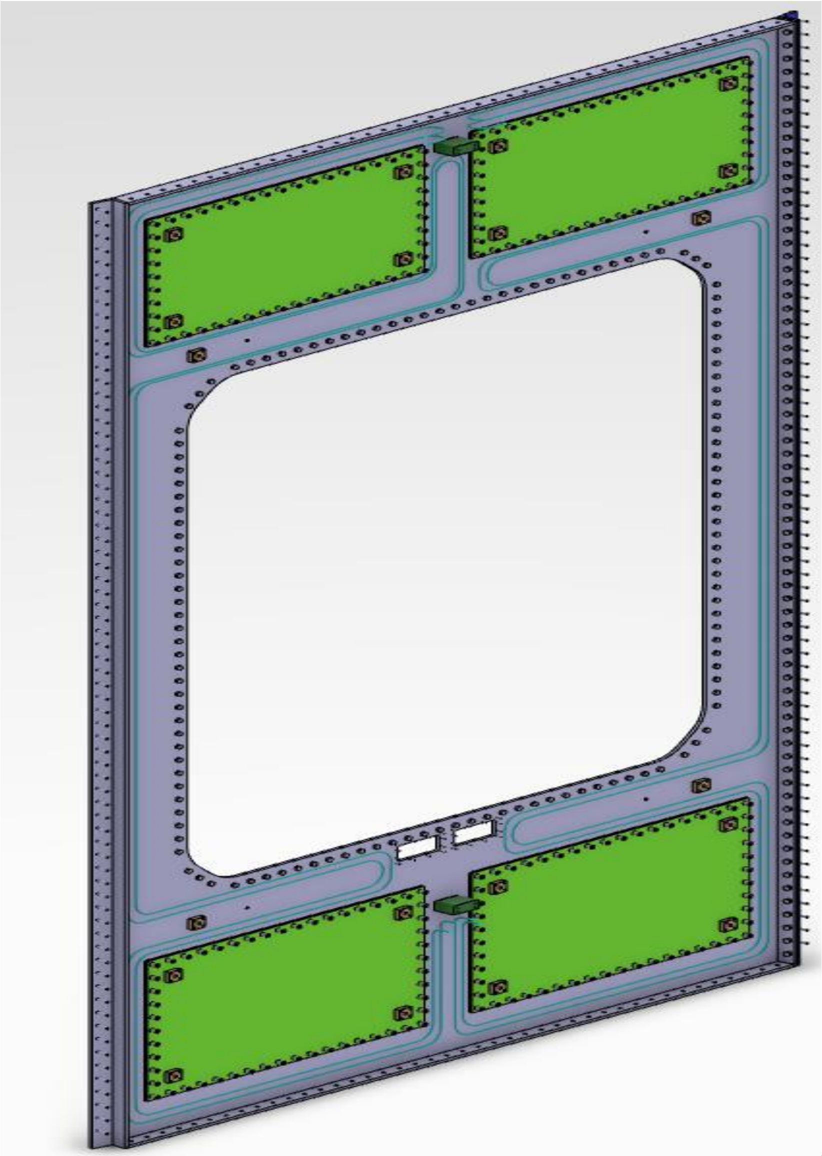
Panel welding deformation control and correction

- Welding deformation control is critical for the repair of CTS. Contractor to analysis the risk during repair works and prepare detail procedure to limit welding deformation and study the best method for panel correction.
- Welding sequence optimization - apply balance welding.
- Keeping sufficient time for next line welding - controlling amount of heating.
- Use of rigid Jig/Fixture during repair work.
- Pre-bending(over-bending) of the panel considering recovery after pipe welding.
- Use of photogrammetry techniques for intermediate surveys monitoring panel deformations could be beneficial in terms of productivity.
- Correction of Panel after welding: applying plastic deformation (fixing the panel and pressing with a hydraulic jack or pull by a chain hoist), counter welding etc..

Contents

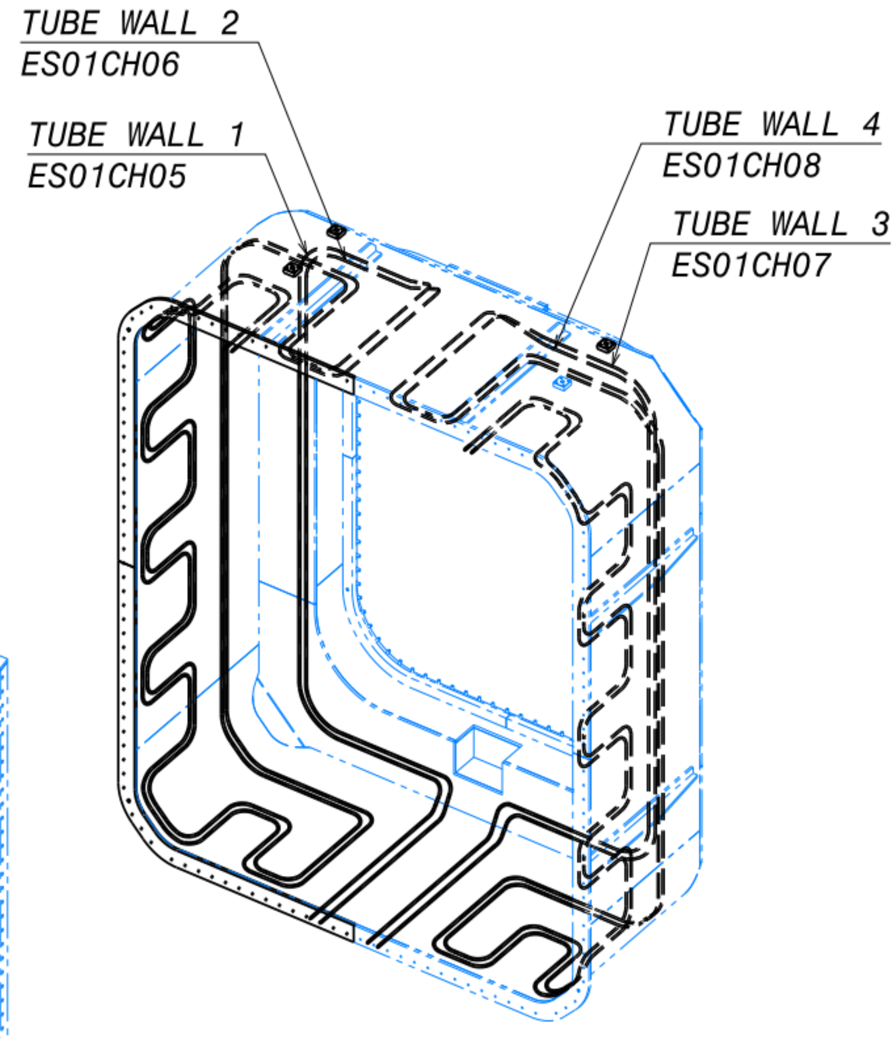
Large size EC Cylinder – 7200x5500x300mm (LxWxH), Panel thk. 20mm. Qty. 18

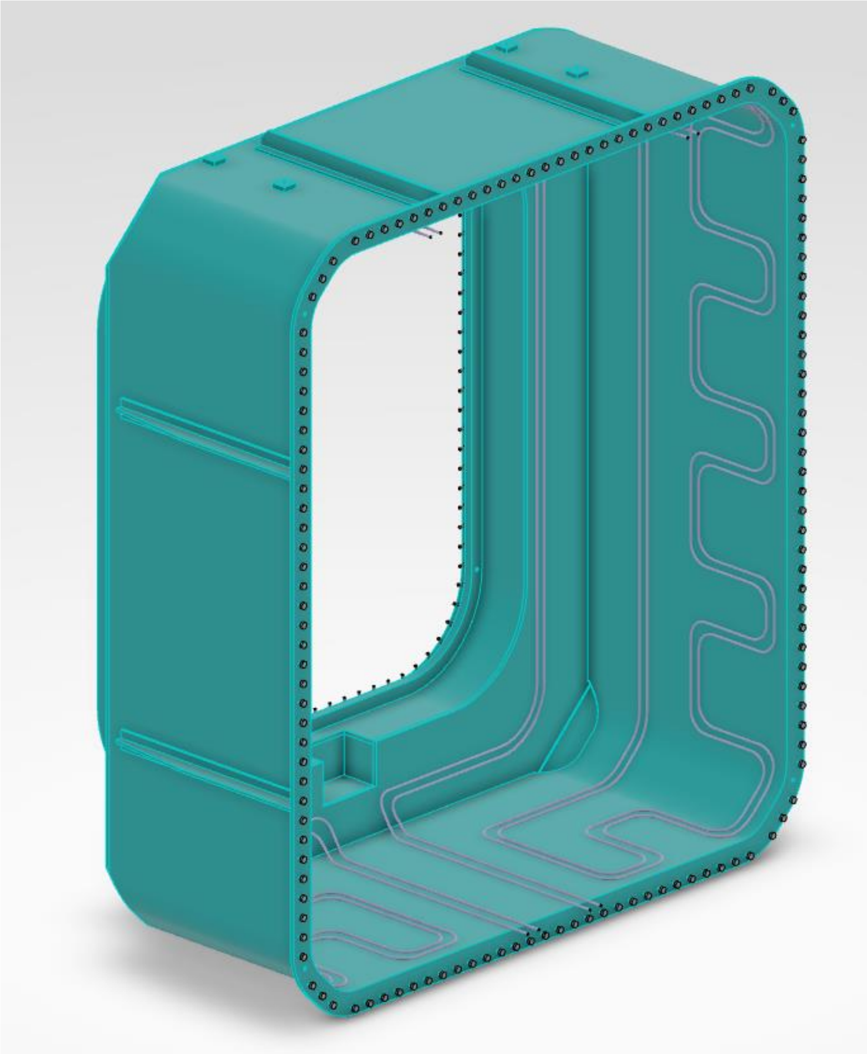




Complicated shape EC Cylinder Port Shroud – 4000x3500x1800mm (LxWxH).

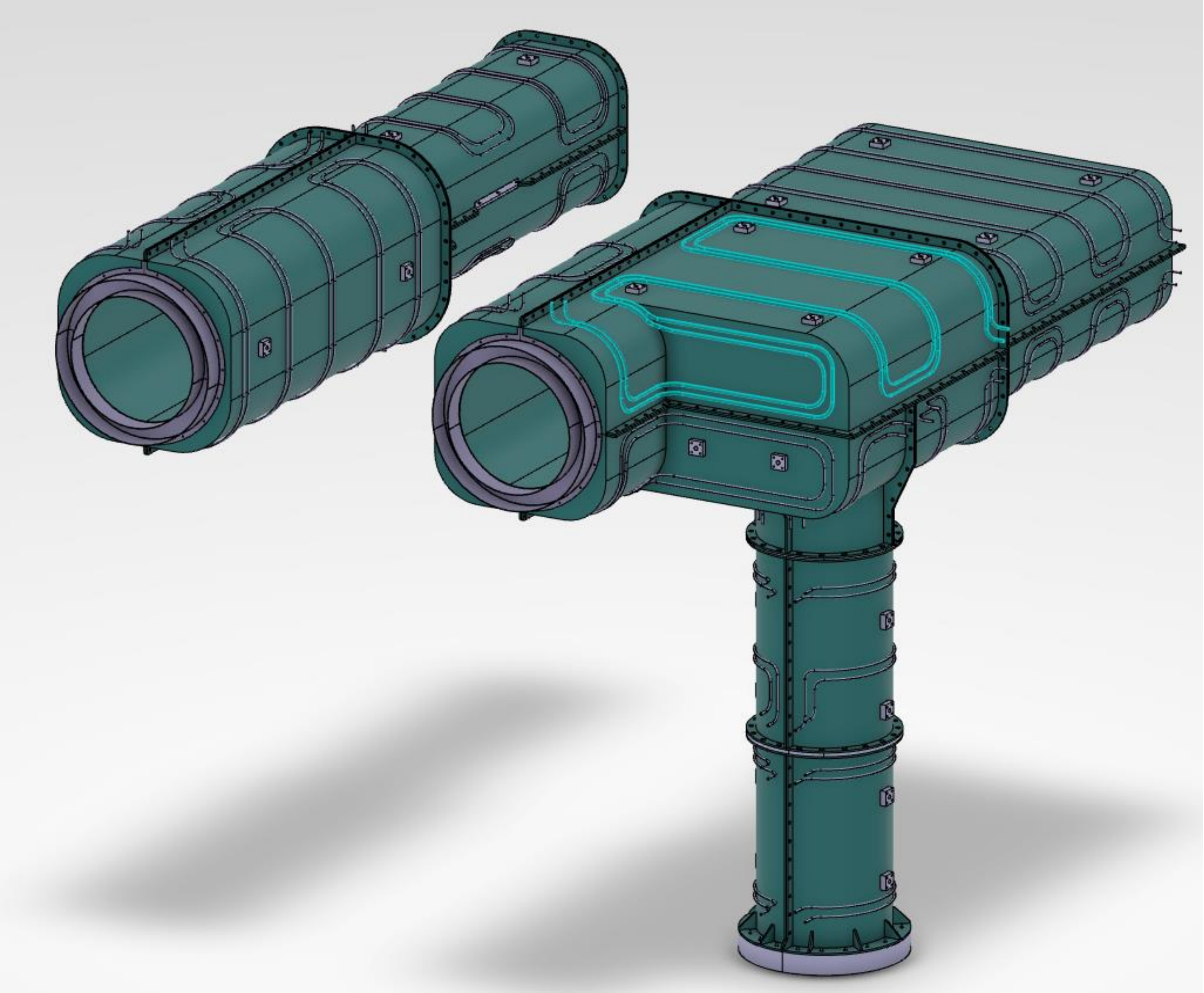
6000Kg/Panel. Panel thk. 20mm. Qty. 15

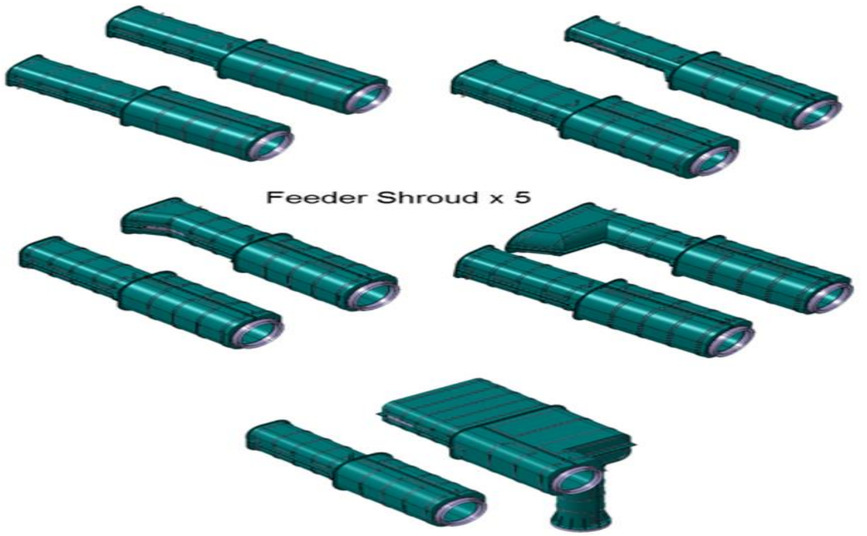




Complicated shape UCTS Feeder Shrouds Panel thk. 10mm.

