Elettra Sincrotrone Trieste

Technical Specification VAC#001	Revision: ...	Date: ...
Manufacturing and Cleaning Technical Specifications for ultra-high vacuum chambers and components		
L. Rumiz , I Cudin		

Revisions

Revision#	Date	Description	Author
01	07/12/2021	Updated version from FESD#060 – RGA test, Bake-out	L.Rumiz
Revision of § 1			
02	10/12/2021	Review of § 1	L.Rumiz
Revisione § 3, § 4, § 12 (lista file permessi)		(aggiornamento riferimenti ISO), (aggiunti materiali permessi),	
03	16/12/2021	Review of § 3 (updated ISO eferences), 4 (added allowed materials), § 12 (allowed files list)	I. Cudin

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1 INTRODUCTION

Elettra-Sincrotrone Trieste S.C.p.A. is a multidisciplinary international research center of excellence, specialized in generating high quality synchrotron and free-electron laser light and applying it in materials and life sciences.

The main assets of the research centre are two advanced light sources, the electron storage ring Elettra and the free-electron laser (FEL) FERMI, continuously (H24) operated supplying their light to more than 30 experimental stations.

The sources, the photon transport system and the experimental stations operate in ultra high vacuum (UHV).

UHV chambers, i.e. chambers operating at a pressure less than 10^{-9} mbar, and the materials and cleaning procedures are critical. Great care must be taken in the fabrication phase to prepare the chambers so that their specific outgassing is suitable to achieve and maintain the requested ultra high vacuum.

2 SCOPE OF THIS DOCUMENT

This document specifies the requirements and procedure that are to be used to produce components and chambers operating under UHV conditions.

This document applies to aluminum, steel and stainless steel components fabricated by forming, machining and welding operations and covers the requirements for design, welding, cleaning, coating, inspection, testing, documentation, packaging and transportation.

The contractor shall secure complete compliance with these specifications. However, where any deviations from these specifications are necessary, they shall be submitted for review to Elettra-Sincrotrone Trieste S.C.p.A. (E-ST), whose written approval is required prior to proceeding. This document is the exclusive property of E-ST and it shall neither be shown to Third Parties nor used for purposes other than those for which it has been delivered.

3 CODES AND REGULATIONS

Following normal industrial practice, the contractor shall comply with the guidelines of the following international organizations:

- International Standards Organization (ISO)
- American National Standards Institute (ANSI)
- American Society for Testing and Material (ASTM)
- American Welding Society (AWS)

The following documents are to be used, or their equivalent at the discretion of the contractor, for the various phases of construction.

- Material certification according to ASTM.
- Welding

ISO 15614-1, ISO 15614-11, test and inspection.
ISO 13919-1, ISO 5817, UNI EN ISO 3834, weld quality, level B: rigorous.
ISO 9606-1, welder qualification.
ISO 15609-3, ISO 15609-1, *welding procedure specifications*, WPS
AWS D1.6, Structural Welding Code - Stainless Steel
AWS D1.2, Structural Welding Code – Aluminum
ASME, BPVC, Section IX, welding processes and welder certification.
ASME, BPVC, Section V, non-destructive tests.
ASME, BPVC, Section II, part C, Specifications for Welding Rods Electrodes and Filler Metals.

 Manufacturing

ASME, BPVC, Section VIII, Division 2

4 MATERIAL SELECTION

All materials used shall be compatible with UHV and UHV pumping systems with the capability of achieving pressures less than or equal to 10^{-9} mbar.

4.1 Allowed materials

Table 1, though not exhaustive, lists some materials compatible with UHV applications. UHV parts must be made of the materials stated in their relevant construction drawing. Deviations from the material indicated in the construction drawing and the use within the UHV system of materials other than those listed in Table 1 require prior written consent of E-ST.

In the event glues are necessary, the contractor shall submit a written declaration of UHV compatibility and proceed only after receiving written authorization from E-ST.

