PR16240 - TECHNICAL SPECIFICATION for the MANUFACTURE, SUPPLY AND TESTING of **COMPONENTS** for the ALUMINA CERAMIC VACUUM VESSEL

SYNCHROTRON DIPOLES MAGNET.

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1 TENDER SUMMARY

The ISIS Synchrotron accelerates a bunched beam of protons to high energies by rapidly cycling a proton beam in a circular orbit. To achieve optimum beam properties the protons are steered around the circle using dipole magnets with poles above and below the beam orbit. The protons themselves are contained within a vacuum chamber. Of primary importance is the avoidance of eddy currents which would lead to the beam being disturbed, high rates of beam loss, and consequentially high radiation levels that would damage components close to the beam. For this reason the vacuum chamber has to be manufactured from a material that has a high resistivity, is strong enough to withstand atmospheric pressure, withstand high irradiation levels, have a low outgassing rate and be able to be manufactured using well proven methods to a high dimensional tolerance at an economical cost.

Alumina has been used successfully to manufacture the dipole vacuum vessels and has resulted in reliable operation of the ISIS Synchrotron for the last 30 years. These vessels are now approaching a 30 year life span and a requirement has been established to manufacture spare vessels for the current synchrotron, and to re-establish the manufacturing knowledge and skills for future synchrotrons being proposed.

This tender relates to the supply of component parts necessary to produce a single replica ISIS dipole vacuum vessel from Alumina Ceramic and Glaze based upon the current design. The specification relates to the SUPPLY of components ONLY, it is intended that the assembly of these components will be undertaken in-house by STFC.

Additional components required for equipment performance verification (such as test samples for tensile/bending testing of the glazed joints) are also included into the scope of supply.

Dipole vacuum vessel consists of several ceramic components connected together by a suitable glazing.

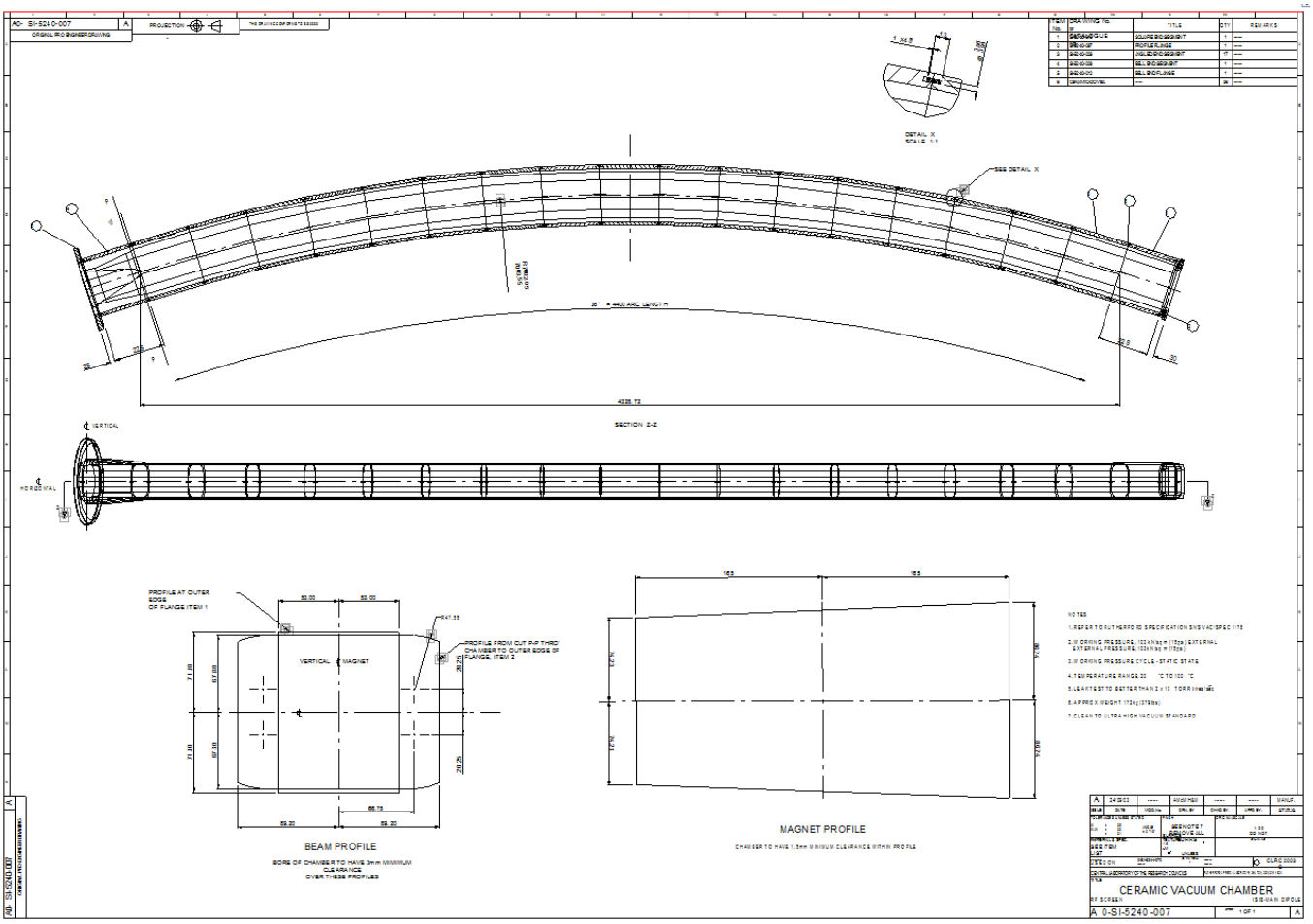

Figure 1 CERAMIC DIPOLE VACUUM CHAMBER

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2 SCOPE OF TENDER

This paragraph outlines the minimum scope of supply to satisfy project requirements.