Total 5 sets. Total 46 parts for 10 Feeder Shrouds.





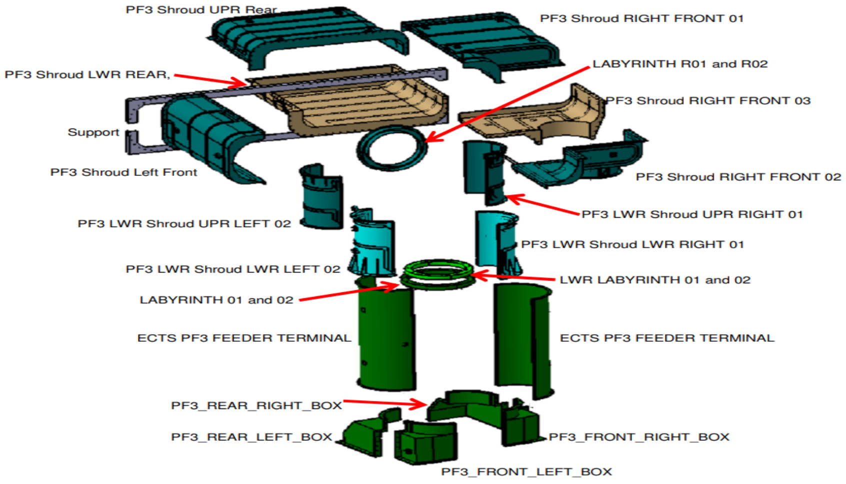
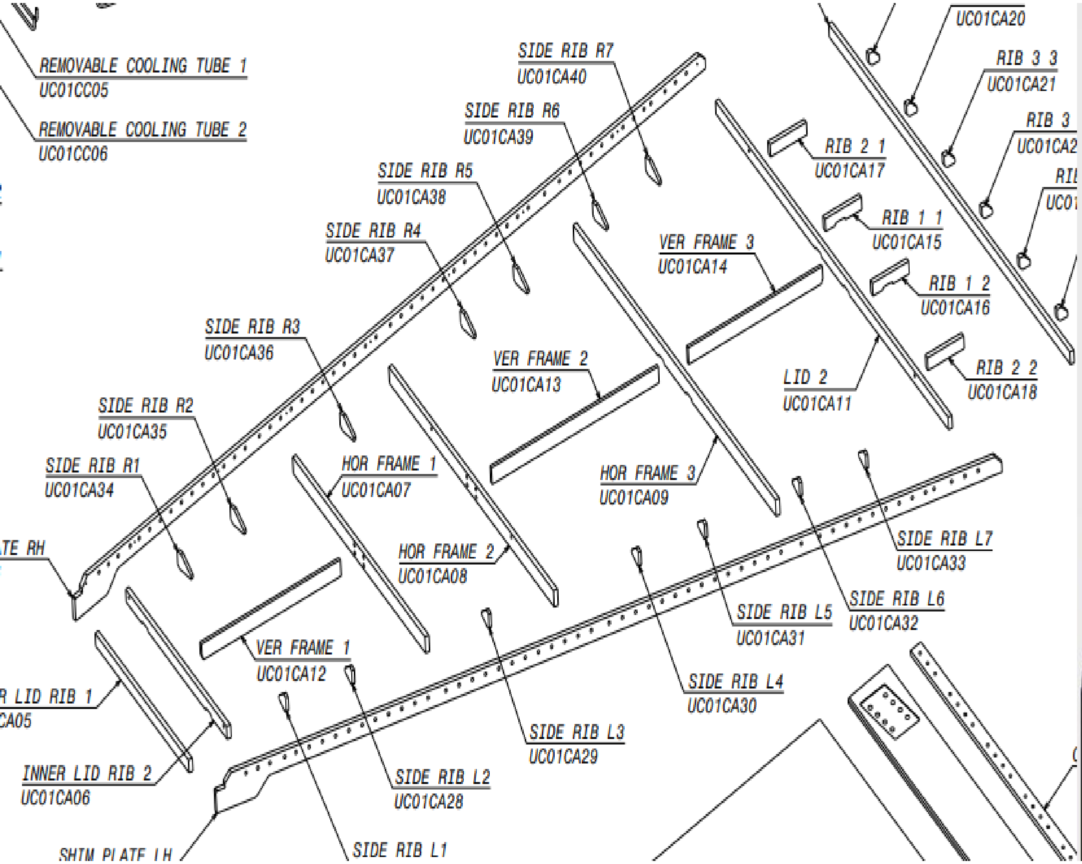
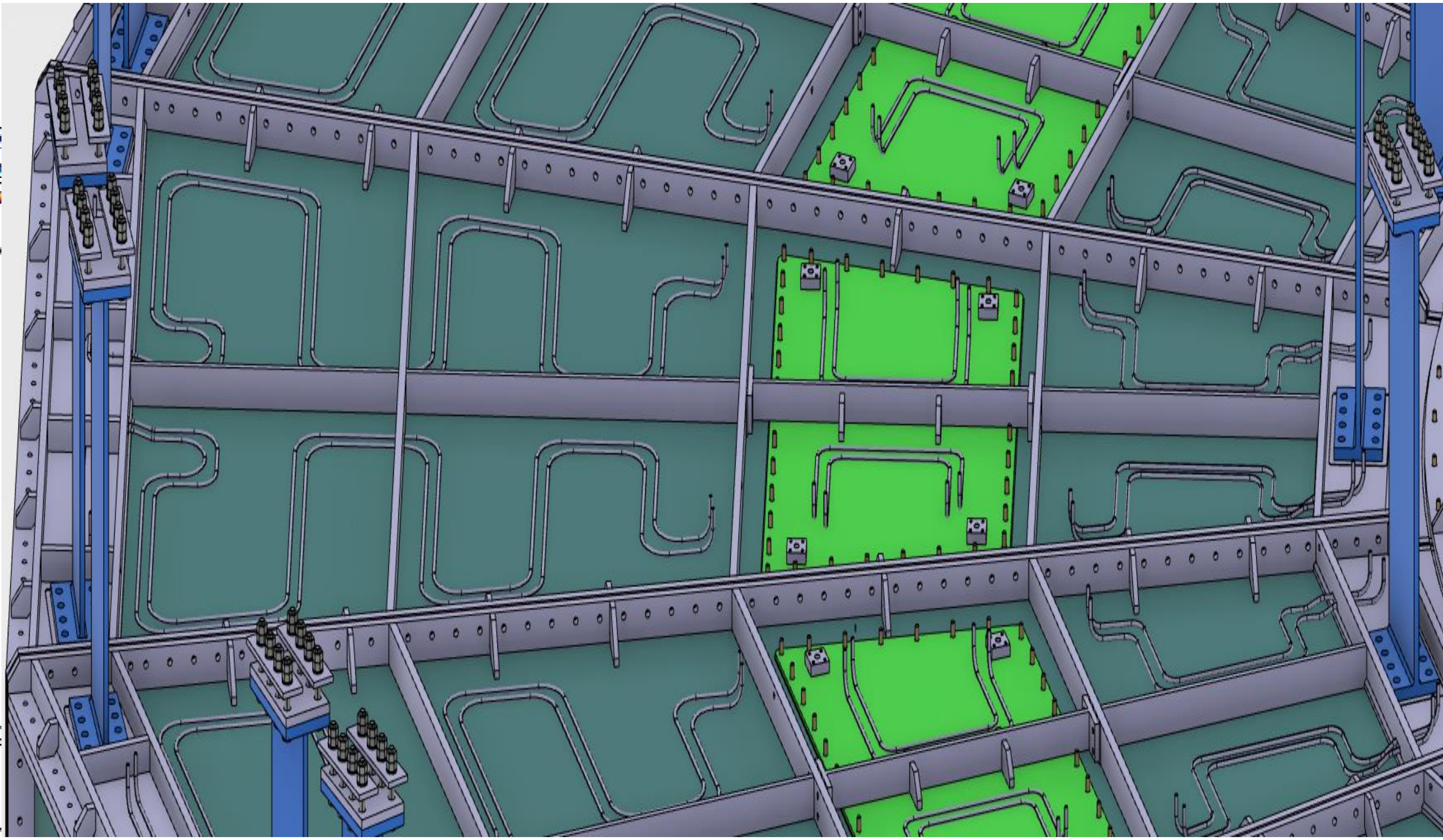


Figure 4.0.1. Explode of parts of PF3 Feeder TS Shrouds

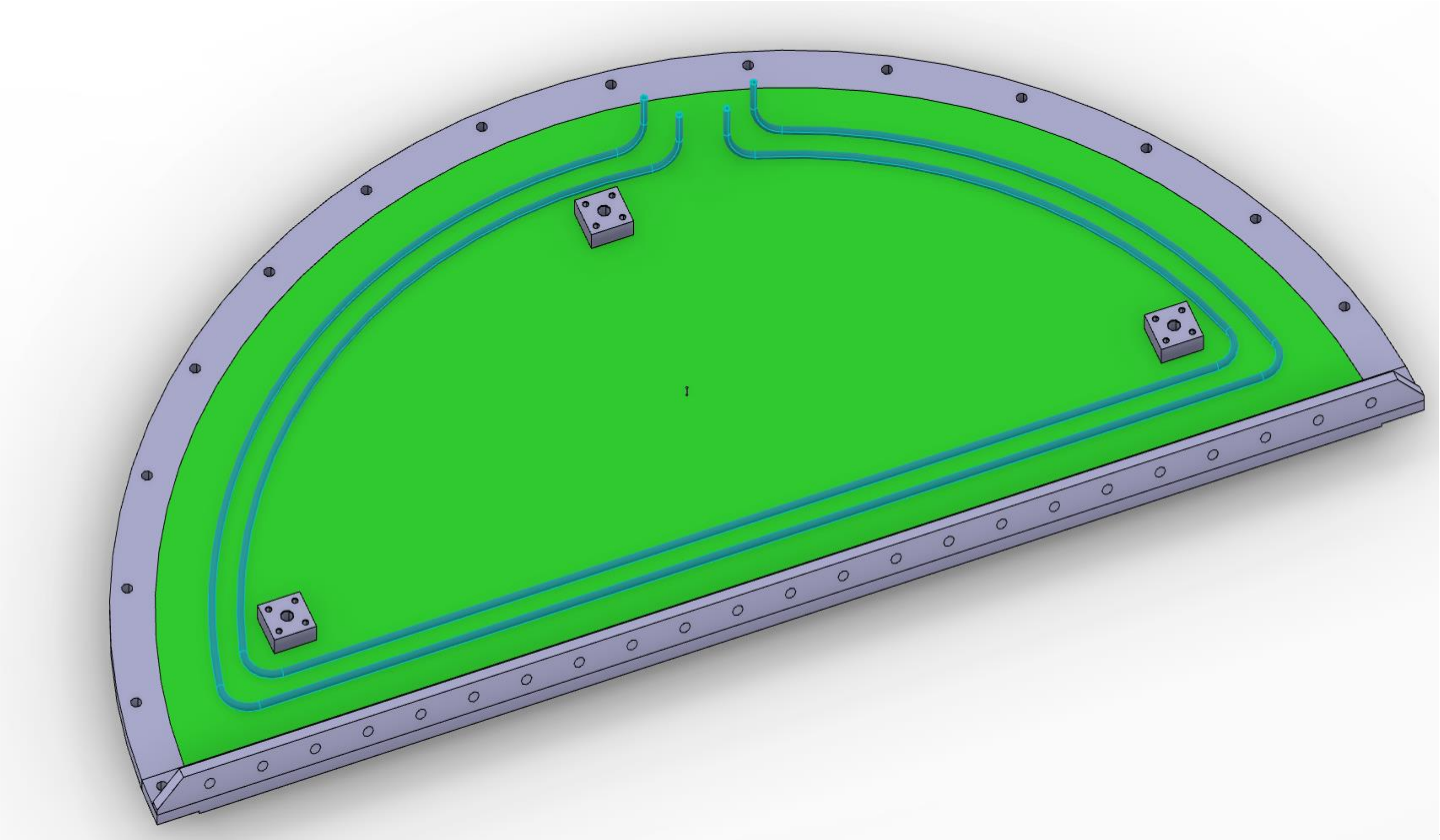
Constraints on UCTS outer lid with frame welded. 6100x3300x300mm (LxWxH).