Stainless Steels - AISI 304L, 304LN, 316L, 316LN, 321, 347
Aluminum and its alloys 5086, Alclad 6061, Alclad 6063, ISO IMgSi6060
High density alumina
Beryllium
Copper (OFC – C10200, OFHC - C10100, OFS-C10700, GlidCop AL-15 - C15715 grade and Al-25 - C15725 grade, CuCrZr - C18150, Cu2Be - C17200)
Tungsten and its alloys (e.g. Densimet 180)
Molybdenum
Glass
Sapphire
Gold

Silver
Mumetal, Monel alloy
Titanium
Niobium
Inconel
PTFE
Macor
Mica

Table 1 – Some UHV compatible materials

4.2 Not permitted materials

Generally, materials with a high vapor pressure are not acceptable for use. In particular: Zinc, Cadmium, Lead, Cesium, Mercury, Potassium, Magnesium, Sodium, Selenium, Strontium. This also excludes the use of any alloy containing the aforementioned materials as possible surface segregation may occur.

4.3 Magnetic permeability

Vacuum chambers and components in vacuum chambers that are placed within the apertures of magnets are required to have a magnetic permeability of $\mu_r \leq 1.01$, unless otherwise stated in the design or order documentation.

4.4 Material certification

All materials within the vacuum system are required to be pre-approved and authorized in writing by E-ST. The contractor shall provide, prior to delivery, the certificate of conformity for the materials used stating the physical and chemical properties and their compatibility with UHV systems.

5 MANUFACTURING

5.1.1 Introduction

The fabrication of components shall be achieved primarily by mechanical means. While commonly used cutting tools are approved, the use of abrasives or polishing compounds should preferably be avoided. In case the requested surface finish cannot be guaranteed solely by machining, then the surface may be polished with one of the approved abrasives in section 5.1.3. Any deviation from the abrasive listed in section 5.1.3 is subject to E-ST approval. The contractor shall determine the proper particle size and pressure to have a uniform distribution and thereby avoid local surface overheating or inclusion of the abrasive particles in the surface.
Polishing by abrasive flow polish or slurry blasting is limited to glass or alumina abrasive particles.

Deburring shall be performed with a file or knife or approved abrasive (see 5.1.3).
Any evidence of contamination or inclusions shall cause the rejection of the components.

5.1.2 Flanges

The knife edge surface of all UHV CF flanges shall be examined prior to any machining operation and the part must be discarded if any defect is observed. The sealing surface must be protected during any machining operation and machining methods compatible with such protection shall be preferred. Parts delivered to E-ST with damaged or defective sealing edge shall be rejected.

5.1.3 Abrasives

The approved abrasives are limited to:

- 3M Scotch Brite
  - Type A, aluminum oxide (Purple)
  - Type S, silicon carbide (gray)
- 3M Wet or dry Fabricut
  - Aluminium oxide or silicon carbide.

Other abrasives can be used with prior written authorization from E-ST.

5.1.4 Cutting Fluids

Cutting fluids and lubricants that may cause contamination of the parts to be used in UHV systems is not permitted. Hence, fluids either with high organic constituents or 50 ppm or more of sulfur or silicone are prohibited. Water-soluble cutting fluids are allowed.
Table 2 shows a list of approved cutting fluids; it is not exhaustive. For any other cutting lubricant, the contractor shall provide E-ST with the fluid composition and a written declaration of UHV compatibility and shall not proceed without prior E-ST written consent.

Isopropyl alcohol
Ethanol
Aqua Syn 55 (G-C Lubricants Co.)
Aqua Cool 21EP-5 (G-C Lubricants Co.)
Aqua Cool 4-EPX (G-C Lubricants Co.)
Cimcool 5 Star 40
Cimperial 1011
Cindol 3102
Diamond Way 2010 (Yamazen)
Dip Kool 862
Dip Kool 868

Dip Kut 819H
Haloform CW-40
Micro-Drop "Advanced Synthetic Lubricant" (Trico)
"Pearl" Kerosene (Chevron)
Perkut 301GG (Perkins)
Rapid Tap
Relton A-9
Rust-Lick Vytron (ITW Fluid Prods.)
Rust-Lick G-25-J (ITW Fluid Prods.)
Rust-Lick WS11 (ITW Fluid Prods.)
Rust-Lick WS600A (ITW Fluid Prods.)
Rust-Lick Safetap Ultima (ITW Fluid Prods.)
Sunnen Man-852
Syntillo 9930 (Castrol)
Tap Magic
"Tool Saver" (Do All Corp.)
Trim Tap

