Specification

for the production and delivery of
the Vacuum Chamber for the ESS Drift Tube Sections

Abstract

The contract will cover the supply of materials, manufacture, inspection, cleaning, testing, vacuum firing, assembly, packing and subsequent delivery to Daresbury Laboratory, Warrington of a large quantity of vacuum beam pipes and vessels.

SCOPE OF SUPPLY

1.1 Introduction to ESS

STFC Daresbury Laboratory is involved in a major contract in construction of the world's most linear proton accelerator, the European Spallation source (ESS). It is located in Lund, Sweden, co-hosted by Sweden and Denmark and has more than 17 Partner Countries, including the UK. The UK contribution is coordinated by STFC. The facility will deliver its first neutrons in 2019 and is expected to be fully operational by 2025.

The European Spallation Source (ESS) will be one of the largest infrastructures in Europe and will be used for neutron production for materials research. It will use a long pulsed superconducting linac and accelerate a 62.5 mA proton beam current to the energy of 2000 MeV. Peak beam power to the target will be 125 MW, 7 times more than the highest power existing facility. The layout of the accelerator is shown in Figure 1-1.

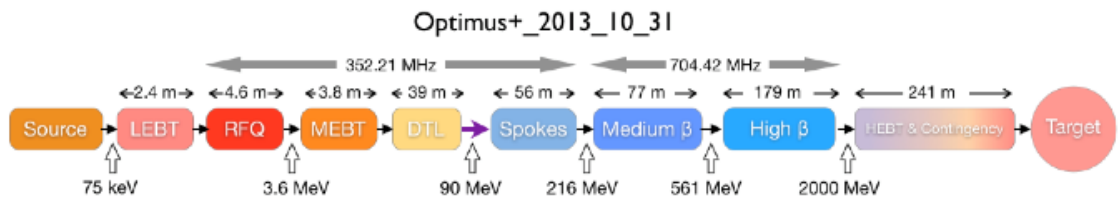

Figure 1-1 : Schematic of ESS Linac

STFC are providing a number of goods and services on behalf of the ESS. This tender is for vacuum chambers for the beam pipe sections, which will predominately sit in the latter half of the accelerator.

1.2 List of acronyms

EN - European standards

ESS - European Spallation Source
FAT - Factory Acceptance Test
ISO - International Organization for Standardization
SAT - Site Acceptance Test
STFC - Science and Technology Facilities Council

1.3 Scope of Contract

1.3.1 The contract will cover the supply of materials, manufacture, inspection, cleaning, testing, vacuum firing, assembly, packing and subsequent delivery to Daresbury Laboratory, Warrington.

1.3.2 The contractor will be required to co-operate closely with STFC Daresbury Laboratory (hereinafter referred to as STFC) and its authorised representative at all stages of the contract. Technical issues will be resolved after adequate discussion.

1.3.3 Any detailed assembly drawings and calculations, tooling, fixtures and manufactured components constructed or otherwise procured under the terms of the contract will become the property of STFC to dispose of as it sees fit.

1.3.4 The parameters of all detailed components and assemblies have been determined by STFC and are fully described in the accompanying drawings. The designs are the property of STFC and must not be disclosed to third parties without its express permission.

1.3.5 The manufacturer will be responsible for any departure from anticipated performance due to the failure of the manufacturer to adhere to any part of this specification.

1.4 Time Scales and Delivery

1.4.1 Timescales for the project are very important. Envisaged delivery to Daresbury Laboratory will be in stages as shown in Appendix B.

1.4.2 A detailed manufacturing programme including all necessary acceptance tests shall be issued by the contractor within 2 weeks of contract placement and must be approved by STFC. This

programme must contain sufficient detail to enable progress on the contract to be monitored accurately.

1.4.3 Written progress reports must be submitted to STFC at intervals of one month during the contract.

1.4.4 No change may be made to the agreed programme without the written approval of STFC. STFC must be contacted immediately of any circumstances which might prevent the contract delivery date from being met.

1.4.5 Factory acceptance testing (FAT) must be made at the Suppliers or at the sub-Suppliers premises. Please refer to section 7 for more information.

1.4.6 Site acceptance testing (SAT) will be performed on some vessels after delivery to STFC, Daresbury. Please refer to section 7.6

1.4.7 Vessels should have all flanges removed before delivery to Daresbury. Flanges should be included with each delivery packaged appropriately as not to damage the knife edges.

2. Materials of Construction

2.1.1 Knife edge flange material shall be austenitic stainless steel material grade 316LN as specified on the individual component detail drawings.