Panel thk. 10mm. Qty. 18

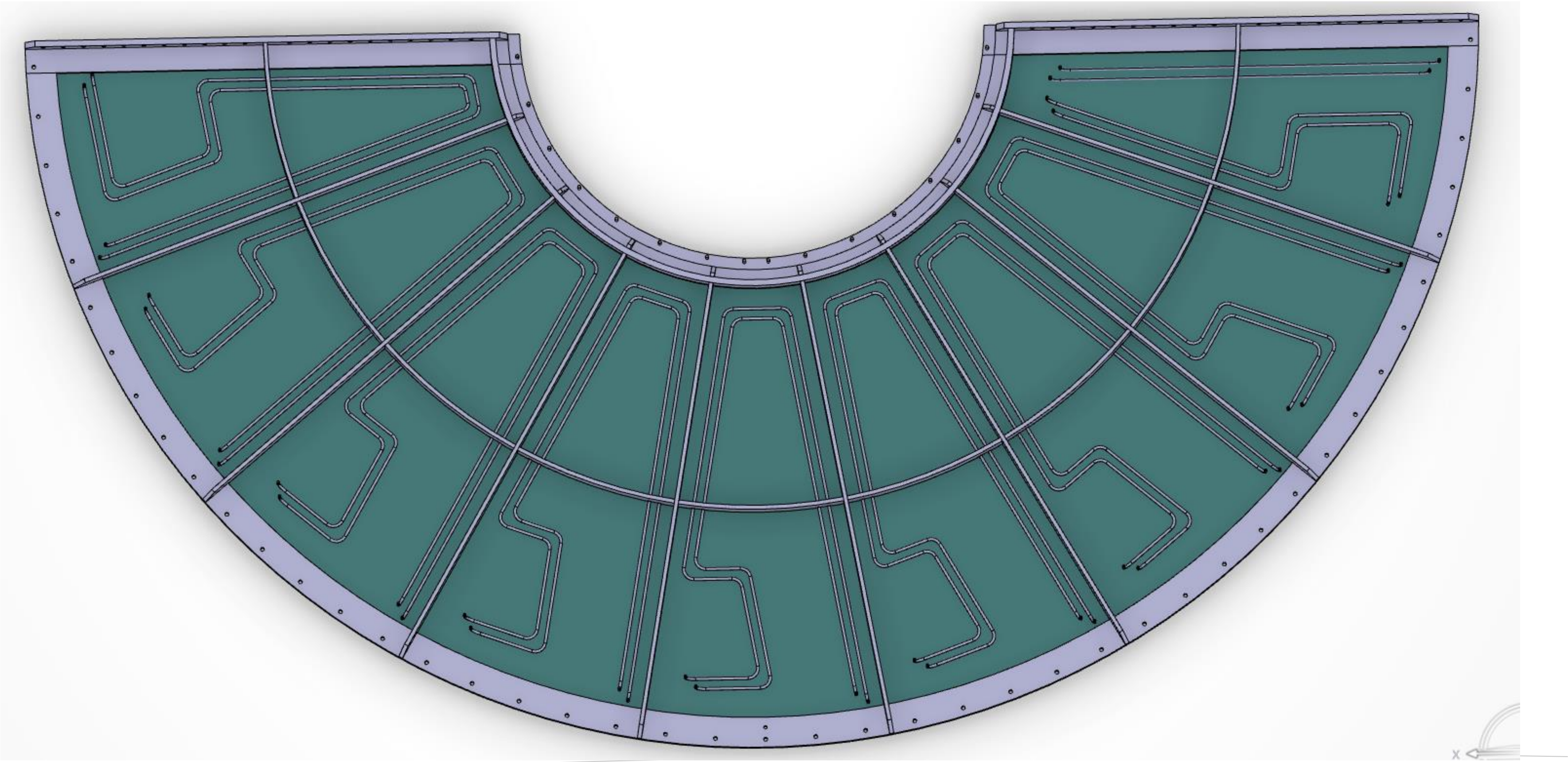




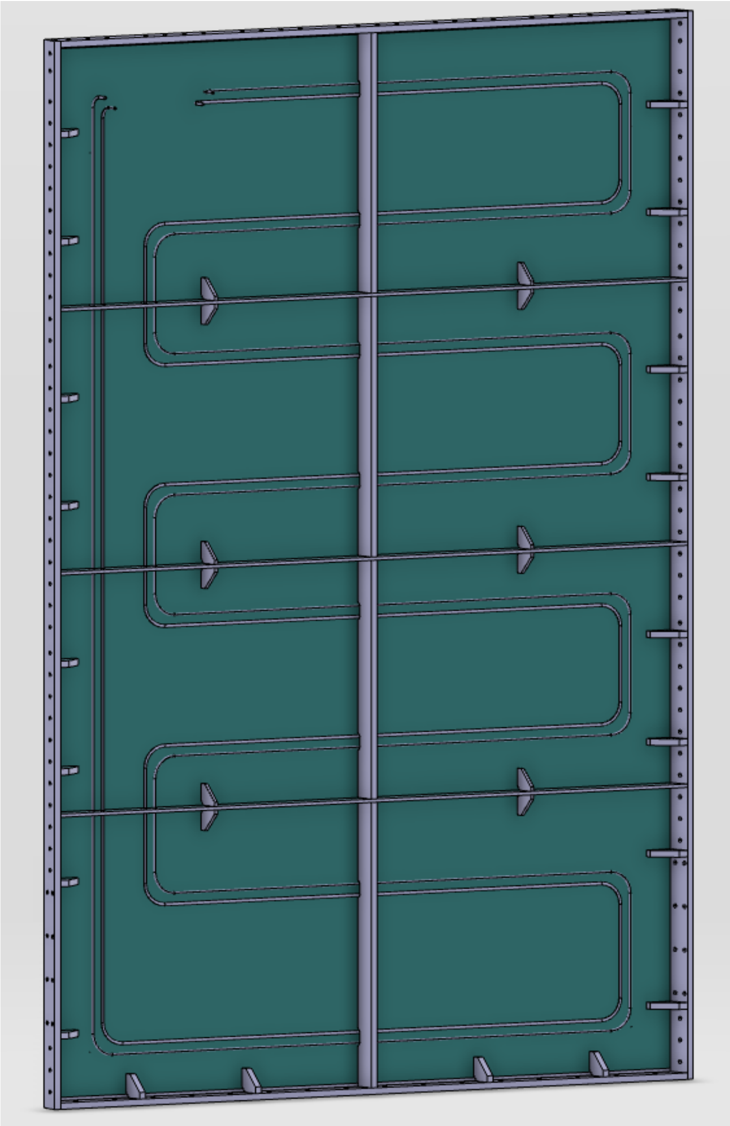
Small UCTS central lid panel – 2400mm OD, Panel thk. 10mm. Qty. 2