Table 2 – Some of the permitted cutting fluids

5.2 Welding and Brazing

5.2.1 Introduction

The welding and brazing zones shall be free of scales, voids, micro cracks, pits, inclusions etc. In order to guarantee that the welding zone is UHV tight, all parts shall be accurately cleaned and all cleaning processes shall be completed within 48 hours of the welding. The parts are to be protected from any contaminants – such as oils, grease, fingerprints, etc. – before, during and after the welding operations and any handling shall be performed with UHV approved gloves. To protect the weld zone from oxidization, parts shall be flushed with inert gas until they have cooled down to a temperature of 60ºC or below. All of the welding of UHV parts shall be performed in compliance with one or more weld standards (see §3) using Gas Tungsten Arc Welding (GTAW), also known as TIG welding, or Electron Beam Welding (EBW); any other method must be specifically approved by E-ST.
All joints shall be internally welded, i.e. on the UHV side of the part. Where this not possible, the weld shall have full penetration up to the UHV exposed surface and have a smooth surface free of defects (diameter of weld bead < 0.3 mm). It is not permitted to perform additional polishing of the weld bead surface. All longitudinal welds shall be continuous. The use of penetrant liquids is prohibited. Welding filler metals shall be used only with written permission from E-ST.

5.2.2 *Bimetallic Components*

The use of bimetallic components obtained by welding or explosion bonding are required to be certified by passing an ultrasonic test showing that the interface between the two materials is complete.

5.2.3 *Weld Burns Removal*

As a general rule it is not advisable to remove burn marks with an acid paste, except to remove any welding scale. For extensive weld burns, the use of one of the abrasives listed in §5.1.3 is permitted.

5.2.4 *WPS and PQR*

The contractor shall qualify all welders for the relevant processes as listed in §3. At the request of E-ST, the contractor shall provide a list of all the welded assemblies and the relevant welding procedures used, *Welding Procedure Specifications* (WPS). Such WPS shall list all of the process parameters (welding operation velocity, type of inert gas, electrode diameter, etc.). E-ST reserves the right to request a sample of all weld configurations and the relevant documentation, *Procedure Qualification Record* (PQR), as a means to qualify the weld process proposed by the contractor. §3 lists the standards to follow to write the WPSs and PQRs.

6 CONSTRUCTION DRAWINGS

Based on the 2D drawings and 3D models provided by E-ST, the contractor shall produce his own fabrication drawings. The contractor is solely responsible for the preparation and content of this documentation.

The contractor shall supply a complete set of the fabrication drawings at least two weeks before production starts. E-ST will review the provided documentation for compatibility with the technical specifications and with all the requirements. E-ST will provide written authorization to proceed with production.

The drawings are original and confidential. The contractor must not:

- disclose, directly or indirectly, any part of the design to a third party for whatever reason may exist without prior written consent of E-ST;
- make a copy of the design in any form and for whatever use without prior written consent of E-ST;
- alter, modify, disassemble or decompile the design;
- patent or register under another name or contractor’s name any components that might include these designs.

7 ELECTROMECHANICAL DEVICES IN VACUUM

Electromechanical devices used in the vacuum system shall have a certificate of compliance with UHV systems. A statement is required of the minimum number of hours of operation within a UHV environment before maintenance or replacement is necessary.

8 BELLOWS

Great attention must be paid when cleaning the bellows, especially with thin wall or welded ones. Given the risk of trapping solvent residues within the convolutions and consequent corrosion related leaks, while cleaning the bellows the use of solvent should be limited. The use of alkaline degreasers (see § 9.3.1, Step 2) should also be minimized because they increase the precipitation of particles that, once trapped within the bellows, could cause perforations or fatigue cracks. If possible, the bellows are to be in their fully extended length during all the cleaning phases (see §9), and before proceeding with the cleaning of all visible traces of contaminants shall be removed with the use of dry air or nitrogen.

The vacuum bake-out for cleaning the bellows shall be done at 250ºC for a minimum of 36 hours. Under no circumstance shall the temperature exceed the brazing temperature if this method has been used to join the parts. Heating and cooling shall be gradual in order to prevent any mechanical damage or leaks.

9 CLEANING

9.1 Introduction

Any deviation from the following cleaning procedures shall be communicated in writing to E-ST and without any E-ST prior written consent the contractor shall not proceed any further.