2.1.2 All knife edge flange fasteners shall be Stainless Steel to BS.970 Pt 1 Grade 316S31 Class 70 to ISO 3506 (A4).

2.1.3 All material shall be as specified on the individual component detail drawings. Where specified chambers are to be constructed from stainless steel grade 316L with a final magnetic permeability of less than 1.005.

2.1.4 All materials unless otherwise stated are to be supplied by the contractor. The contractor shall supply all blanking flanges gaskets and fasteners as required.

2.1.5 For any material not supplied by Daresbury Laboratory, material certificates are required. These should state the material specification, ladle analysis, room temperature mechanical properties and finishing process used.

2.1.6 Following cleaning of each vessel assembly and components as detailed in 3.5 the final assembly should be assembled using only silver plated copper gaskets for the CF flanges.

3. DRAWINGS AND SPECIFICATIONS

3.1.1 Manufacture of the components will be in accordance with relevant drawings and specifications supplied by STFC, including:

3.1.2 Knife Edge Vacuum Flange Details to STFC drawing 48/037 Issue M as shown in Appendix D

3.1.3 ASTEC-VAC-QCD-spc-002, General Specification for the Design, Construction and Handling of Ultra High Vacuum Vessels, Components and Assemblies for ASTeC Vacuum Projects

3.1.4 All manufacturing techniques shall be in accordance with specification ASTEC-VAC-QCD-spc-0002. Particular attention is drawn to Sections 4 (Conditions and Handling) and 7 (Machining and Fabrication) of that specification.

3.2 Welding

3.2.1 All welding shall be to BS EN 1011-3:2000, and must be executed by the TIG process unless specified otherwise.

3.2.2 All parts to be welded must be degreased as described in Section 7 of ASTEC-VAC-QCD-spc-0002 prior to welding.

3.2.3 To prevent undue oxidation of the vacuum surfaces all welds are to be backed by an inert gas purge.

3.2.4 Vacuum sealing welds made externally must have full penetration leaving a smooth surface on the vacuum side.

3.2.5 Under no circumstances must dye penetrant be used to check weld integrity.

3.2.6 Since the welding procedure is of great importance in determining the vacuum performance of the vessel, STFC reserves the right at any time during the production period to call upon the contractor to demonstrate that the agreed procedures are being carried out.

3.3 Brazing

3.3.1 All brazing shall be to BS 1723 Pt 2 Section 5.

3.3.2 All vacuum brazing to be finished flush and shall be free from any defects such as blow holes, cavities and any sign of inclusion.

3.3.3 The contractor shall specify filler material and procedure for any vacuum brazing with the tender. The written agreement of STFC will be given prior to brazing.

3.3.4 Should Nickel Plating be required to ensure an adequate braze, the nickel plating should be blister tested in vacuum to 900°C for good adhesion. There must be no peeling or blistering of the nickel plated surfaces.

3.3.5 If at any stage of manufacture a weld or braze is shown to be defective, no rectification shall be done without the prior written approval of STFC.

3.4 Vacuum Cleanliness

3.4.1 For the vacuum components to be completely compatible with the UHV vacuum environment a high degree of cleanliness will be necessary at all stages of production to guarantee an acceptably low outgassing rate and weld integrity.

3.4.2

3.4.3 All mechanical cold working operations must exclude the use of heavy organic lubricants since these can be retained to some extent in the surface after the process.

3.4.4

3.4.5 The plate material is to be cleaned before any cutting or forming operation commences. It will be sufficient to swab with acetone, isopropyl alcohol or similar solvent. If a guillotine or press is to be used the blades should be cleaned. Care must be taken that any particulates are removed from the surface of the metal sheet before such operations to ensure that they are not pressed into the surface during cutting or forming.

3.4.6 When the plate material or any other component forming part of or within the vacuum envelope has been cut, formed and finally machined, the vacuum surface must never be in contact with oily or greasy objects (including bare hands leaving finger prints) unless a thorough cleaning operation is scheduled to follow immediately after.

3.5 SURFACE TREATMENT

3.5.1 Vacuum Firing is an important technique used to anneal the steel thus reducing the magnetic permeability following machining, working and welding and should be carried out on chamber assemblies where specified.

3.5.2 Where specified (see Appendix C) stainless steel components will be vacuum fired at 950°C for 2 hours. Where this is not possible a list of those components must be supplied to STFC with reasons why it is not possible. For chamber assemblies where 316LN flanges are used the vacuum firing can be carried out following welding of the flanges.

