Flexible supports of the COMPASS Upgrade tokamak

TECHNICAL SPECIFICATION

CU_CUPG-02-01-01_PTD_Annex No. 1 – Technical Specification

IPP INSTITUTE OF PLASMA PHYSICS OF THE CZECH ACADEMY OF SCIENCES

Inspection

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LIST OF RELEVANT STANDARDS AND OTHER DOCUMENTS

EN 1090-2	Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures
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EN 10222-5	Steel forgings for pressure purposes - Part 5: Martensitic, austenitic and austenitic-ferritic stainless steels
EN 10250-4	Open die steel forgings for general engineering purposes - Part 4: Stainless steels
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EN ISO 5817	Welding — Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded) — Quality levels for imperfections
EN ISO 9606-1	Qualification of testing of welders - Fusion welding – Part 1: Steels
EN 14732	Welding personnel – Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials
ISO 15614-1	Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys
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EN 10204	Metallic products - Types of inspection documents

EN ISO 6892-1	Metallic materials — Tensile testing — Part 1: Method of test at room temperature
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EN ISO 22825	Non-destructive testing of welds — Ultrasonic testing — Testing of welds in austenitic steels and nickel-based alloys
EN ISO 23279	Non-destructive testing of welds - Ultrasonic testing - Characterization of discontinuities in welds
ASTM F21-20	Standard Test Method for Hydrophobic Surface Films by the Atomizer Test
CEN/TS 13388	Copper and copper alloys - Compendium of compositions and products
ISO 2768-1	General tolerances — Part 1: Tolerances for linear and angular dimensions without individual tolerance indications
EN ISO 10012	Measurement management systems — Requirements for measurement processes and measuring equipment

1 BASIC DESCRIPTION AND EXTENT OF DELIVERY

1.1 Subject of the delivery

[1.1.1]
The subject-matter of the contract is manufacture (including purchase of materials and specified tests), assembly and delivery of **16 Flexible supports of the COMPASS Upgrade (COMPASS-U) tokamak.** The assembly of each flexible support will take place at the place of manufacture (**the production site**). Once the flexible supports are fully assembled at the Supplier's production site, the Supplier shall measure the dimensions of the supports and assess its compliance with the specification. After the compliance check-up, the Supplier will arrange for delivery of the flexible supports to the COMPASS-U assembly site (**the construction site**).

1.2 Purpose of the flexible supports

[1.2.1]
Flexible supports of the COMPASS-U serve as supports of the steel support structure of a new scientific device, the COMPASS-U tokamak. This device is designed to confine hot plasma allowing studies of thermonuclear fusion physics. Strong magnetic field will be used to confine the plasma and extreme electromagnetic forces are expected to be acting on structures of the tokamak. This places high demands on the strength of the flexible supports and the magnetic properties of the material and the fasteners used. Therefore, all materials used to produce the flexible supports must be of high strength and non-magnetic (or only weakly magnetic) and it is essential to test each batch of the used material for its strength and magnetic properties. AISI 316L stainless steel (see below for more details) was chosen as the main structural material for the flexible supports. Mechanical design of the flexible support is shown in Figure 1.