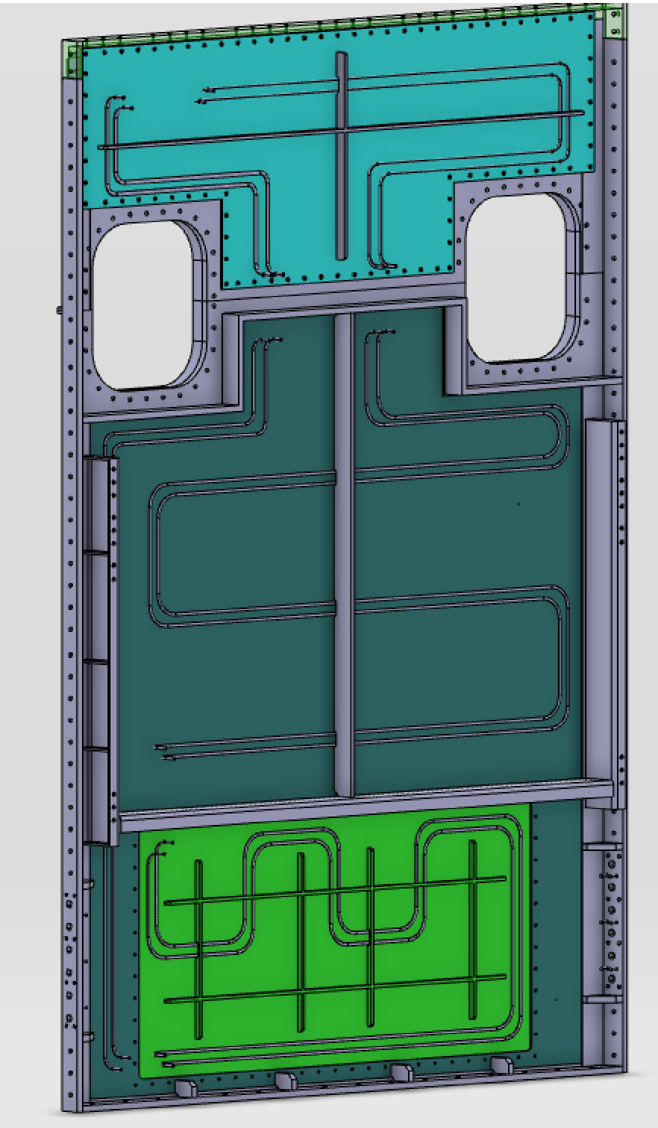


UCTS inner lid panel – 7200mm OD, Panel thk. 10mm. Qty. 2

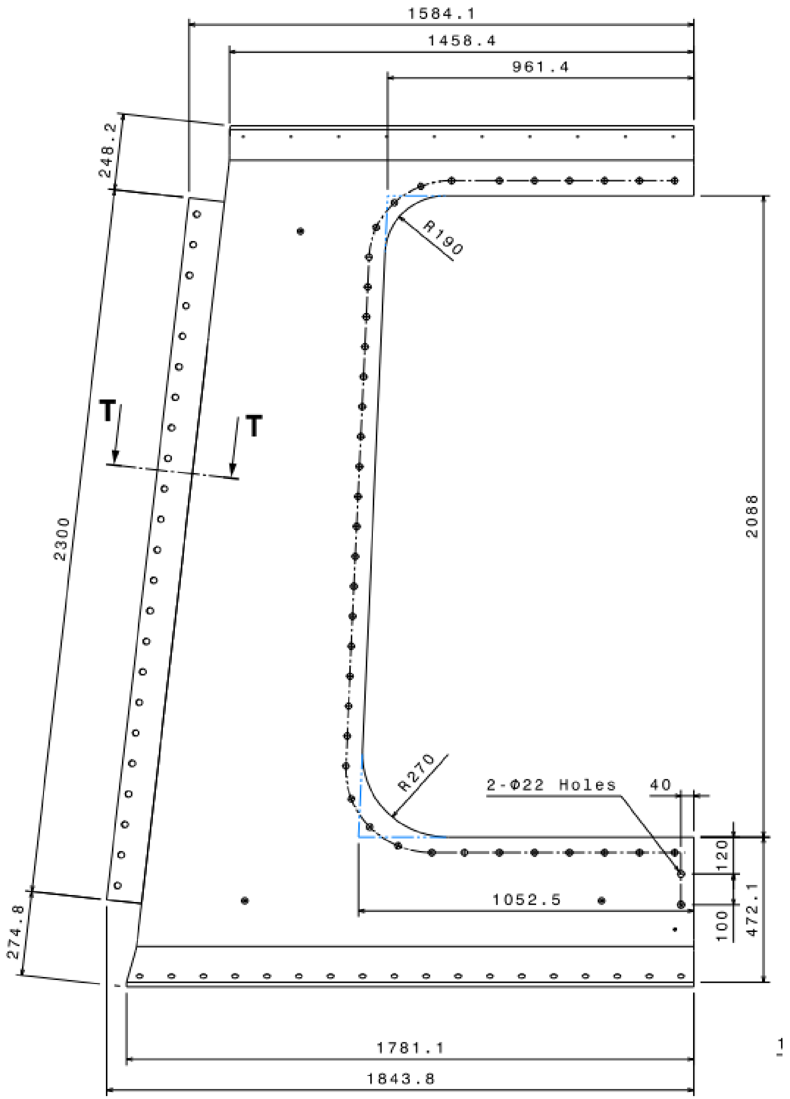


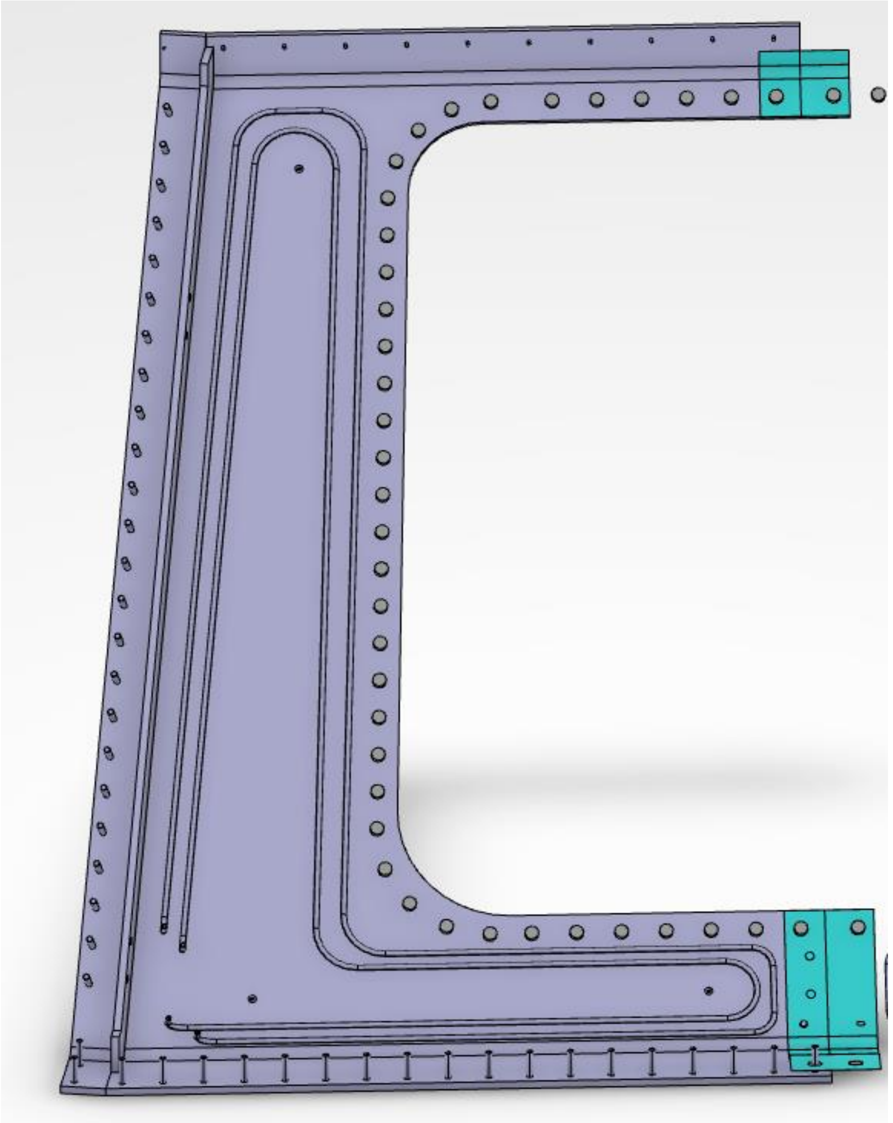
UCTS Cylinder – 5000x3400x300mm (LxWxH), Panel thk. 10mm. Qty. 18



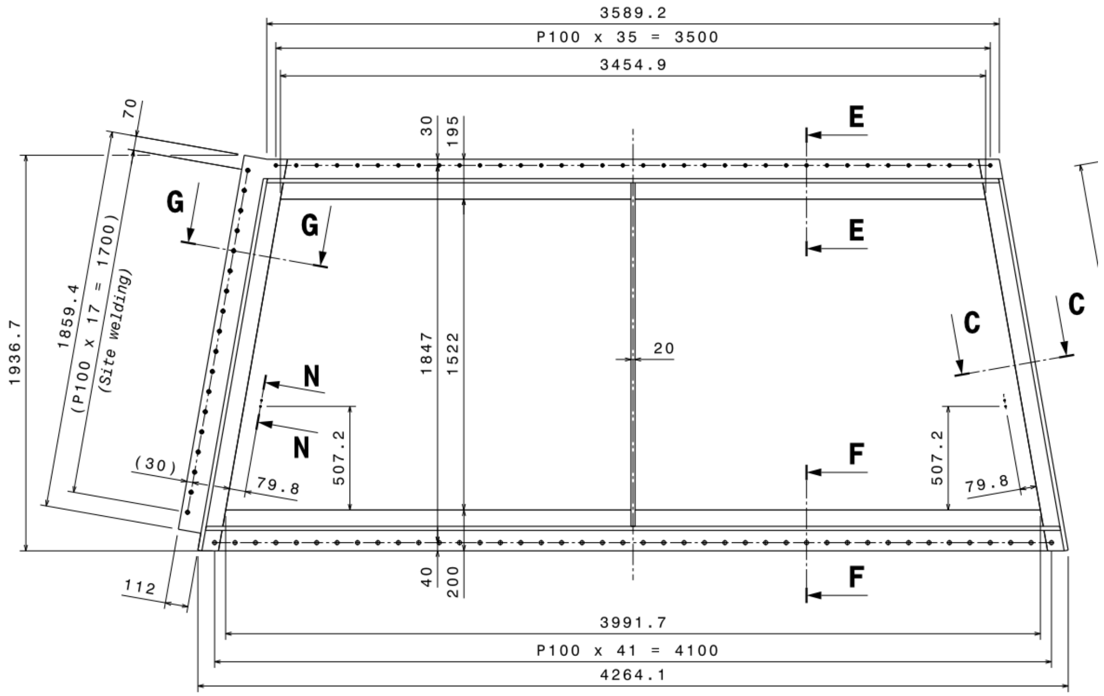


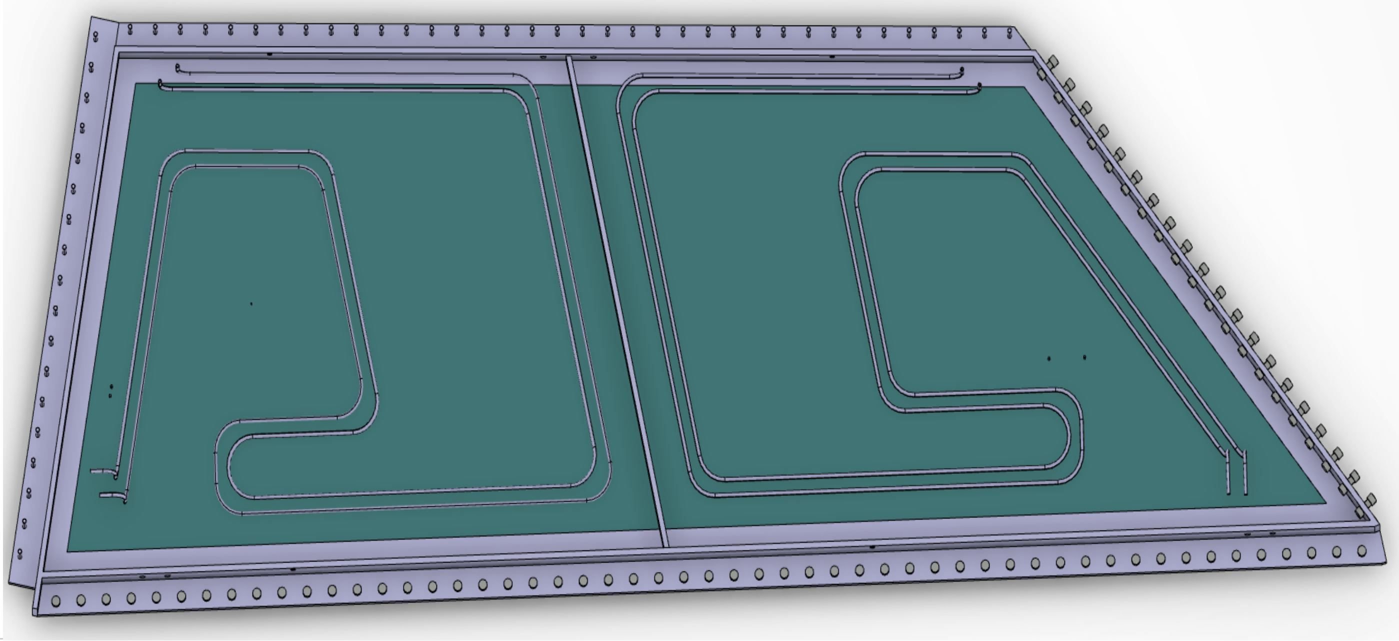
ECTS upper VVTS ring – 2800x1900x300mm (LxWxH), Panel thk. 20mm. Qty. 36



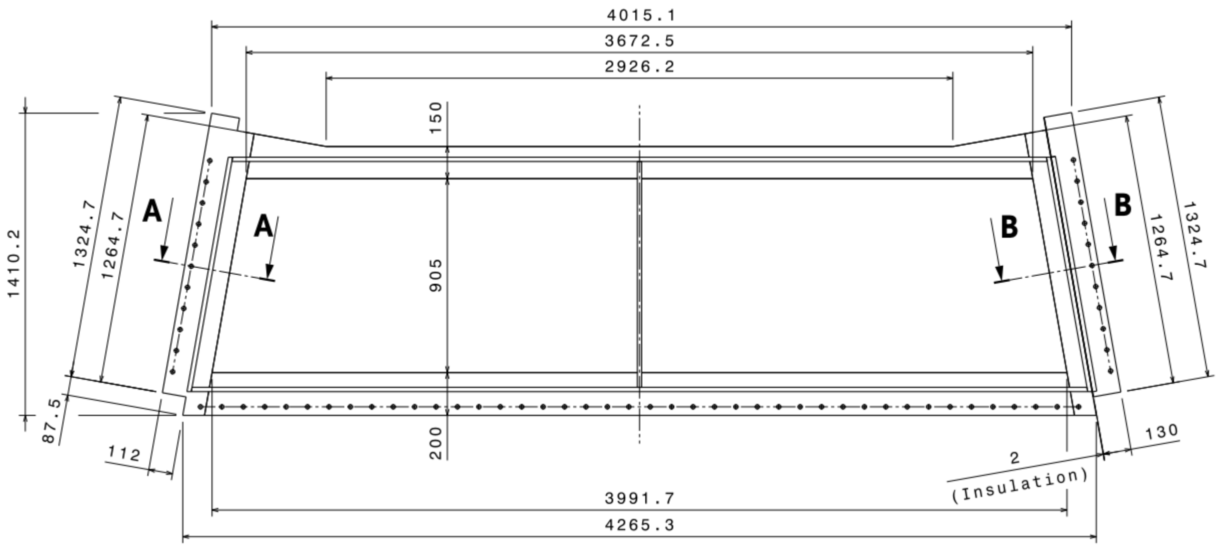


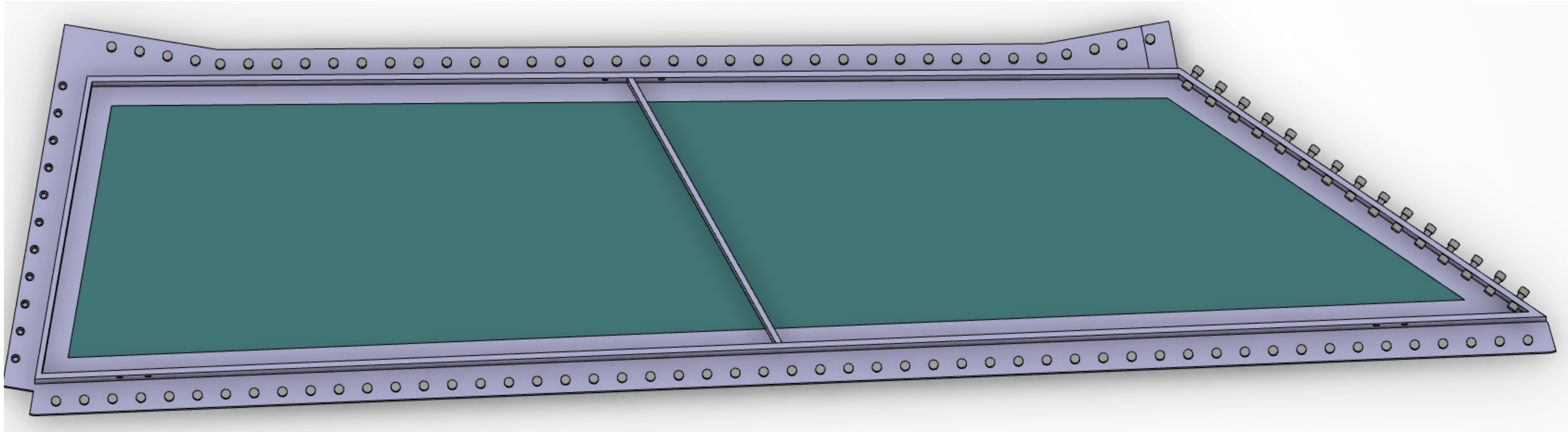
Upper ECTS ring – 4300x2000x300mm (LxWxH), Panel thk. 10mm. Qty. 18