3.5.3 The vacuum firing will be performed in a vacuum furnace that is appropriately pumped. After the chamber is evacuated to below 1×10^{-6} mbar, heat should be applied in steps up to 950°C. The heat rise should be controlled so that at no time does the chamber pressure exceed 5×10^{-5} mbar. Firing at the maximum temperature should continue for 2 hours.

3.5.4 There should be no discoloration of the work piece after vacuum firing.

3.5.5 Contractors shall declare in the tender return whether they have the facility to vacuum fire in-house or plan to sub-contract this step. Details of the proposed equipment & processes for vacuum firing should be submitted as part of the tender return.

3.5.6 Contractors should advise Daresbury vacuum specialists in the tender return on any aspect of the vacuum firing process proposed which, based on their experience, they believe could be invalid or inappropriate and submit alternative solution(s).

4. PROTECTION AND TRANSPORT

4.1.1 Following the final vacuum test at the contractor's premises, all blanking flanges must remain on the vessel. The vessel is to be let up from vacuum with dry nitrogen (dew point < -70°C) and the port used for connection to the leak detector and/or pumps is to be blanked off with a stainless steel flange and gasket.

4.1.2 Components and assemblies must be protected during storage and carriage in such a way as to prevent movement due to any vibration during transit. All components and assemblies to be transported in such a way as to allow adequate access of handling equipment. Details of packing and required handling equipment to be approved by STFC before delivery. All packaging will be retained by STFC unless agreed otherwise.

5. Delivery

5.1.1 The delivery schedule is given in Appendix B. The cost of delivery to STFC Daresbury should be included in the tender. If required STFC reserves the right to delay delivery by up to three months to be compatible with ESS operations, with one month's notice. There shall be no extra charge to STFC for this. The Delivery Address for this tender is; ETC, Daresbury Laboratory, Keckwick Lane, Warrington WA4 4AD

5.2 Warranty

The equipment shall be warranted for at least two years from the date of site acceptance (usually within one month of delivery) or from three months after delivery if site acceptance is delayed.

GENERAL REQUIREMENTS;

6. Supplier's responsibilities

The Supplier is solely responsible for meeting all the requirements of this Contract and for all aspects of the performance of the device: mechanical, electrical, thermal, as well as safety aspects, including testing and certification.

The Supplier will be responsible for the final design, the production methods and the correct performance of all the items supplied, irrespective of whether they have been chosen by the Supplier or suggested by STFC. Any approval or acceptance by STFC of the design and components does not release the Supplier from their responsibilities in this respect.

The Supplier will be required to work in close contact with the Project Manager at STFC at all stages of the contract, in order to resolve any technical issues or problems that arise in the most timely and efficient manner. All contact with STFC referred to below should also take place with the Project Manager.

6.1 Contract management

6.1.1 Contract engineer

The Supplier shall assign an engineer to be responsible for the technical execution of the Contract and its follow-up, including all contacts with STFC, throughout the duration of the Contract.

6.1.2 Time schedule and progress reports

A written progress report shall be sent to STFC every month during the contract. This report must contain as a minimum a list of activities and milestones achieved since the previous report, any delay

or technical issues which are likely to affect the performance or the schedule and any proposals to address these slippages or technical issues and an updated schedule and/or milestone list.

The Supplier will inform STFC immediately in writing where a delay of more than two weeks against any milestone in the agreed programme is anticipated. The Supplier shall make available evidence of all corrective actions being undertaken to mitigate the impact on the contract deliverables.

Throughout the project the Supplier shall report any risks or concerns that specifications cannot be met as soon as possible, with a full explanation of why they cannot be met. Submitting such reports shall not result in the Supplier being released of their responsibility for meeting their contractual liabilities under the contract.

6.1.3 Factory access and inspections

STFC reserves the right to carry out regular and/or spot inspections at the Supplier’s premises and where deemed necessary that of its sub Suppliers. Contract inspections concern all contract compliance issues including schedule and quality performance.

STFC and the ESS reserve the right to be present to witness any tests carried out at the Supplier's or any sub-contractor’s premises.

6.1.4 Design review meeting

Within one month of the submission of the design report, a design review meeting shall be held with the Supplier. At this review, the Supplier will present in detail their plan for the execution of the contract, a Quality Assurance plan, the proposed design solution and a list of interfaces with the other parts of the RFDS. STFC and the Supplier must agree that the solution proposed is suitable and can proceed for manufacturing.