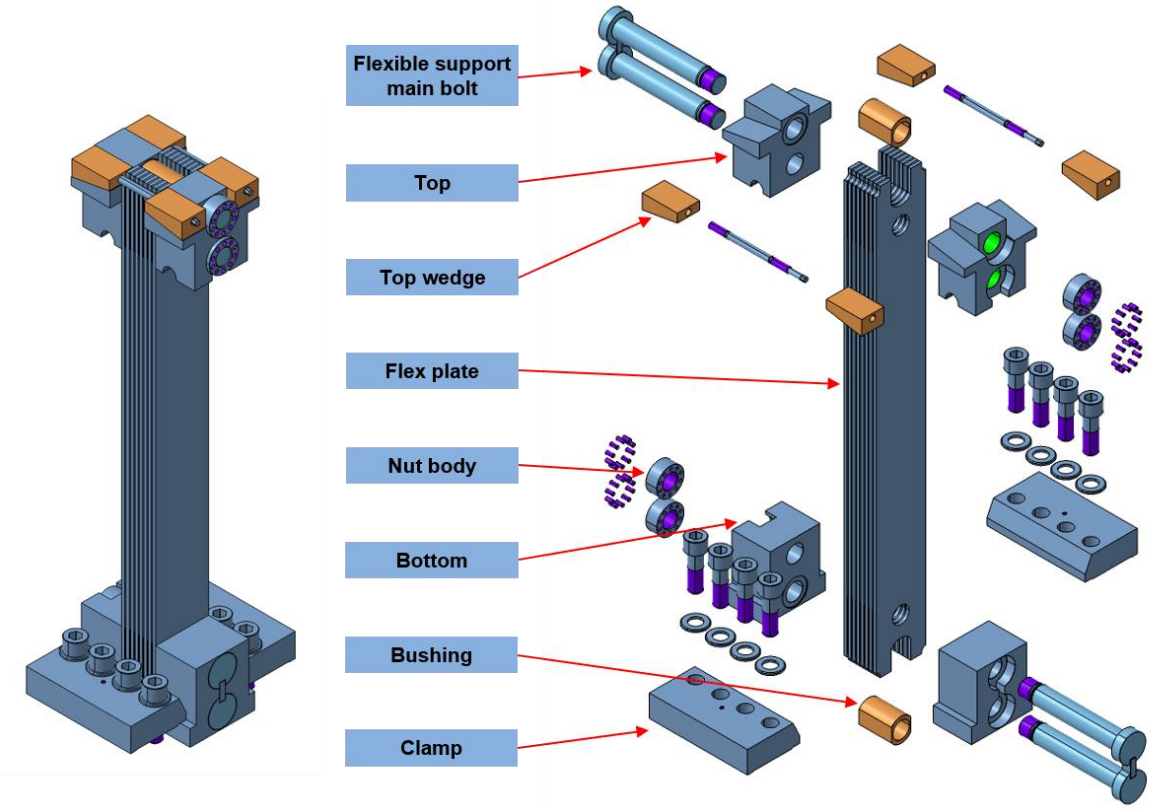

Figure 1 Left: CAD model of the flexible support. Right: exploded view of the flexible support components.

[1.2.2]
The function of the 16 flexible supports is to ensure a precise and stable position of the support structure which supports another tokamak components as coils and the vacuum vessel of the device. This means supporting the device, fixing its position precisely and transferring the dynamic forces that arise during operation, these include namely:

- gravitational force of the tokamak device of ~ 300 t in total,
- rapid shock forces generated by a sudden interruption of the current in the plasma acting on tokamak structures with a total force in the order of several MN transferred to the flexible supports,
- thermomechanical forces associated with the operating temperature of the support structure (77 K to 293 K) attached to the flexible supports at their top ends and room temperature cryostat base attached to the flexible supports at their lower ends.

[1.2.3]
There will be a temperature gradient from 77 K to 293 K along the flexible supports when the support structure is operated at 77 K and the top end of the flexible supports will be translated approximately 10 mm in horizontal direction with respect to the lower end. This is due to thermal shrinkage of the support structure while the lower end of the flexible supports is attached to a room temperature cryostat – see Figure 2.