9.2 Cleaning Conditions

Proper cleaning conditions must be established during the whole manufacturing and assembly process of UHV components.

Construction, cleaning and assembly shall be carried out in an adequately clean area efficiently separated and isolated from the machine shop.

Some of the parameters that require careful control are: ambient temperature, the way the air is circulated, the work area and proper work surface cleanliness.

For this purpose, it is required that in the work area:

- It is strictly forbidden to smoke, prepare or consume food or beverages;
- It is prohibited to use fluids or materials that contain sulfur which can corrode the vacuum parts;
- laboratory smocks, head covers, gloves and shoe covers are required;
- an adequate number of hand tools and fixtures, cleaned and degreased, must be permanently kept within the clean area and promptly available.

- all fixtures and tools that come in contact with the vacuum components shall be in stainless steel or aluminium (do not use carbon steel, brass, copper, etc.);
- lift systems shall have adequate protection in order to prevent any oil or contaminant leakages from getting onto the parts being machined.

The contractor shall indicate what are the work area cleanliness standards. If this is not possible then the company shall state how they intend to achieve and maintain the required cleanliness standards. An inspector from E-ST will verify the adequacy of the clean work area.

9.3 Cleaning Procedures for the Surfaces Exposed to Vacuum

The finish and cleanliness of the surfaces exposed to vacuum is paramount for obtaining the required vacuum level.

The cleaning materials and the subsequent storage must not leave residues.

Sandblasting or shot peening of the surfaces exposed to vacuum is not allowed. Lapping or other polishing methods are not allowed, except for those specified in §5.1.1.

At the end of the machining, parts shall have a surface finish Ra < 0.8, without oxides or other impurities, unless otherwise specified in the mechanical drawing provided by E-ST or in the purchase order documentation.

A complete surface cleaning procedure shall include the following steps:

1. Degreasing
2. Chemical etching to remove oxides
3. Buffer chemical polishing (optional)
4. High pressure rinsing
5. Drying and storage.

Surface treatments shall be carried out before welding and repeated before proceeding with the final vacuum checks.

Detergents, solvents, chemical baths and operating procedures shall be submitted to E-ST for approval.

9.3.1 Degreasing

Degreasing, necessary to remove oils and grease, must be performed in two steps so that both organics and inorganic oils are eliminated.

***STEP 1**. Degreasing by Organic Solvents*

The following organic solvents can be used: acetone, benzole, Detersol, Citranox. Denatured ethanol is not allowed. Compounds contaminated during machining with oils or grease shall be degreased with perchloroethylene vapor at 120ºC or, alternatively, will be high pressure rinsed with alkaline detergent approved by E-ST inspectors.

***STEP 2**. Degreasing by Alkaline Phosphate-free Detergent*

Such rinsing shall be conducted at about 60ºC, with alkaline phosphate-free detergent in an ultrasound bath. Special care shall be taken to avoid damage to the part material (for example, aluminium).

9.3.2 Rinse

All parts after degreasing shall be washed in 30-40ºC water. A pre-rinse can be carried out using tap water, but the final rinse shall be done with purified running water.

9.3.3 Oxide Removal

Removal of oxides formed during machining or welding shall be achieved via chemical etching or buffer chemical polishing (BCP) or electropolishing (EP). Do not clean ceramic feedthroughs chemically.

9.3.4 Mirror Finish (optional)

A mirror finish, to be achieved via BCP or EP, may be requested.

9.3.5 Neutralization

During rinsing, after the chemical baths, a neutralization bath is necessary to eliminate any acid trace.

9.3.6 Surface Protection

Surfaces that require a high surface finish, like seal contact surfaces, shall be protected from chemical agents with a coating of varnish or other equivalent means.

9.3.7 Bathing Methods

Mechanical bathing methods (bath agitation, part motion, etc) shall be chosen according to the piece geometry in order to guarantee the rinsing/chemical etching of the part homogeneously.

9.3.8 Drying and Storage

After cleaning and the final vacuum checks, parts shall be dried with inert gas (i.e. nitrogen, argon) and subsequently stored as indicated in §14. Cleaning tools (bathtubs and brushes) shall be in stainless steel, nylon or polyethylene.

9.4 Bake-out

For a complete cleaning of a vacuum chamber or component, two methods may be used, either in a vacuum oven, or by means of and external heating system. For the first method, bake-out shall be carried out by heating parts in a vacuum oven, pumped by suitable roughing and turbomolecular oil-free pumps.