A set of minutes will be produced by the Supplier following the meeting, accurately recording the agreements and actions, and sent to STFC for approval.

6.1.5 Progress meetings

A programme of technical and progress meetings will be agreed between the Supplier and STFC during the Design review meeting. These should take place at least every month and may take place via a remote connection.

6.1.6 Design approval prior to manufacture

Unless otherwise agreed in writing, STFC must approve the final design report before the Supplier proceeds to ordering of any materials, components or equipment required to fulfil this contract and equipment manufacture shall not start without STFC’s written prior agreement on the design.

No acceptance or approval by STFC of any procedure or test shall release the Supplier from their responsibility in fulfilling the terms of the contract.

6.2 Engineering standards and manufacturing specifications

6.2.1 Metric system - The design, systems, parts and components shall be in accordance with the metric system.

6.3 Documentation

All documentation, information and drawings shall be produced in MS Word, .pdf and .dxf formats. All documentation, including "as built" drawings, certificates, manuals, etc, shall be written in English.

6.4 Manufacturing drawings

A complete set of drawings shall be provided in electronic format. The drawings shall be prepared in accordance with ISO 8015:2011 or BS 8888. A complete set includes:

- Detailed mechanical construction drawings;
- Detailed electrical circuit diagrams, if appropriate;
- Complete mechanical assembly in 3D (.dxf format);
- Wiring diagrams, if appropriate;
- Complete list of parts including details of all components, manufacturer, type number and, whenever applicable, datasheets.
- Material certificates

7. Factory Tests and Delivery

The factory tests shall establish that the equipment completely fulfils this Contract. If the tests show that any part of the specification is not met, then it shall be corrected and the tests shall be repeated by the Supplier at no extra cost to STFC. The equipment shall be fully tested in the factory, but STFC

General arrangements for tests

Testing shall at all times conform with local safety codes. In the event of marginal design or performance, STFC reserves the right to require additional or more extensive testing to be conducted at no extra cost to STFC.

Throughout the contract, the test requirements which are to be carried out by the supplier prior to delivery (to demonstrate compliance with this Contract shall be reviewed along with STFC. All the test procedures shall be formulated and all test procedures shall be identified for STFC's approval.

STFC and its authorised representatives must have access to the premises of the Supplier for the purposes of inspection and witnessing of tests. STFC must be entitled to witness all tests defined in this CONTRACT and must be sent in advance the planned schedule of the tests with at least 10 days' notice.

STFC reserves the right to reject any material or component which does not fulfil this Contract.

7.1.1 The supplier should provide leak test data and RGS scan data to STFC before any vessel is shipped to Daresbury.

7.1.2 STFC or its authorised representative shall have reasonable access to the manufacturer's works and the premises of any sub-contractors for the purposes of inspection and the witnessing of tests.

7.1.3 All tests must be undertaken with equipment and procedures approved by STFC.

7.1.4 All tests shall be properly recorded on test certificates and results submitted to STFC.

7.1.5 Traceability of any works and processes undertaken will be important in qualifying the chambers as acceptable – especially where test results are equivocal or produce anomalies that may make full acceptance problematic. In the interests of both STFC and the contractor therefore, we strongly recommend that in addition to individual signed-off test certificate and other documentation a log or journal is maintained for the duration of the job. This log should be made available for inspection by STFC at any time.

7.2 Tests at Contractors Premises

7.2.1 After manufacture and before acceptance each component will be subject to the following tests at the manufacturer's works.

7.2.2 With the components suitably supported, check all relevant dimensions and record the actual measurements. If any of the specified dimensions are not achieved, no rectification is to be made without the prior approval of STFC.

7.2.3 Check that vacuum sealing faces are flat and free from distortion. Any clamping rings of rotatable flanges should be free to rotate and should not rock on the inner part. New correctly sized copper gaskets should fit the flanges without interference.

7.2.4 Leak test to ASTEC-VAC-QCD-spc-0004 (See Appendix C) using only silver plated copper gaskets for the knife edge flanges. It is essential to use metal seals between the leak detector system and the vessel to eliminate helium permeability associated with elastomer seals. The proposed system should be in accord with those specified in section 5.4.2 or 5.4.3 of ASTEC-VAC-QCD-spc-0004 (See Appendix D) and must be agreed in advance between the manufacturer and STFC. Method 3 as described in Section 5.4.4 may not be used in this case. The measured leak rate is to be < 1.10-11 mbar litre sec-1. If necessary, Daresbury vacuum specialists may provide advice and assistance in providing techniques to ensure that the final leak rate is < 1.10-11 mbar litre sec-1. A member of the ASTeC vacuum science group from Daresbury will be present to witness the leak rate measurements detailed in section 5.4.2 or 5.4.3 of ASTEC- VAC-QCD-spc-0004 (See Appendix C).