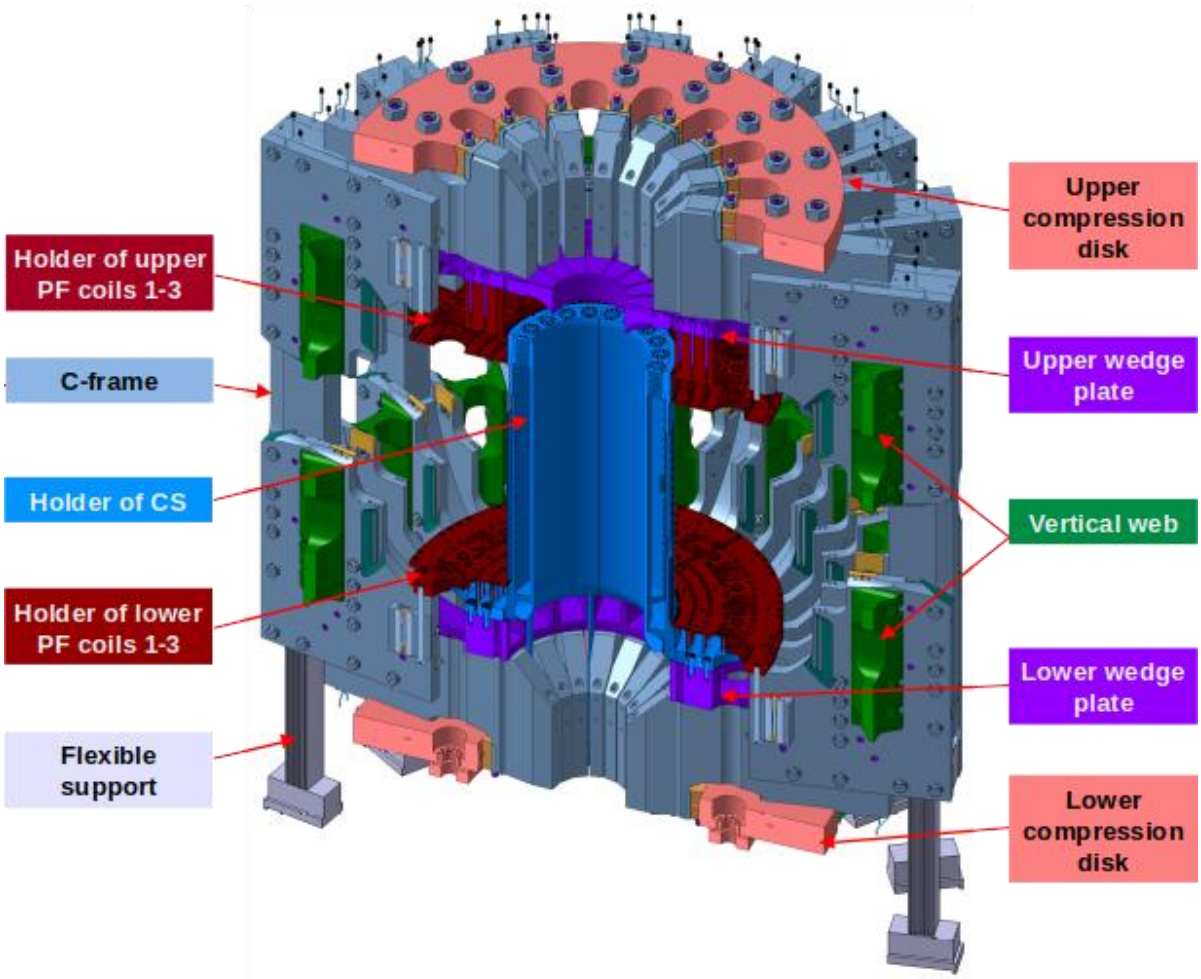

Figure 2 Cross-section of the COMPASS-U support structure with flexible supports attached from the bottom.

1.3 Classification of the flexible supports

[1.3.1]
The Supplier shall follow the directive 2001/95/ES for the manufacturing and delivery of the flexible supports.
Application of the standard EN 1090-2 EXC3 is required wherever it is not specified differently in this technical specification.

1.4 Design of the flexible supports

[1.4.1]
Part of the Technical Specification is the initial design of the flexible supports. The supplier will prepare Production Documentation including manufacturing drawings of individual parts based on this specification.

[1.4.2]
Partial modifications of the design of the flexible supports by the Supplier are possible, provided that the structural limits of the materials are not exceeded, and the functional properties of the flexible supports are not limited.

[1.4.3]
The combined mechanical and thermal stress shall not exceed two-thirds of the yield strength ($R_{p0.2}$) of the material of the flexible supports at the operating temperature.

[1.4.4]
All changes to the flexible supports in comparison to the initial design must be approved by the Contracting Authority.

2 TECHNICAL ASSIGNMENT

2.1 Construction material

[2.1.1]
The material for the flexible supports must meet the requirements arising from specific environmental conditions: high mechanical loads, high vacuum, operating temperature ~77-293 K and high magnetic field.

[2.1.2]
Construction materials of the main components of the flexible support denoted according to EN 10088-3, EN ISO 3506-1 and CEN/TS 13388 and their mandatory mechanical parameters are listed in Table 1. Material of remaining components is specified in the attached drawing and their properties shall follow EN 10088-3 and EN ISO 3506-1.

Table 1 Material parameters of individual components.