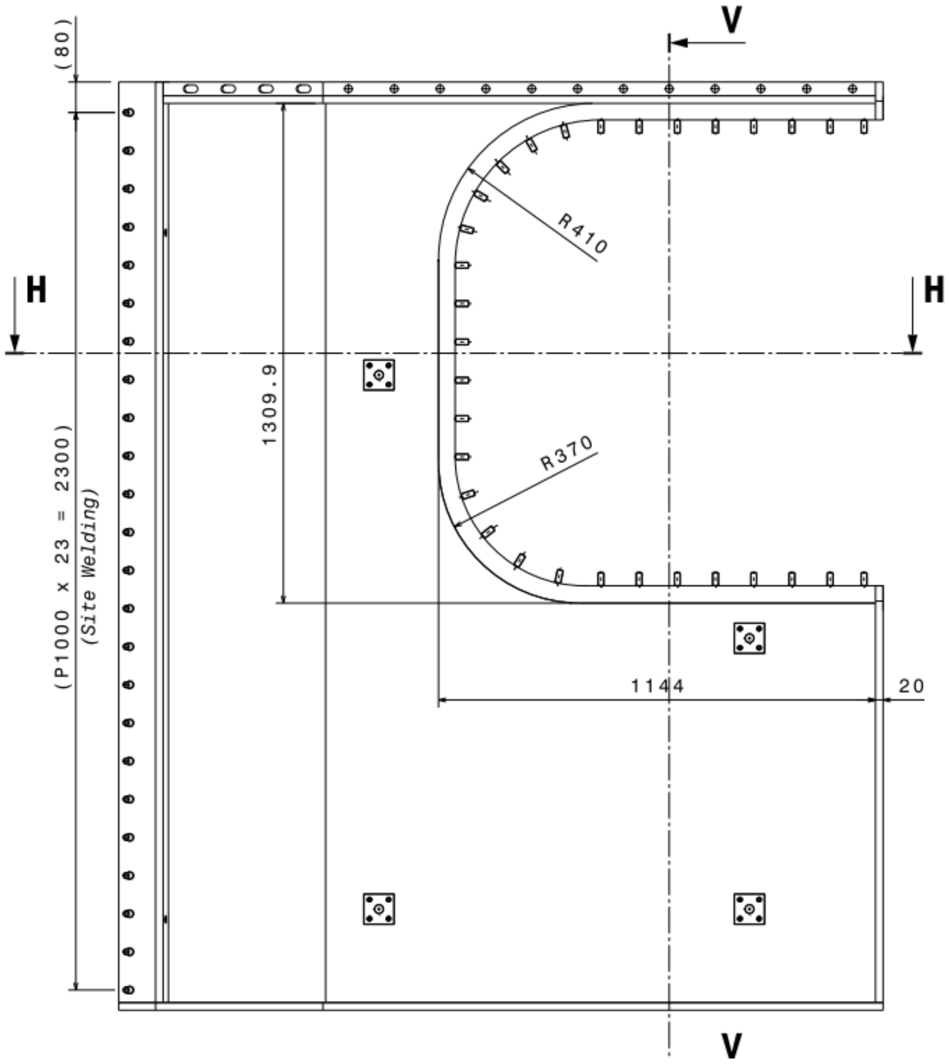


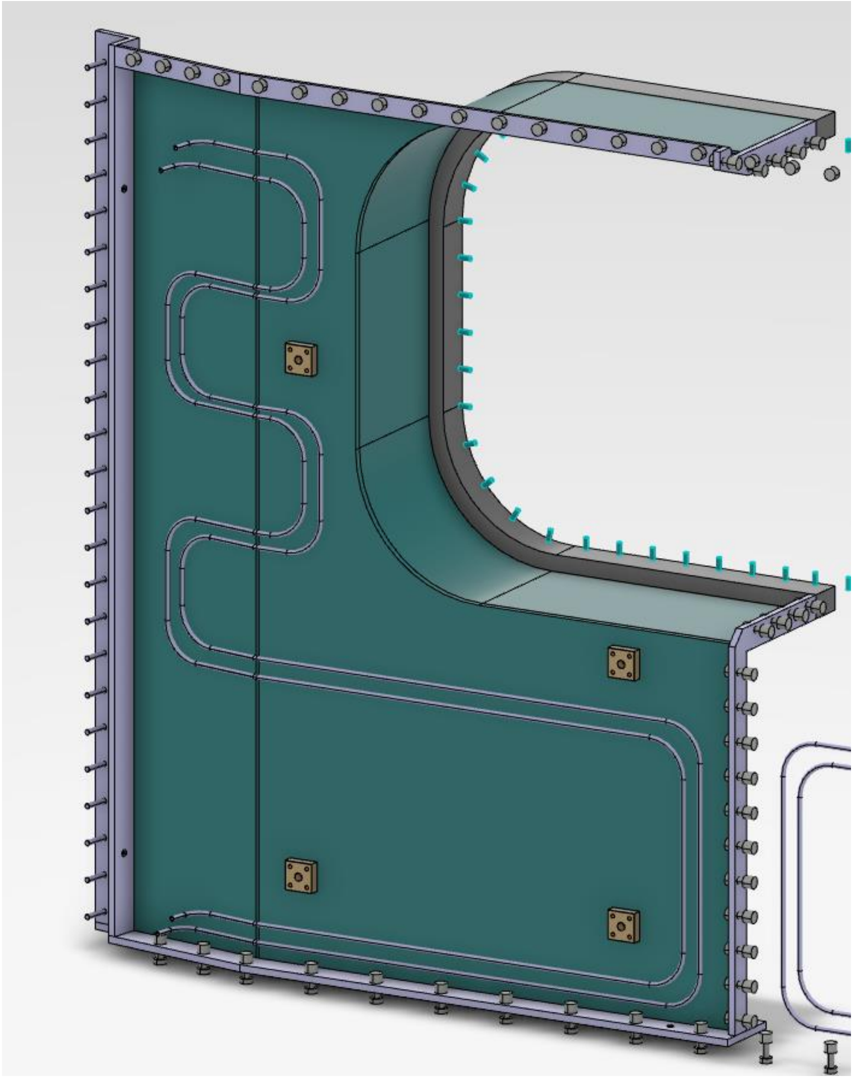
Lower ECTS ring – 5500x1400x200mm (LxWxH), 800Kg/Panel, Panel thk. 10mm. Qty. 18



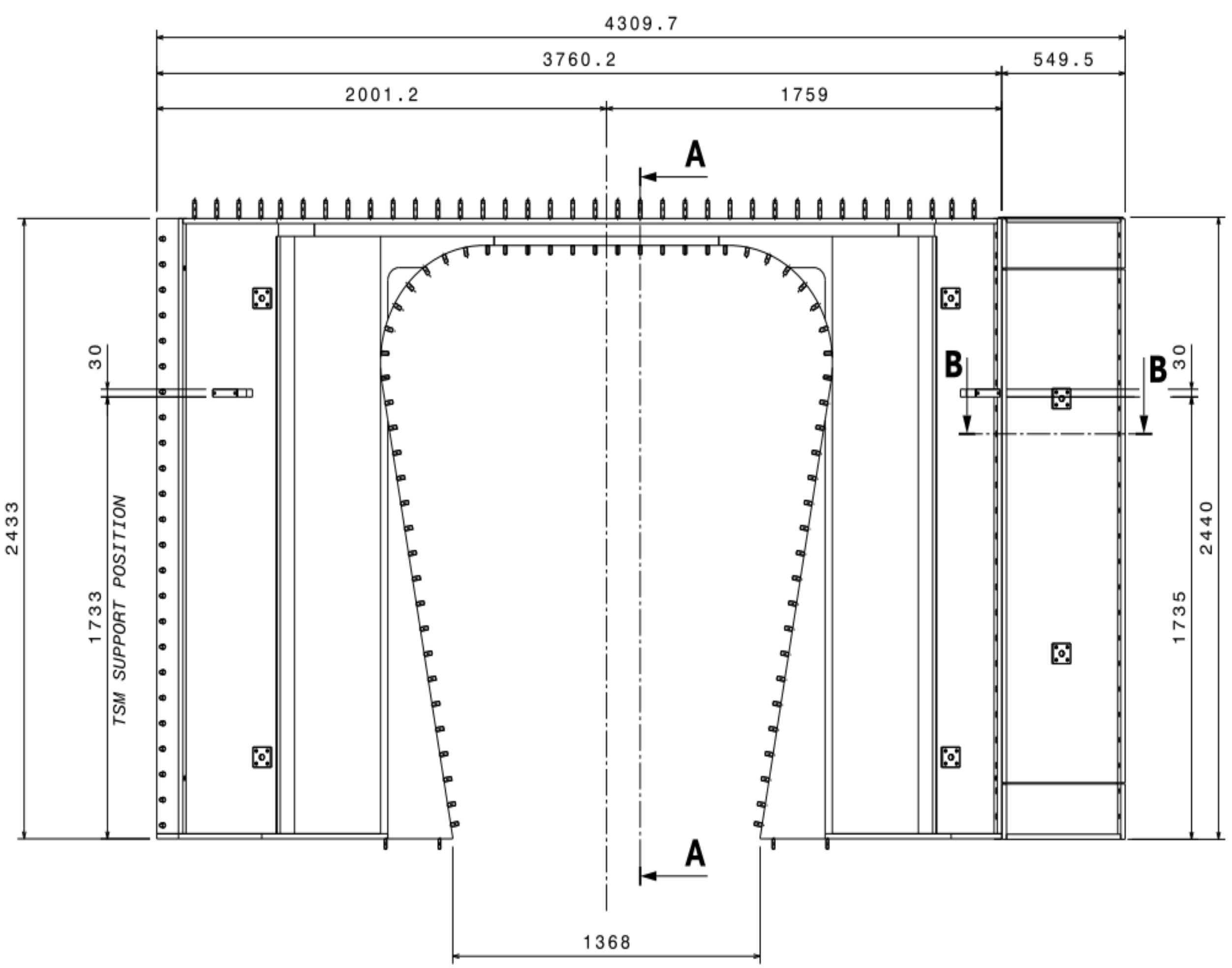


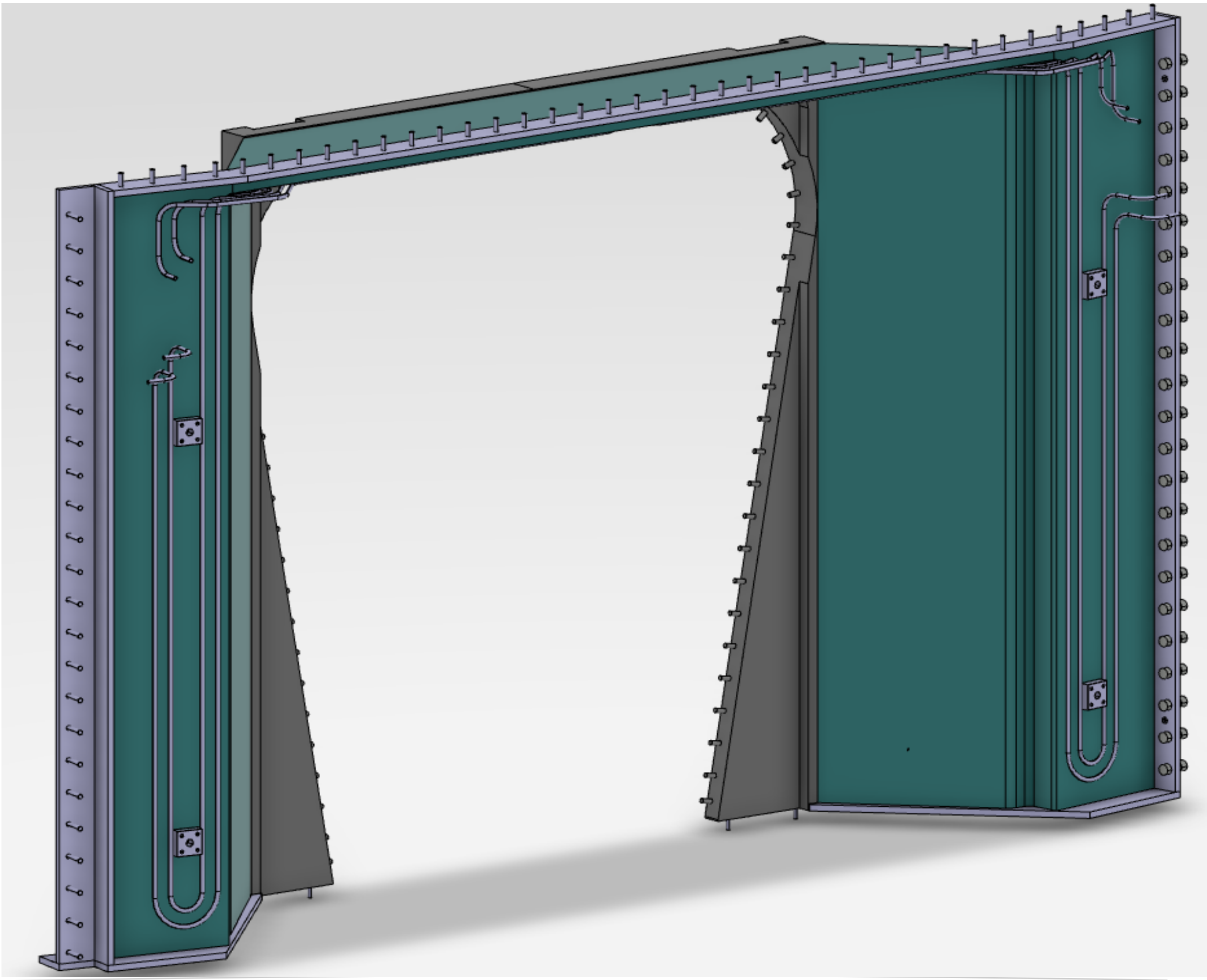
Lower ECTS Cylinder – 2400x1900x600mm (LxWxH), 1000Kg/Panel, Panel thk. 20mm Qty. 18