Parts should not be assembled together but can be baked together during the same bake if the maximum temperature allowed of each component permits this.

In order to clean only the surfaces exposed to the vacuum of a vacuum chamber or a vacuum component, it may be sufficient to heat the component by means of heaters of adequate power applied to its external surface exposed to air. Multiple components can be assembled together if they can be heated to the same maximum temperature allowed by each of them separately. The bake-out must be performed with the system pumped by suitable oil-free primary and turbomolecular pumps.

Proper temperature control, ±5ºC, shall be achieved. Maximum bake-out temperature shall be compatible with the material physical and chemical properties. In particular, it is advisable not to exceed 250ºC for stainless steel and copper and 180ºC for aluminum. In some cases – i.e. bellows, optical viewports, feedthroughs, etc. – maximum local temperature must be accurately controlled to avoid damaging the part or the vacuum tightness. Critical components must be certified to withstand at least 120ºC for 24 h. Prior to bake-out, the contractor must indicate in writing the maximum bake-out temperature, and this must be approved by E-ST.

Bake-out must not start at pressures higher than 10^{-5} mbar. The oven pumping system must be capable of reaching 10^{-8} mbar or lower at the end of the process. The heating and cooling temperature ramps must be linear and span over 24 h. In case of critical components like bellows, optical viewports and feedthroughs, heating and cooling speeds shall be carefully chosen to prevent mechanical damage or leaks.

The part must withstand the maximum bake-out temperature for 48 h or longer. The bake-out is considered complete when, during cool down, the part temperature is close to room temperature and pressure in the oven is $\leq 1\times10^{-8}$ mbar.

The vacuum system shall be gradually filled with dry nitrogen and the part protected and stored as described in §14.

The contractor shall prepare a report describing the vacuum system, the bake-out diagram starting and final conditions (temperature and pressure).

The bake-out data shall be also provided in electronic format (ASCII).

The contractor shall inform E-ST in advance of the upcoming bake-out and allow an E-ST inspector to attend the operation.

9.5 Residual Gas Analyzer (RGA) Test

A vacuum test with a quadrupole residual gas analyzer (RGA) provides information about the composition of the residual gas present in the vacuum chamber. The mass spectrum must cover the range 1-200 atomic mass units (a.m.u.), and the instrument must detect partial pressures lower than 5×10^{-13} mbar. The test shall be performed when the pressure is less than 5×10^{-9} mbar.

The use of a Faraday cup detector only is not allowed, and detection will be achieved by means of a secondary electron multiplier (SEM) with conversion dynode or equivalent.

The instrument shall be calibrated on nitrogen (28 a.m.u.) and the calibration factor shall be stated on the attached documentation together with:

 RGA model
 detector type and operating voltage.
 ion source type
 filament current
 electron energy
 any other parameter relevant to the measurement conditions.

The test is performed at the end of the bake-out. The instrument filament must be outgassed beforehand during the bake-out cool-down starting at 80ºC. The vacuum system must be isolated from the turbo molecular pumping system with all metal gate valves. Adequate sputter ion pumps shall maintain the UHV condition. The test report shall also include:

 description of the vacuum system
 test phases
 initial and final pressure and temperature conditions.
 the analog diagram with logarithmic scale of the peak intensity versus the a.m.u.

Raw data, comprising pressure and temperature versus time, shall be saved in electronic format and delivered together with the paper documentation.

The test is accepted if the sum of the intensity values of the peaks referred to masses > 28 a.m.u., excluding the intensity value of the mass peak 44 a.m.u., is three orders of magnitude smaller than the total sum of the peak intensities in the 1-200 a.m.u. range. E-ST reserves the right to have its designated representative(s) witness the test.

10 ACCEPTANCE TEST

Great care shall be taken in carrying out the vacuum inspections and the contractor shall provide the entire test setup. This section establishes the procedures that need to be followed, the instrumentation requirements, the personnel training and qualification prerequisites and acceptance criteria. Besides the requirements of the present document, the guidelines expressed in the ASME Boiler and Pressure Vessel, Section V, Article 10, Leak Testing shall be followed.

10.1 Acceptance Requirements

Components intended for UHV use at the E-ST facility shall meet the acceptance class (b) (see Table 1).