Part number	Item	Material	Alternative material	$R_{p0.2}$ (293 K) Yield strength at 293 K	R_m (293 K) Ultimate tensile strength at 293 K
102659_V01_PRT	TOP	316 L (1.4404)	316LN (1.4429)	210 MPa	
102660_V01_PRT	TOP				
102665_V01_PRT	BOTTOM				
102666_V01_PRT	BOTTOM				
102663_V01_PRT	FLEX PLATE			250 MPa	
102698_V01_PRT	FLEXIBLE SUPPORT MAIN BOLT	316 LN (1.4429)	A4-80	300 MPa	500 MPa
102711_V01_PRT	TENSIONING BOLT	A4-70		300 MPa	500 MPa
102708_V01_PRT	NUT BODY	316LN (1.4429)	A4-80		
102661_V01_PRT	TOP WEDGE 1	CuAl10Fe3Mn2 (CW306G)	316L (1.4404) or 316LN (1.4429) with TiN coating	100 MPa	
102662_V01_PRT	TOP WEDGE 2			100 MPa	
102697_V01_PRT	BUSHING			200 MPa	

[2.1.3]
Furthermore, the used steel must achieve an absorbed energy value of at least 60 J at 77 K in the standard Charpy impact test (see EN ISO 148-1, KV_2 value).

[2.1.4]
Ensuring low magnetic permeability is an important requirement for the flexible support material. Sufficiently stable materials with low magnetic permeability in the temperature range of 77-293 K, for which the permeability does not increase even in locally loaded areas, must be used. Processing (e.g. welding) must be done using methods that do not lead to an increase in the magnetic permeability of the processed materials.

[2.1.5]
Materials used for manufacture of flexible supports shall meet limits for relative magnetic

permeability specified in Table 2:

Table 2 Requirements on magnetic permeability of used materials.

Binding requirements for rel. magnetic permeability	T=293 K	T=77 K
Base material	< 1.02	< 1.05
Welds	< 1.1	< 1.2
Milled and otherwise machined surfaces (surface layer thinner than 2 mm)	< 1.2	< 1.3
Bolts larger than M30 under load	< 1.1	< 1.2
Bolts smaller than M30 under load	< 1.2	< 1.3
Aluminium bronze material (CuAl10Fe3Mn2)	< 1.4	

2.2 Steel quality

[2.2.1]
The supplier shall verify the quality of the steel by classifying the internal defects in the material in accordance with EN ISO 10228-4 for forgings and EN 10307 for flat products (or equivalent).

[2.2.2]
Quality class 3 according to EN ISO 10228-4 is required for forgings. Quality class S3/E4 is required for flat products. Acceptance of lower quality class is subject to approval by the Contracting authority.

2.3 Welds

[2.3.1]
The Supplier can propose design modification in order to use welds instead of the bolted connections. Such design modification is subject of approval by the Contracting Authority.

[2.3.2]
Welds shall not contain closed volumes with capillary connection to the surface (see CU_ORD_VacuumRequirements).

[2.3.3]
Welds on all components must have a clean metal surface. It is not necessary to machine the welds. The welds must be free of scale, holes, capillaries, burns and other similar defects.

[2.3.4]
The selected weld metal material shall be compatible with the base material and provide stability against delta ferrite formation and thus also limit the risk of increased magnetic permeability in the weld even when cooled down to 77 K.

[2.3.5]
For structural welds, a non-destructive test of the welds shall be carried out to detect possible defects. The Supplier shall design a suitable test method for each weld and describe it in the Production Documentation.

[2.3.6]
Welds and their inspection will be performed in accordance with standards EN ISO 3834-2 and EN 1011-3 and welding procedure qualification according to EN ISO 15607, EN ISO 15609-1, EN ISO 15614-1, and related standards, i.e. welding procedure specification (WPS) and welding procedure qualification report (WPQR) are required. Welding must be performed by personnel certified according to EN ISO 9606-1. The welding must follow EN ISO 5817 and meet the quality requirements for category B set in this standard.

[2.3.7]
If the option to use structural welds is used, the Contracting Authority also requires a demonstration on 3 sample welds, with similar volume and geometry to the final product using the same materials. These samples will be submitted to the Contracting Authority for analysis.

2.4 Surface treatment

[2.4.1]
The aim of surface treatments is to achieve vacuum and low temperature compatibility. The surface treatment of the flexible supports shall minimize the actual surface area, allow cleaning of parts suitable for high vacuum and prevent vacuum low temperature welding.

[2.4.2]
The maximum permissible roughness of machined and unmachined surfaces of the flexible supports must not exceed the value Ra3.2, measured in accordance with ISO 21920-2:2021. The Surface roughness requirement can be loosened to Ra25 for non-functional/contactless surfaces. The desired surface roughness can be achieved via:

- Machining.
- Stainless steel shot blasting or shot peening to compact the surface.
- Surface passivation.

The used technology must not introduce unwanted impurities into the surface of the material.

[2.4.3]
The surface shall generally be easy to clean, and wiping with a cloth napkin must not tear the fibres of the napkin.