7.2.5 The contractor will be responsible for the supply of all vacuum test equipment and the connections to the leak detector.

7.2.6 Carry out leak test refer to 7.2.4 .

7.2.7 Carry out vacuum acceptance tests as stated in ASTEC-VAC-QCD-spc-005 section 9.

7.2.8 To be acceptable, the measured leak rate shall be less than 1.10-11 mbar l sec-1; the assessed outgassing rate shall be less than 1.10-13 mbar l sec-1cm-2; the cleanliness limits shall be those listed for UHV in Appendix 2 of the above specification. A member of the ASTeC vacuum science group from Daresbury will be present to witness the outgassing rate measurements. It is possible that

Daresbury may permit concessions on these rates but at the discretion of a member of the ASTeC vacuum science group.

7.2.9 Magnet permeability of less than 1.005 all over is required. Material must be tested before start of fabrication and after welding.

7.3 Tests at Contractors Premises by STFC staff

7.3.1 Before acceptance the vessel will be required to satisfy the following tests.

7.3.2 Leak test to ASTEC-VAC-QCD-spc-0004 (See Appendix C).

7.3.3 Cleanliness tests to section 9 of ASTEC-VAC-QCD-spc-0005(See Appendix C).

7.3.4 STFC reserves the right to repeat any or all of the tests detailed in section 7.3 – 7.4 of this document.

7.3.5 Magnet permeability test less than 1.005 all over.

7.4 Factory tests

The factory and site acceptance testing will include any or all of the tests specified in the preceding sections of this specification and shall serve to demonstrate compliance with all requirements of this CONTRACT. The plans for Factory Testing should be specified in the tender.

Following tests shall be performed at the Factory for all the components to ensure they meet the requirements:

1. Visual inspection, to ensure uniformity of the surface, absence of penetration of welding material inside the components, cleanliness etc.
2. Verification of the dimensions, finish and quality criteria;

7.5 Approval before delivery

The results of all FAT must be recorded on test certificates in English and sent to STFC before delivery of the tested components to the STFC. Delivery of these components shall not commence until successful completion of all the tests and after written authorisation by STFC.

7.6 Site acceptance tests

Acceptance tests will be carried out at STFC, Daresbury or STFC approved site in UK on selected items to establish that the equipment meets the specification and that no damage or changes have occurred during transport. These tests will be performed on equipment in crates for which the tiltwatch or shockwatch indicators have triggered. They will also be performed on selected equipment at random. These tests will be performed within four weeks of arrival at the STFC.

Site acceptance will be given by STFC only after all items have been delivered in accordance with the conditions of the contract, all tests specified have been successfully completed, all other documents and certificates have been supplied to STFC.

In the event of any errors being found during the site acceptance tests, the Supplier shall correct them immediately at their cost.

8. QUALITY ASSURANCE AND GUARANTEES

The Supplier shall maintain and apply a quality assurance program compliant with ISO-9001 or equivalent for the design, manufacture and testing of all systems and equipment provided by them. CE marking or equivalent of equipment should be applied wherever required.

All systems shall be designed and constructed with an expected operational lifetime of greater than 20 years. It is understood that maintenance may be required during this period. Subassemblies should be designed for repair rather than replacement.

Appendix A - Drawing List

Name	DWG No.	Revision	Total Qty
Beam Pipe 2 Port	289-10725	B	26
Beam Pipe 1 Port	289-10726	B	26
Blank Pipe	289-10835	B	36

Appendix B - List of Deliverables

Batch Details: Quantity and Delivery Dates

DWG Number	Name	Batch 1	Batch 2	Batch 3
289-10725	Beam Pipe 2 Port	10	10	6
289-10726	Beam Pipe 1 Port	10	10	6
289-10835	Blank Pipe	20	20	6

Appendix C – Supplied Documentation

Document
ASTEC-VAC-QCD-spc-0005
ASTEC-VAC-QCD-spc-0004
ASTEC-VAC-QCD-spc-0003
ASTEC-VAC-QCD-spc-0002
Vac/Certconf/001
48/037 Issue M (Knife Edge Vacuum Flange details)