Class (a)	1) localized leaks: < 5 x 10^{-11} mbar l/s 2) overall leaks: < 1 x 10^{-10} mbar l/s per component

Class (b)	1) localized leaks: < 1 x 10^{-10} mbar l/s 2) overall leaks: < 2 x 10^{-10} mbar l/s per component
Class (c)	1) localized leaks: < 2x 10^{-10} mbar l/s 2) overall leaks: < 5 x 10^{-10} mbar l/s per component

Table 3 – Acceptance classes for vacuum leaks

The description of the required methods to perform and certify the tests are in the following sections. Table 3 refers to Helium leaks. The air leak rate can be easily calculated from the formula:

$$P(air) = \frac{P(He)}{2.7}$$

10.2 Pumping Systems

Given the demanding cleaning requirements, the contractor shall use vacuum systems with the reference following parameters:

- Oil-free roughing pump with 5-30 m^3/h pumping speed and 10^{-2} mbar ultimate pressure.
- Oil-free turbomolecular pump with 100-500 l/s pumping speed.

Adopting an oil-free pump shall prevent the vacuum parts from being contaminated.

10.3 Measuring Equipment

The test measuring equipment must consist of

- Pirani vacuum gauge for low-medium vacuum (1 bar – 10^{-3} mbar)
- Cathode ionization vacuum gauges for high and ultra high vacuum (10^{-3} – 10^{-11} mbar)

10.4 Inspection

10.4.1 Introduction

The required tests aim at discovering and eliminating vacuum leaks. By creating a helium atmosphere around the vacuum vessel, if there are leaks, helium will enter the chamber and the mass spectrometer will detect it.

Flanges, piping, bellows and valves shall be in stainless steel AISI 316L, unless otherwise specified by E-ST. For these components, other materials such as copper, brass, aluminium, etc. are generally not permitted.

The connection pipes between the part being tested and the pumping system shall have adequate conductance. All gaskets and seals shall be in metal.

An inspector designated by E-ST will verify the qualification level of the personnel responsible for the contractor's vacuum tests.

10.4.2 Inspection Procedure

The test setup shall include the following devices

- Helium mass spectrometer with sensitivity 10^{-5} – 10^{-11} mbar l/s
- Calibrated leaks at 10^{-8} mbar l/s

Once the machining is completed, parts shall be cleaned as indicated in §9 and welded. Afterwards the following checks shall be performed:

- Preliminary check to discover massive leaks and removal thereof.
- Local and integral leak check, leak detection and removal thereof.

During all tests, sealing shall be performed using metal gaskets. Viton® gaskets are not recommended since Viton® is permeable to Helium.

10.4.3 Leak Detector Calibration

In order to get accurate leakage rates, the leak detector shall be calibrated. This is done by means of a small helium filled vessel with a shut-off valve that releases a given amount of gas. The device should be calibrated before each use.

10.4.4 Background Determination

The goal of this operation is to determine the background value above which leaks will be measured. Once the calibration is completed (see §10.4.3), the instrument background is recorded. The record is valid after 3 minutes of stabilized signal.

10.4.5 Response Time

The response time is the time required until the instrument reading reaches the ultimate value as measured according to section §10.4.4, ±5%, after calibration with a calibrated leak.

10.4.6 Room Temperature Vacuum Inspection

Prior to outgassing cycles, it is necessary to perform several inspections at room temperature, complete or partial as needed, on each component to guarantee that total and local leaks are within the requested specifications as in 10.1.

10.4.7 Localized Leaks

Once the leak detector is calibrated, a dynamic helium atmosphere shall be realized over all the surface of the part, to verify the presence of any possible leak. Subsequently, dosing the helium flow, an accurate scanning of the surface, with particular attention to the weld joints, shall be carried out.

10.4.8 Total leak rate

The following steps shall be taken:

1. Seal tightly the part in a polyethylene bag
2. Cover the leak detector with a polyethylene sheet so that it will be shielded from helium.
3. evacuate the component bag with a roughing pump
4. introduce helium in the component bag up to 1 bar pressure
5. record with the leak detector the measured leak for at least twice the response time. A metal seal must be used.