[2.4.4]
All cutting fluids shall be water soluble, free of halogens, phosphorus and sulphur. Where this is not possible, a suitable cleaning method shall be provided to maintain the required cleanliness of the part, see chapter 5 Cleaning.

[2.4.5]
All bolts shall be treated against galling with regards to the high vacuum and cryogenic temperature environment. A suitable coating method is silver plating or TiN coating.

[2.4.6]
The anti-seize coating will be applied to the functional part of the bolts, i.e. their threads. Coated washers under the bolt heads or nuts shall be used. In cases where this is not possible, the entire surface of the bolt shall be coated.

[2.4.7]
At interfaces where there is a risk of sticking of parts together, use of Al-Bronze is proposed to minimise the risk of vacuum welding. Alternatively, stainless steel with TiN coating can be used.

2.5 Vacuum compatibility

[2.5.1]
The flexible supports will be located inside a cryostat with strict high vacuum requirements (pressure of ~10^{-5} Pa). This creates constraints on dead volume, outgassing and material finish requirements.

[2.5.2]
No part of the flexible supports shall contain virtual leakage caused by the presence of dead volumes. Dead volume means any free space in the volume of the material that is connected to the surface of the material by a passage with a cross-section <1mm^2.

[2.5.3]
All welds (if any) must be pickled or passivated either by chemical means (pickling gel/solution) or by electrochemical pickling. Any solution used must then be neutralised and thoroughly cleaned.

[2.5.4]
The flexible supports must be cleaned before packing for transport. When packing, it is necessary to make precautions to avoid any contamination of the cleaned parts. Used lifting devices, means of transport, auxiliary fasteners and tools must be thoroughly cleaned before handling parts to avoid contamination of cleaned parts and packing material.

[2.5.5]
Detailed specification of vacuum compatibility is provided in the accompanying document CU_ORD_VacuumRequirements.

2.6 Tolerances

[2.6.1]
Tolerances for the assembly of the flexible supports are indicated in the attached drawing.

[2.6.2]
ISO 2768-mK tolerances should be followed where not specified differently.

3 DRAWINGS AND 3D CAD DATA

[3.1.1]
The 3D CAD model of flexible supports is available in the archive *CU_CUPG-02-01-01_PTD_Annex No. 1 – Technical Specification-A1-CATIA.zip* and in the file *CU_CUPG-02-102658_V01_ASM_C05_CAD.stp*.

[3.1.2]
The assembly drawing of the flexible support is provided in the file *CU_CUPG-02-01-01-102658_V01_DRW_B02_DRW.pdf*. Manufacturing drawings of individual parts shall be prepared by the Supplier as part of the Production Documentation (see section 7.3).

[3.1.3]
The documents referred to in [3.1.1] and [3.1.2] are an integral part of this Technical Specification.

[3.1.4]
In the event of a discrepancy between the information provided in different documents, the following order of importance shall apply from highest to lowest:

1. Technical specification (base document),
2. 3D CAD model,
3. Drawing documentation.

[3.1.5]
The locations for the bolt threads are marked in the 3D models with an RGB colour code: (128, 0, 255) (dark purple).

4 INSPECTION AND TEST REQUIREMENTS

4.1 Proof of the chemical composition

[4.1.1]
The Supplier shall prove compliance of a chemical composition of materials intended for the manufacture of the flexible supports with prescribed standards (see section 2.1).

4.2 Demonstration of mechanical properties of materials

[4.2.1]
The Supplier shall document mechanical properties for each batch of materials to be used in the manufacture of the flexible supports.

[4.2.2]
The tensile test will be carried out according to EN ISO 6892-1 at room temperature.

[4.2.3]
The Charpy impact test will be carried out at 77 K according to EN ISO 148-1 and related standards.

4.3 Demonstration of magnetic properties of materials

[4.3.1]
The supplier shall carry out a test of the relative magnetic permeability for each batch of materials intended for the manufacture of the flexible supports.

[4.3.2]
The relative magnetic permeability of the material at room temperature shall comply with the requirements given in [2.1.5]. Alternatively, a test at liquid nitrogen temperature (77 K) can be performed and if the material meets the requirements of [2.1.5] at this temperature, it can be used for the manufacture of the flexible supports without necessity of the room temperature test.

[4.3.3]
The measurements will be carried out according to EN 60404-15, preferably using a magnetic permeability meter (chap. 6 of the standard).