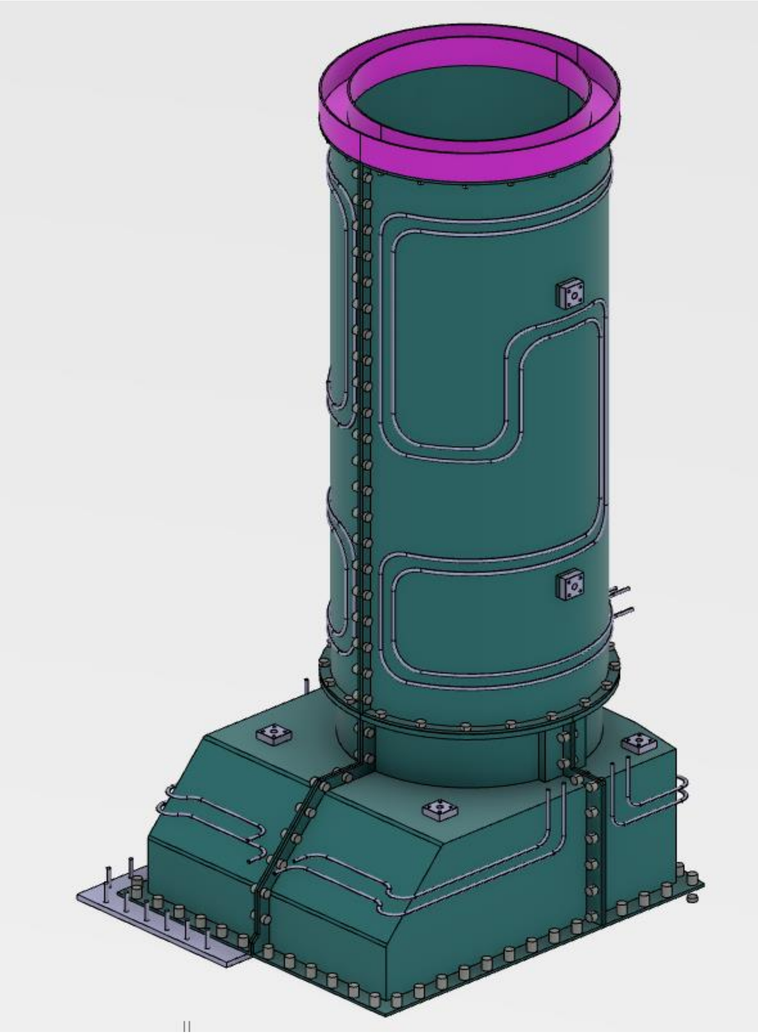


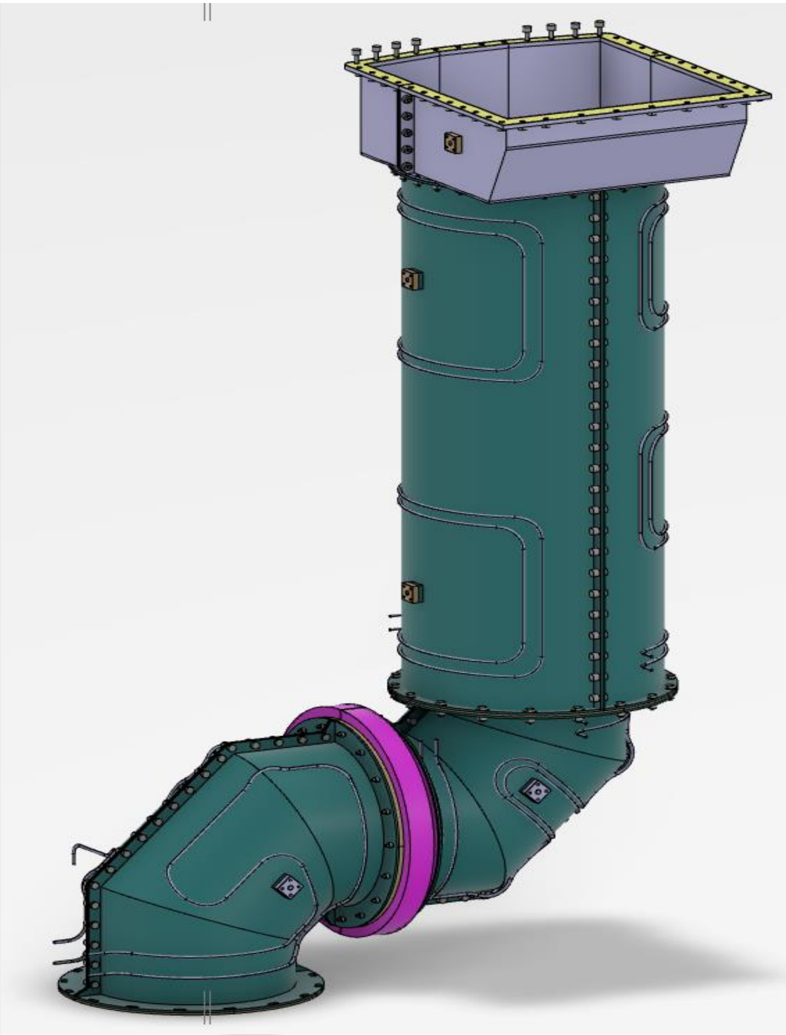
Lower ECTS Cylinder – 3900x2600x800mm (LxWxH), 2000Kg/Panel, Panel thk. 20mm. Qty. 9





PF3 and PF4 Shroud – Panel thk. 10mm. Total 2 Shrouds. Total 14 parts for 2 Shrouds





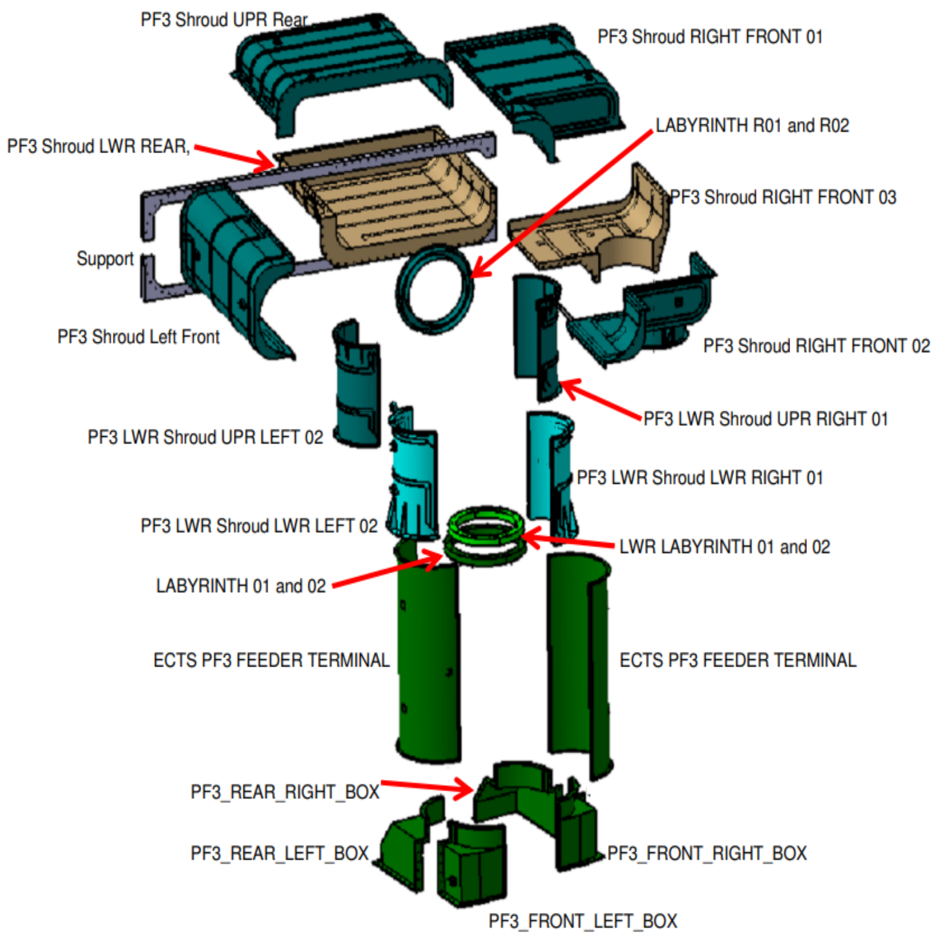
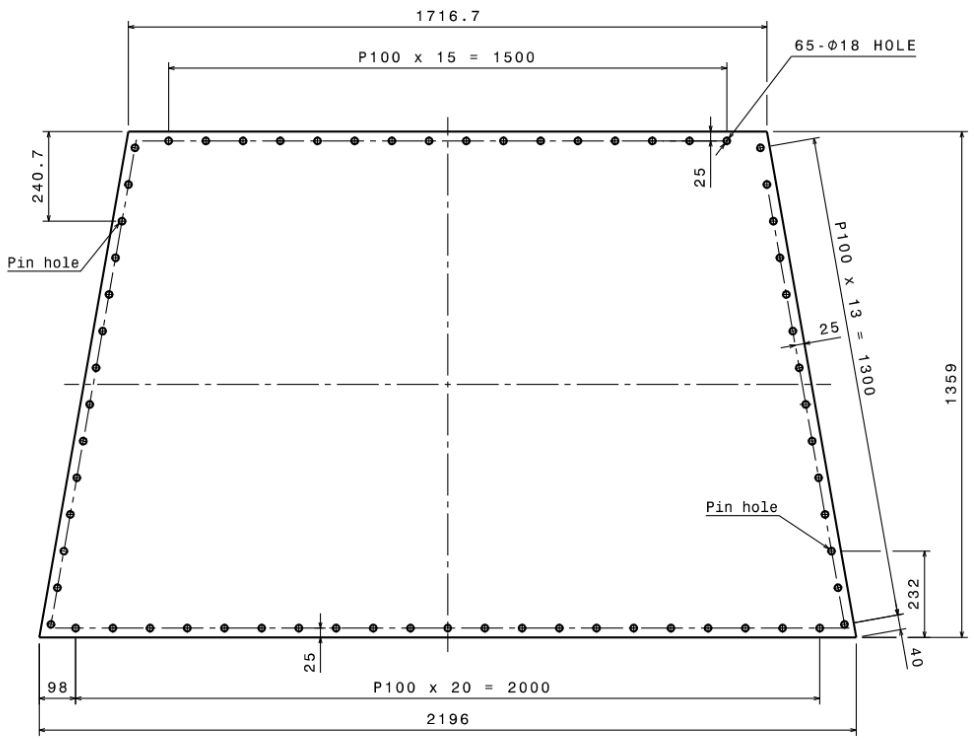
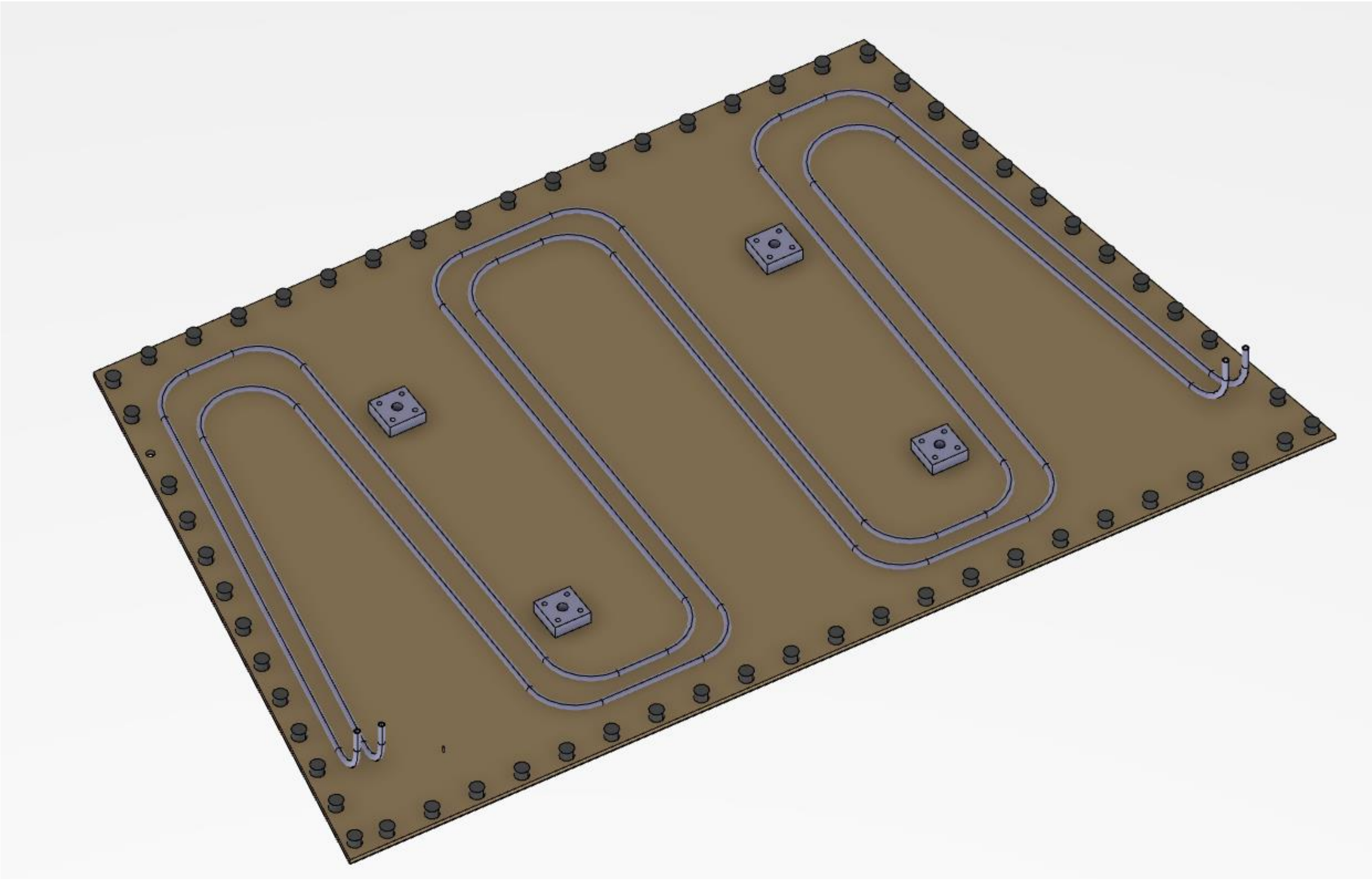