10.4.9 Acceptance Requirements

In order for the inspection results to be accepted, it is necessary that the part meets the requirements as stated in §10.1. If leaks fall within the specified limits, the test is successful and the measured values are recorded in the Test Report (§ 10.4.10). If the part does not pass the test, then the contractor will take corrective actions and the leak check shall be repeated.
All the performed operations, including possible weld repairs, shall be included in the Test Report. Each component shall be certified and its documentation (§ 12) will indicate localized and total leak values.

10.4.10 Test Report

The contractor shall prepare a Test Report including the following:

- Test layout and system dimensioning
- Mass spectrometer type and model
- Instrument calibration and tune-up
- Calibrated leak certification
- Acceptance criteria
- Measured leaks and possible weld repairs, if necessary.

11 MARKING

All chambers and vacuum parts shall be permanently marked, by vibro-pen, Electroerosion, laser, etc., clearly and in areas easily accessible with the relative drawing code and a serial number that unequivocally identifies the part. Acids, adhesive labels and felt markers are prohibited. The identification code shall be present on the protective packaging, where adhesive labels are allowed.

12 FINAL REPORT AND DOCUMENTATION

Prior to shipping, the contractor shall provide the E-ST with a copy of the accompanying documentation indicating test results, analyses and checks performed by the contractor, or appointed third party agency, to establish compliance with the ordered part. A template of such documentation together with the Quality Assurance Plan shall be submitted to E-ST for acceptance. This report must include the following:

- Name of the qualifying third party agency, if different from the contractor, and test or analysis date.
- Copy of all the construction drawings, both in electronic and paper form. Acceptable formats are IGES, STEP, Catia, AutoCad.
- Inspection results performed to determine compliance to E-ST design. Acceptable formats are PDF, Microsoft Word or Excel.
- Weld test results.
- Copy of encountered non-conformities, if the case, and corrective actions taken.

13 QUALITY ASSURANCE PLAN

At least two weeks before production starts, the contractor shall submit to E-ST for approval a Quality Assurance Plan (QA). The IS0 9001:2000 code (or newer versions) provides preferred guidelines for the QA plan, which must guarantee that each fabricated part complies with the present specifications. E-ST must accept the proposed plan and notify the contractor in writing prior to production. The QA plan must include at least:

- Inspection and part rework procedures
- Critical welds inspection procedure
- Post-weld dimensional tolerance validation
- Production traceability
- Summary of documentation to be provided (see §12)
- Methods of inspection and dimensional control of parts or portions thereof including a description of the measuring machines, the control sequence and frequency, rejection criteria and possible corrective actions, data recording plan.

14 PACKAGING

Produced parts, once cleaned and ready for shipping, shall be placed in nylon or polyethylene bags filled with dry nitrogen and sealed. Silica gel may be used to keep the external packaging dry. Extra care shall be taken to protect the flange sealing surface with polyethylene caps or blank flanges with gaskets.

The component shall be prepared for shipping according to good shipping standard practices and in agreement with the current norms and regulations relative to packaging and shipping of goods, in order to prevent any damage to the parts. In particular, heavy boxes must allow for forklift handling.

15 CORRECTIVE ACTIONS

In the event that any part or portion thereof is rejected by E-ST as a result of poor workmanship or non-compliance to the present specifications, the contractor shall take corrective action on the material or process, or both as necessary, on all items or portions thereof which were similarly manufactured which are subject to the same cause for rejection within ten working days. Acceptance shall be withheld until inspections and tests have shown that the corrective action was successfully implemented and the part or any portion thereof conforms to the requirements of the present specifications.

16 RIGHT OF INSPECTION

Elettra-Sincrotrone Trieste S.C.p.A reserves the right to have its designated representative(s) witness, at the place of manufacture, processing/fabrication operations including metal forming, inspection of weld preparations, electron beam welding parameters and vacuum tests and recording charts, etc. E-ST reserves the right to have its designated representative witness, at the place of manufacture, the inspections, analyses, and tests established under the contractor's QA Program to demonstrate compliance with the present specifications. E-ST reserves the right as well to sample and inspect the production at the manufacturing place in order to verify compliance with the present document. The contractor commits himself to give advance notice to the person designated by E-ST of any critical upcoming operation.

The intent of the E-ST in witnessing inspections, tests, and/or processing/fabrication operations is to ensure that production operations will produce vacuum parts conforming to the present specifications.