4.4 Proof of dimensional conformity

[4.4.1]
For each manufactured flexible support, the Supplier shall prove the dimensional conformity with the approved Production Documentation.

[4.4.2]
The dimensional conformity check shall be performed by measuring instruments with a valid metrological confirmation according to EN ISO 10012. The Contracting Authority can request the Supplier to provide valid calibration certificates.

[4.4.3]
The Supplier shall, upon request and without undue delay, allow the Contracting Authority to inspect the dimensions of any part by its own measuring instruments.

4.5 Proof of quality of semi-finished steel products

[4.5.1]
The Supplier shall prove the volume quality of the steel semi-finished products of the main flexible

support components (components 102698, 102665, 102666, 102663, 102659, 102660) by a non-destructive testing (NDT): by the radiographic method (X-ray) or ultrasonic method. For forgings the tests are governed by EN 10228-4, for flat products by EN 10307 or equivalent. Full volume inspection (100% testing) is required for the above-mentioned components

[4.5.2]
On the basis of the made NDT, the Supplier shall draw up a report to document the compliance of the steel with the requirements set out in chapter 2.2.

[4.5.3]
The Supplier shall perform a local test of all welds (if any). The Supplier shall design a suitable non-destructive testing method for each weld and describe it in the Production Documentation.

[4.5.4]
The Supplier shall demonstrate in a protocol that the quality of all welds (if any) conforms to the requirements set out in chapter 2.3. Each weld report will include a photograph of the weld and the result of the examination.

4.6 Tests of fasteners

[4.6.1]
Testing of chemical composition and mechanical properties of fasteners shall be secured and documented or certificates 3.1 according to EN 10204 proving conformity with prescribed material and strength class shall be provided.

[4.6.2]
Conformity of magnetic permeability of fasteners with requirements stated in chapter [2.1.5] shall be demonstrated for randomly selected fasteners in the amount of 10% from each fastener type.

5 CLEANING

5.1 Cleaning the parts before assembling of each flexible support

[5.1.1]
The flexible supports will be transported to the construction site in assembled condition. Individual parts must be carefully cleaned and completely degreased before assembly (as this cannot be done afterwards without the need to disassemble and reassemble them). Cleaning of parts of sawdust, scale, grease, and other contaminants must be carried out in accordance with the rules for the use of parts in high vacuum and the document CU_ORD_VacuumRequirements.

[5.1.2]
After cleaning, the Supplier shall limit the handling of parts as much as possible. All subsequent operations, especially packing and placing on transport frames, shall take place in a clean environment.

[5.1.3]
Already assembled flexible supports can only be lightly cleaned before packing if needed - for example, blowing off dust with dry nitrogen or cleaning individual areas with solvents (wash with acetone and then with pure ethanol or pure isopropanol). The assembly as a whole can no longer be washed with the recommended cleaning procedure due to possible fluid deposits in inaccessible areas.

5.2 Cleaning procedure

[5.2.1]
Cleaning of the components of the flexible supports is a multi-step process to remove any contaminants (grease, oils, etc.) that would restrict the evacuation of the cryostat in which the flexible supports will be installed in. The source of contamination by impurities is usually the material production process (scale, dirt, etc.), machining (cutting fluids, etc.) and handling (hand grease, sweat, contamination of handling equipment, etc.).

[5.2.2]
All processes used for cleaning or handling of parts of the flexible supports shall be vacuum compatible.

[5.2.3]
The cleaning procedure must not disturb the surface finish of the parts.

[5.2.4]
Recommended cleaning procedure:

- Step 1 - Mechanical cleaning: Removal of coarse dirt by suitable means - brushes, compressed air, vacuum cleaner.
- Step 2 - Washing: Wash with a suitable detergent (for example Elma Clean 115c or Tickopur R33) diluted in deionised water at the appropriate temperature.
- Step 3 - Cleaning: Cleaning in an ultrasonic cleaner or high-pressure cleaner.
- Step 4 - Rinsing: Remove detergent and remaining dirt with deionised water. A high-pressure cleaner can be used.
- Step 5 - Drying: Drying in a low-dust, hydrocarbon-free atmosphere. Dry nitrogen or a clean air stream can be used.
- Step 6 - Cleanliness check

[5.2.5]
The Supplier shall clean all parts of the flexible supports except the long flexible plates (part

102663_V01) in an ultrasonic cleaner. Use a high-pressure water cleaner is allowed for the long flexible plates (part 102663_V01) if cleaning in ultrasonic cleaner is not feasible.