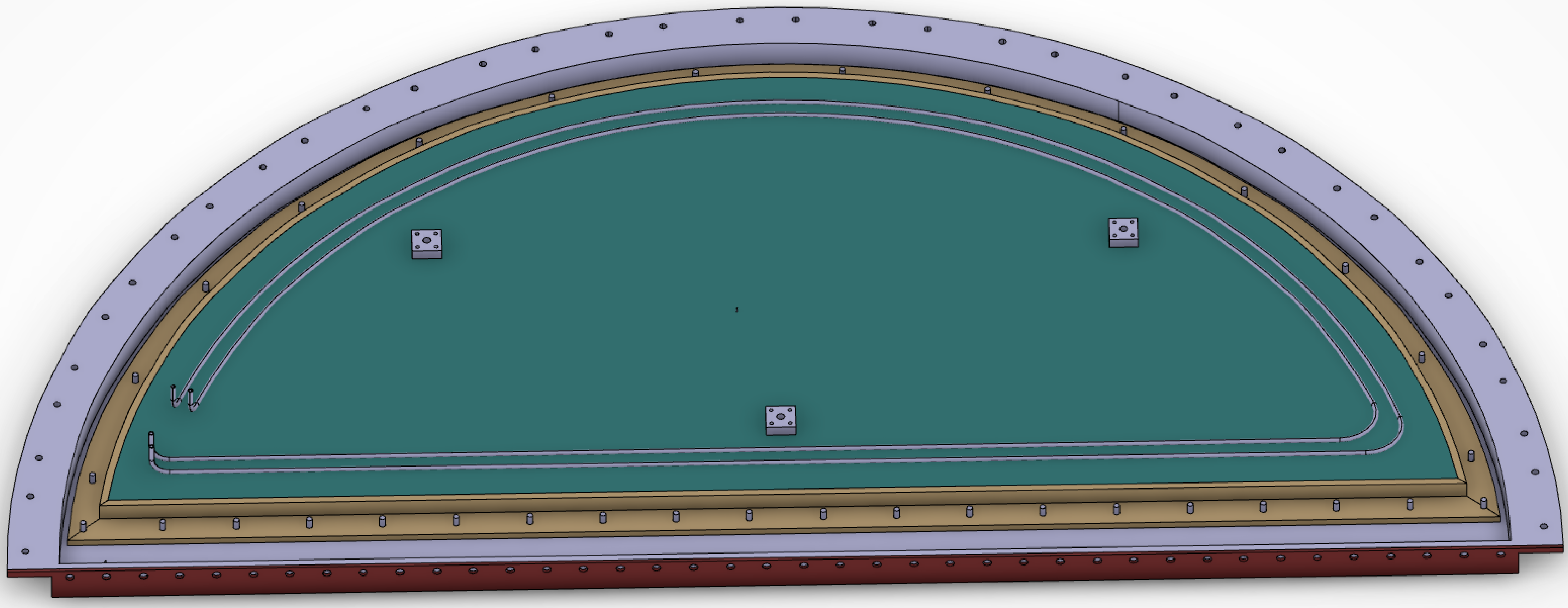
Figure 4.0.1. Explode of parts of PF3 Feeder TS Shrouds

STS side removal panel – 2200x1800x200mm (LxWxH), Panel thk. 10mm. Qty. 9

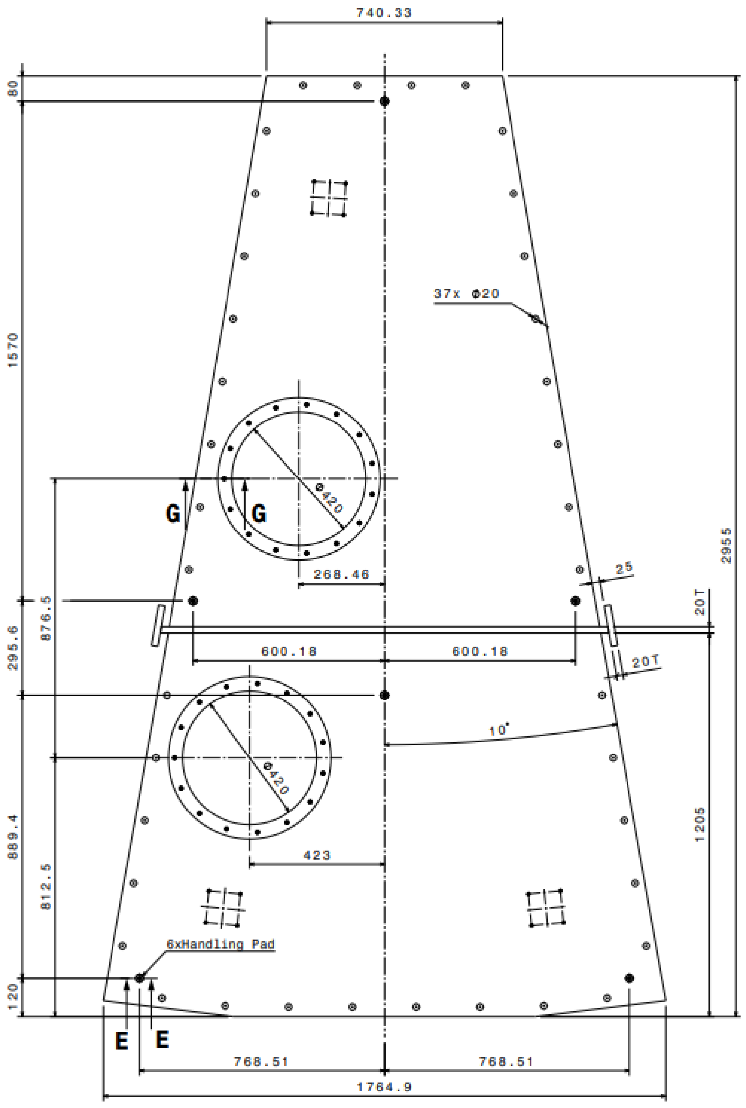




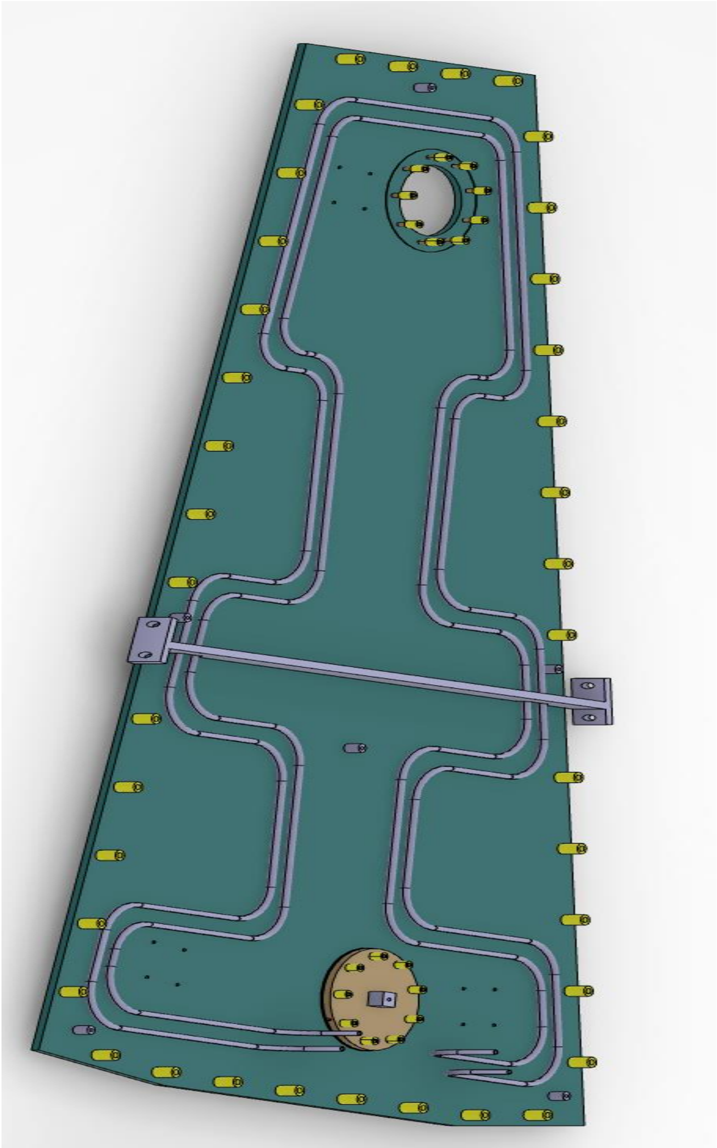
LCTS floor center – 4240mmOD, Panel thk. 10mm. Qty. 2



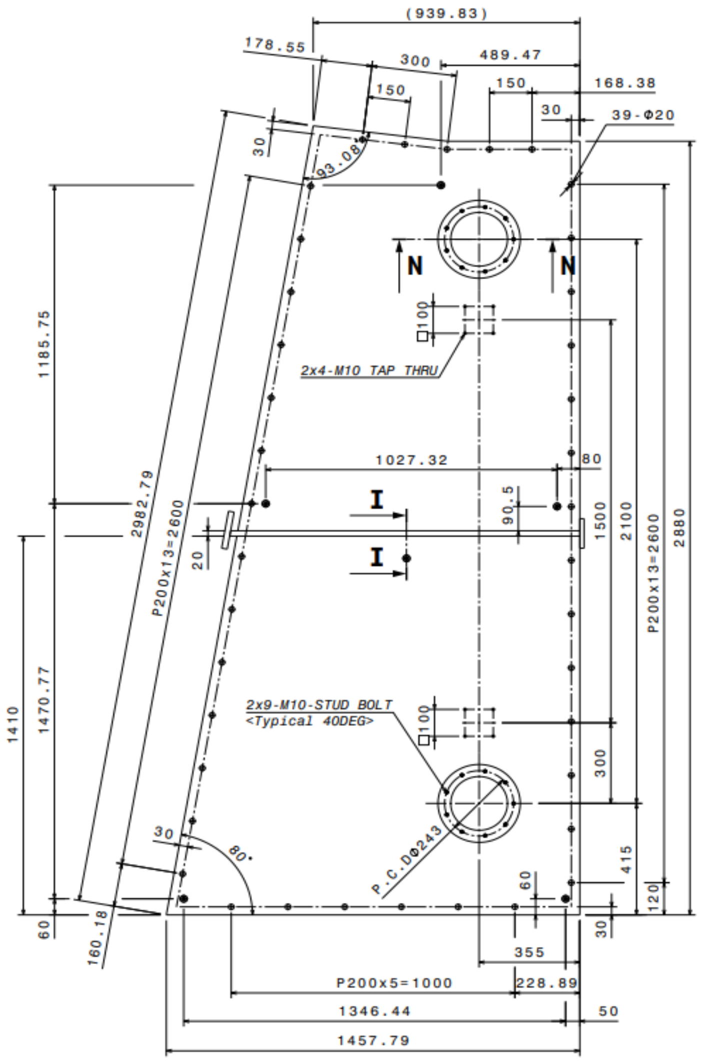
LCTS floor panel IB – 2900x1700x200mm (LxWxH), Panel thk. 10mm. Qty. 18