[5.2.6]
The cleanliness check must pass three tests:

- Test 1: UV light verification. The entire surface of the parts must be illuminated in the dark with a sufficiently strong UV-A source and all surfaces must be visually inspected. No contamination (layers, splashes, droplets, spills, etc.) must be visible under UV light.
- Test 2: Verify cleanliness with a clean cotton cloth. After wiping the surface, there must be no visible contamination of dirt on the cloth.
- Test 3: Verification of purity with deionised water. When spraying with deionised water, a continuous layer of water must be formed on a flat surface (no beading up of water).

The recommended procedure for performing the tests is given in ASTM F21.
If the cleanliness verification fails, the cleaning process must be repeated.

[5.2.7]
The details of planned processes for cleaning or handling shall be described in the production documentation and shall be approved by the Contracting Authority as part of the approval of the entire documentation. If these processes are changed or new processes are selected during the course of the work, these processes shall be approved by the Contracting Authority prior to their application.

[5.2.8]
The proposed cleaning procedures must be appropriate to the type of contamination. If cutting fluid is used for machining, it must be verified that it is cleanable by the proposed procedure.

[5.2.9]
After cleaning, all parts shall be handled in such a way that their cleanliness is not compromised. The use of clean gloves (powder-free latex or nitrile gloves, cotton gloves) is mandatory. Gloves must be changed regularly to prevent cross-contamination.

6 MARKING AND TRANSPORT

6.1 Marking of parts and transport frames

[6.1.1]
All flexible supports shall be marked electrochemically or by stamping or a similar method with a unique number from 01 to 16.

[6.1.2]
The position of the marking in relation to the flexible support must be the same for all pieces and shall be agreed with the Contracting Authority.

[6.1.3]
Supplier shall pack marked flexible supports and place them on transport frames. All transport frames must be clearly marked with a label on the frame. The marking shall contain identification(s) and weight(s) of flexible support(s).

6.2 Packaging and handling

[6.2.1]
Cleaned flexible supports shall be carefully packaged to prevent contamination during handling, storage and transport. Preferred materials used for packaging are polyethylene, aluminium foil, cellulose-based fabric/paper, or a combination thereof. All materials used shall be low in volatile substances (dyes, plasticizers, anti-corrosives, hydrocarbons, etc.)

[6.2.2]
All surfaces shall be protected against accidental damage (during handling, storage, etc.). The packaging must be able to withstand all planned operations, e.g. lifting by crane, lifting by forklift, attachment to truck trailer, etc.

[6.2.3]
The use of adhesive tape to protect and package parts is limited to packaging where steel will not be contaminated by the tape. The adhesive tape must not come into contact with the surface of the parts.

[6.2.4]
Flexible supports shall be packed dry.

[6.2.5]
Persons handling parts must wear clean powder-free latex, nitrile or cotton gloves and be dressed in clean work overalls. All such protective equipment must be changed frequently enough to prevent cross-contamination.

[6.2.6]
The handling equipment used must not cause contamination of clean parts. Care should be taken especially (but not exclusively) with tie-downs (e.g. oil curtains, ropes or hooks) and crane hoists / crane tracks/ forklifts (dripping lubricant).

6.3 Transport

[6.3.1]
Transport to the Construction site shall be carried out only after approval of all required documents by the Contracting Authority – see chapter 7.

7 DOCUMENTATION

7.1 General requirements on documentation

[7.1.1]
The Supplier shall prepare a **Production Documentation**, **Quality Documentation** (individual certificates, test reports etc.), **As-built Documentation** and **Photo Documentation**.

[7.1.2]
The documentation shall be prepared either in Czech or in English language. The documentation is subject to the approval of the Contracting Authority as well as any revision of the documentation.

[7.1.3]
The Supplier shall submit the **Production Documentation** to the Contracting Authority for approval no later than **3 months after the effective date of the contract**.

[7.1.4]
The Supplier shall submit the **As-built Documentation**, **Photo Documentation** and **Quality Documentation** to the Contracting Authority for approval prior to the transportation of the flexible supports to the construction site.

[7.1.5]
The contracting authority shall review the documentation and either approve or request modifications within 15 days of receipt for approval.

[7.1.6]
Ordering the material prior to the approval of the Production Documentation is on the own risk of the Supplier as this might by incompatible with the final approved documentation.