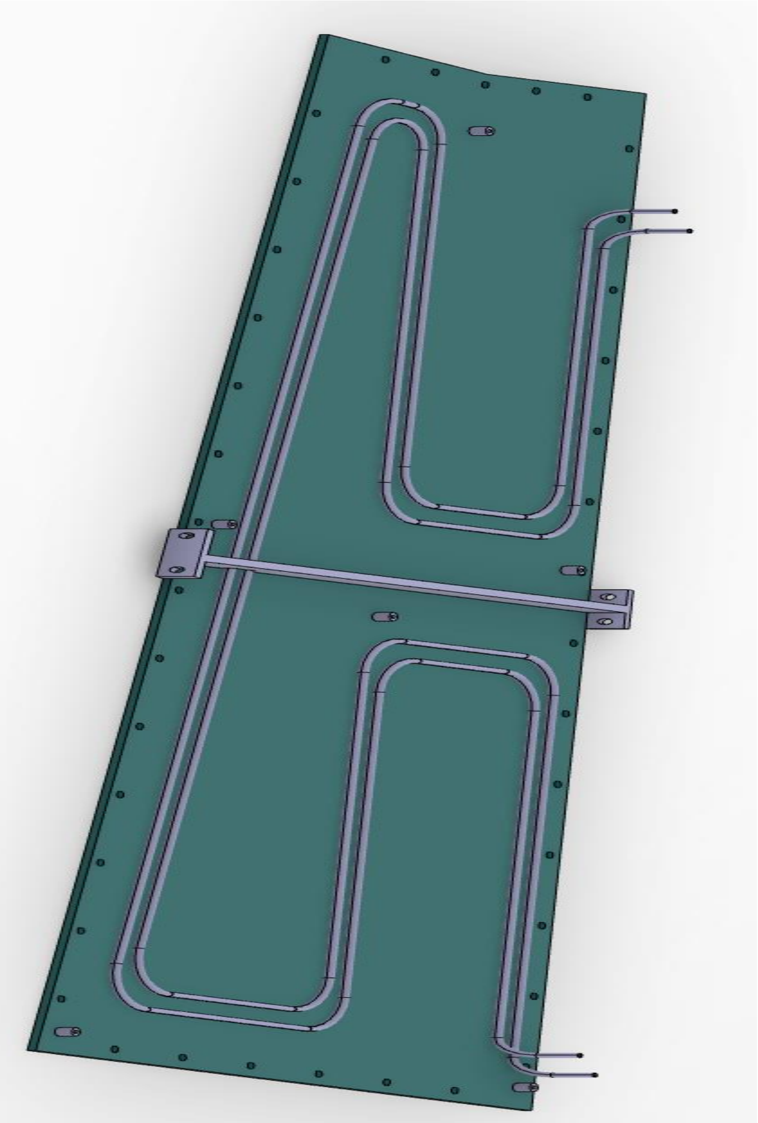
Panel Inboard Assy



LCTS floor panel OB – 2900x1400x200mm (LxWxH), Panel thk. 10mm. Qty. 36



Panel Outboard LHS Assy



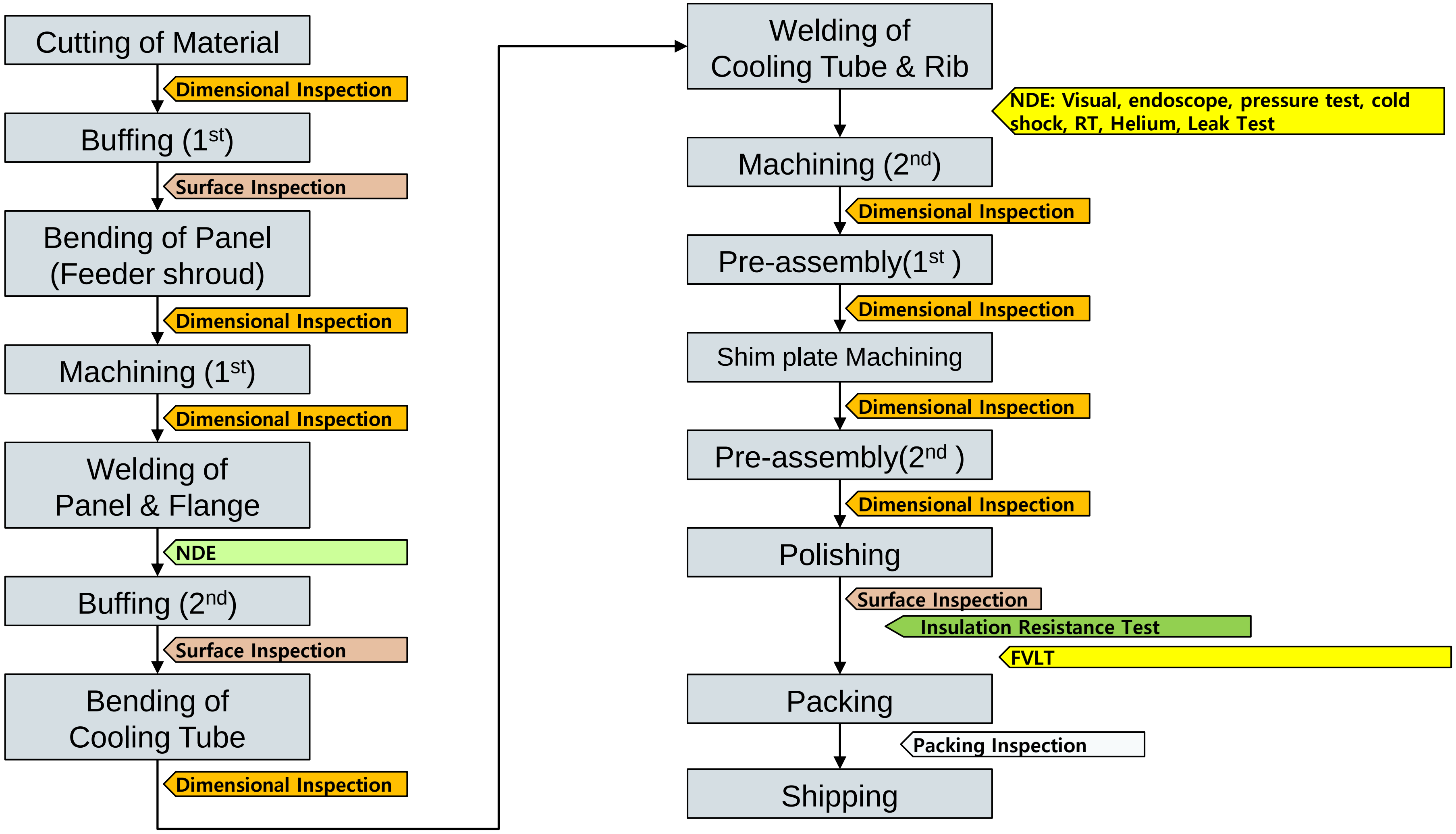
Contents

CTS Remanufacture Scope of Work

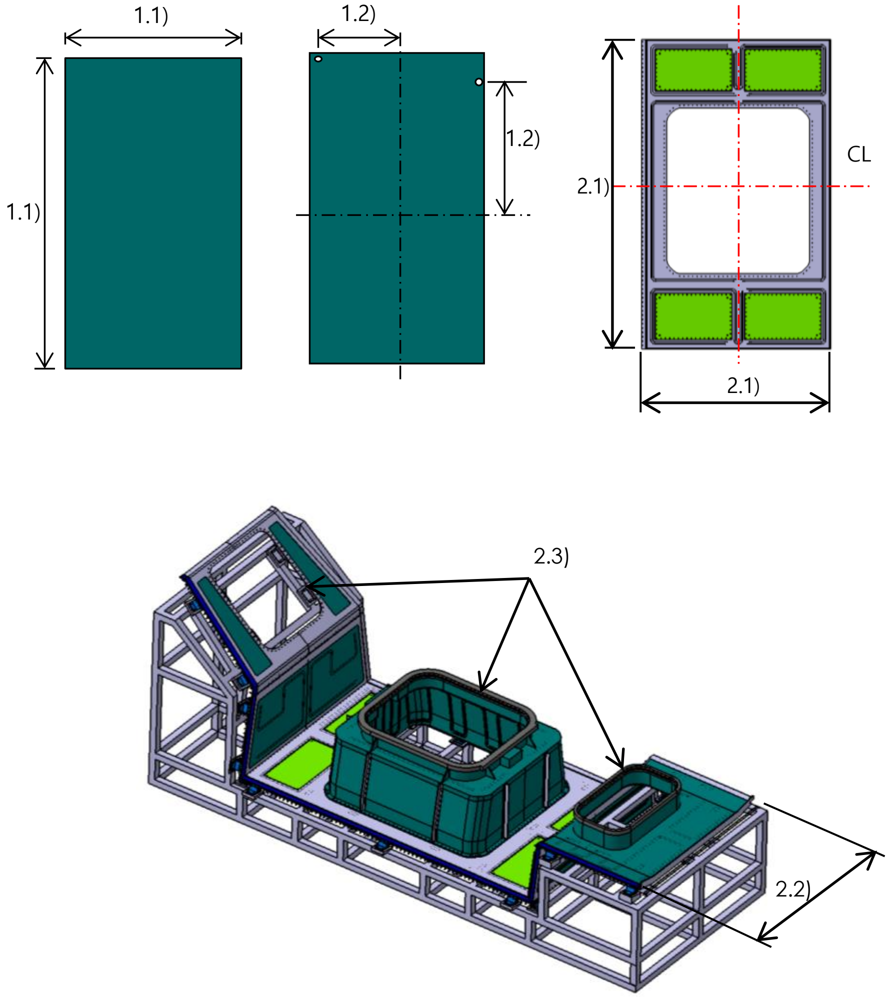
Considering the quality, cost, schedule, and risks for panel repair, we may remanufacture (without silver coating) all the panels instead of repair. The BoM is the same as repair scope of work but technical requirement are different. Please refer IO manufacturing drawings for detail requirements. Below is the main activities for remanufacture.

- To perform detail engineering for panel and pipe fabrication according to IO input drawings.
- To procure all the raw material for all the 297 no. panels
- To remanufacture all the 297 no. panels according to detail design.
- To perform NDE for panel and pipes according to IO requirement after each manufacture step.
- To provide all the machine, equipment, tools, consumable for the whole remanufacture process.
- To design and provide the frames needed for manufacture and transportation.
- To clean, packing and shipping the component to IO worksite.
- To perform dimensional inspection and as-built survey.

CTS Fabrication workflow

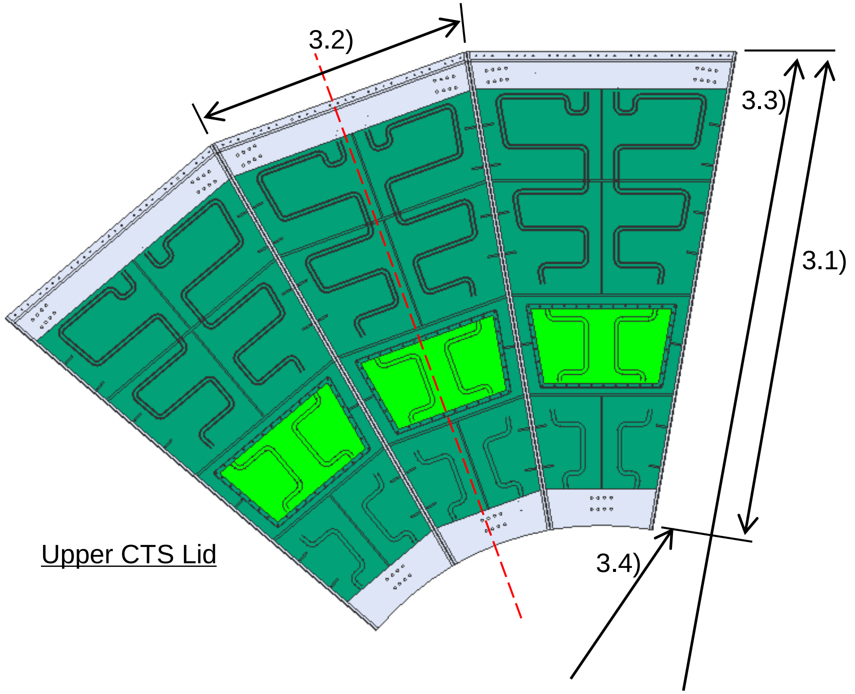


CTS Remanufacture - Tolerance Requirement



Items		Tolerance
Description	**Figures**	
General Tolerances of CTS and STS		
1) Overall length and width for the all panel in pieces	See mark **1. 1)**	±5 mm
2) Tolerance of drilled holes from the center line of all parts in pieces	See mark **1. 2)**	±1 mm
3) Mismatch of drilled holes between assembles.	**-**	±2 mm
4) Panel plate thickness	-	±1 mm
Equatorial CTS and STS		
1) Overall length(= L) and width(=W) for the each 20º -Panel & Frame	See mark **2. 1)**	±2 mm
2) Overall width of the Central CTS after pre-assembly of the 20º sector	See mark **2. 2)**	±2 mm
3) Positioning tolerances of the upper port connecting duct, equatorial port connecting duct, and lower port con-necting duct after pre-assembly	See mark **2. 3)**	±5 mm
Mutual deviation of the all sectors in the 360º toroidal direction	-	15 mm
Mutual deviation of the all sectors in the 360º poloidal direction	**-**	10 mm

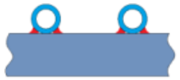
CTS Remanufacture - Tolerance Requirement



Items		Tolerance
Description	Figures	
Floor CTS		
1) Overall length for the each 20º -Panel & Frame		±5 mm
2) Overall width for the each 20º -Panel & Frame in outer diameter		±5 mm
3) Overall width for the each 20º -Panel & Frame in inner diameter		±3 mm
4) Outer diameter of the 360º floor sector		±7 mm
5) Inner diameter of the 360º floor sector		±3 mm
Lid CTS		
1) Overall length for the each 20º -Panel & Frame	See mark **3. 1)**	±5 mm
2) Overall width for the each 20º -Panel & Frame in outer diameter	See mark **3. 2)**	±5 mm
3) Overall width for the each 20º -Panel & Frame in inner diameter		±3 mm
4) Outer diameter of the 360º floor sector	See mark **3. 3)**	±7 mm
5) Inner diameter of the 360º floor sector	See mark **3.4)**	±3 mm

CTS Remanufacture - NDE Inspection

- ➢ Pipe to pipe weld (orbital welding) 100% RT, cold shock test, pressure test, helium leak test and endoscope inspection.

NDE INSPECTION PLAN FOR WELDING JOINT			
Description	Welding Joint	Requirement	ASME SEC VIII DIV. 2
Flange + Flange		RT or UT	RT or UT 10% PT 10%
Panel + Panel		PT	Visual inspection
Panel + Flange		PT	Visual inspection
Panel + Port shell		PT	Visual inspection
Panel + cooling tube		Endoscope	Visual inspection