7.2 Quality Documentation

[7.2.1]
The Supplier shall provide certificates and attestations related to the manufacture of the flexible supports (qualification of welders, WPS, WPQR, …) prior to any related activity.

[7.2.2]
On the basis of the inspections and tests carried out, the Supplier shall without undue delay issue

1. certificates of the chemical composition of the structural material,
2. certificates of the magnetic properties of the structural material,
3. certificates of the mechanical properties of the structural material,
4. protocols of NDT of the volume quality of semi-finished products,
5. metrological protocols for the manufactured parts,
6. weld inspection protocols, if applicable.

The protocols shall contain identification and calibration status of the equipment used, and identification of the inspector/tester. All protocols are subject to the approval of the Contracting Authority.

[7.2.3]
The Supplier shall issue all inspection documents related to the chemical composition, mechanical and magnetic properties of the structural material as Inspection Certificates 3.2 according to EN 10204 on its own expenses. Inspection Certificates 3.2 shall be approved by a third-party certified inspection authority selected based on prior approval by the Contracting Authority (e.g. TÜV SÜD, TÜV NORD, TÜV Rheinland or other).

7.3 Production Documentation

[7.3.1]
The Supplier shall prepare **Production Documentation** that shall, among other things, contain the final design of the individual parts of the flexible supports and describe in detail manufacturing process of the individual parts of the flexible supports (including welding documentation, if applicable) and their assembly.

[7.3.2]
The Production documentation shall contain **manufacturing drawings** and **3D CAD models** of all parts of the flexible support. Drawings shall be provided in PDF format and 3D CAD models in CATIA V5-6 or STEP format.

[7.3.3]
The Production documentation shall contain detailed **Inspection and Test Plan** in accordance with chapter 4.

[7.3.4]
The Production Documentation shall include a detailed **List of production materials**: i.e. the list of semi-finished products (forgings, rolled plates, ...) for the manufacture of individual parts of the flexible supports.

[7.3.5]
The List of production materials shall include following information for individual items:

- material,
- dimensions,
- weight.

[7.3.6]
The Contracting Authority reserves the right to designate selected manufacturing, inspection, test and/or assembly operations as mandatory Witness or Hold points. The Supplier shall provide the Contracting Authority with notice five working days in advance of such points.

7.4 As-built Documentation

[7.4.1]
The Supplier shall prepare the **As-built Documentation** to document all changes made to the flexible supports components and procedures compared to the approved Production Documentation.

[7.4.2]
In the case of small changes, the As-built Documentation may be in the form of an annex to the Production Documentation.

7.5 Photo Documentation

[7.5.1]
The Supplier will provide Photo Documentation of the entire production process. The aim of the Photo Documentation is to document the methods of machining and handling of individual manufactured parts.

8 OTHER

[8.1.1]
If the Contracting Authority requests the Supplier to make a geometric change to a component of the flexible supports, the production of which has not yet started, and if this change does not require a change in the quantity of input raw materials or processing technology and time, the Supplier shall make this change without this affecting the time and price of the flexible supports.

[8.1.2]
The Supplier shall allow presence of representatives of the Contracting Authority during all stages of the manufacturing process. The Contracting Authority shall be granted the right to make photo and video documentation of the work in progress. Traveling of these representatives to the production site is on the expenses of the Contracting Authority.

[8.1.3]
The Contracting Authority and the Supplier shall meet at least once per month to discuss the progress of the realization of the extent of delivery. The form of the Regular Progress Meetings (online or in person) is to be agreed between both sides and shall be organized by the Supplier. The Supplier shall summarize the discussion that took place in Regular Progress Reports. The Regular Progress Report of the meeting shall be submitted one week after the meeting took place at the latest.

9 ACCOMPANYING DOCUMENTS

9.1 CAD data

CAD 3D models are provided in the archive *CU_CUPG-02-01-01_PTD_Annex No. 1 - Technical Specification-A1-CATIA.zip* and in the file *CU_CUPG-02-102658_V01_ASM_C05_CAD.stp*.

9.2 Drawing documentation

Technical drawing is provided in the file *CU_CUPG-02-01-01-102658_V01_DRW_B02_DRW.pdf*

9.3 Vacuum requirements

Detailed requirements on vacuum compatibility of used materials and for cleaning procedure are available in the document *CU_ORD_VacuumRequirements*.

9.4 Shipment unloading area

Details on the delivery site and shipment unloading area are available in the document *CU_DOC_ShipmentUnloadingArea*.