The supply shall include the following items:

- Material/glazing Qualification Samples (refer to section 2.1 of this document for details);
- Vacuum Vessel Components (refer to section 2.2 of this document for details);
- Tooling (refer to section 2.3 of this document for details);
- Documentation (refer to section 2.4 of this document for details);
- Miscellaneous (refer to section 2.5 of this document for details).

The specialized nature of the components and the unique difficulties in their manufacture dictates that there must be a close, well-functioning relationship between the contractor and STFC for all of the components. Following the manufacture, testing and delivery of the qualification samples (which will subsequently be referred to as 'Phase 1'), there is to be a pause. The pause will last no more than 3 calendar months after the receipt of the last test sample on the RAL site. This break will allow STFC to critically examine the quality and performance of the delivered components. At this point STFC reserves the right to cancel the subsequent manufacture and supply of the production components. Should STFC deem that 'Phase 1' has been successful and wishes to continue with the procurement, then written confirmation will be given to proceed with 'Phase 2', which consists of the supply of the production components.

After supply, assembly and testing of a single production unit ('Phase 2'), STFC reserves a right to put an additional order for one or more production units (as per 'Phase 2'). This can be considered as 'Phase 3' of the project. For the whole duration of the 'Phase 3', which is at least 4 years, supplier shall be ready to supply additional equipment shall STFC request it.

2.1 Material/Glazing Qualification Samples

This section is related to the Phase 1 of supply. During this phase the following parts shall be provided to STFC:

- Qualification samples for Flexural Strength (Four Point Bending Test) test (as per P/N: SI-5240-560, SI-5240-640, SI-5240-643, SI-5240-649);
- Qualification samples for Vacuum Leak test (as per P/N: SI-5240-461);
- Qualification samples for Direct Tensile Test (as per P/N: SI-5240-467 or similar). This only will be required for additional testing if information obtained from other tests is not conclusive.
  Quote is not required at this point.

The use of a particular grade of alumina or glaze, is subject to the ability of the Supplier to provide test pieces to prove such materials are of adequate joint strength, and vacuum performance to satisfy STFC requirements (temperature, pressure etc.) as per section 4.1 of this document.

STFC has designed qualification pieces to be tested based on:

(i) European Standard EN 843:1 (2006);
(ii) Internal ISIS Vacuum base pressure and leak test criteria (refer to individual drawings).

After the qualification samples have been supplied, they shall be evaluated by STFC against baseline performance criteria within a specified time period (nominally 10 working weeks). In the event STFC needs additional time to evaluate an alternative solution the delivery schedule shall be deemed to run from the end of this evaluation period.

Refer to section 4.6 for detailed description of the test samples and required number of samples.

2.2 Vacuum Vessel Components

This section is related to the 'Phase 2' of supply. During this phase the following parts shall be provided to STFC:

- ONE set of components to assemble complete vacuum vessel, as per the Bill of Materials (P/N: SI-5240-007).

Note that final assembly will be done by STFC.

2.3 Tooling

This section is related to all Pha6ses of this project.

Supplier must provide all the required equipment in order to manufacture, assemble, quality control and testing of the components (both qualification and production). This includes (but not limited):

- Equipment for manufacturing of the Alumina Ceramic Components (for all the Phases of this project):
  - Dry bag Isostatic Pressing of Alumina;
  - Green machining of unfired Alumina components;
  - Firing of Alumina Components;
  - Post fired machining and Diamond grinding of Alumina Components;
  - Fully Fired glazing of components as specified on individual components' drawings.
- Quality/dimensional control gauges etc.
- Vacuum leak testing of components (including manufacture of leak test end fittings and seals as necessary).

All the bespoke tooling shall remain the property of STFC and shall be securely stored for recall by STFC at any time, for a minimum of four years.

2.4 Documentation

As a minimum the following documentation shall be supplied to STFC:

- Material (Alumina) specification;
- Glazing specification;
- Dimension Inspection (including full dimensional report) of manufactured components;
- Ultrasonic testing results (components thickness measurements and cracks detection);
- Outgassing tests results;
- Copies of Alumina Ceramic Components Tooling Drawings.

All the contractual and technical documentation must be provided in English.

2.5 Miscellaneous

The cost of the following items shall be included into the Tender response:

- Provision for delivery (including packaging);
- Supply of all relevant Quality Assurance documentation (refer to sections 5 of this document)
- Project management related cost.

Supplier is not required to provide the detailed cost breakdown for each of the above as long as total cost is included into the final proposal.

3 GENERAL CONDITIONS FOR TENDERING AND CONTRACTING

3.1 Tender Information Clarification

STFC wishes to ensure that no doubt exists as to the interpretation of this Technical Specification. Under the procurement system we use, any questions/queries would have to be raised through the Emptoris System and responses issued through Emptoris. If the response clarifies the tender, then it would then be made available to all potential tenders.

The supplier is advised that tender evaluation shall include assessments of references / experience of similar work as well as tooling and press equipment procurement. The requirement to involve a third party shall be recorded against scores in these specific criteria upon evaluation.

3.2 Contract Technical Liaison

The supplier shall assign a single person to be responsible for communication between STFC and supplier, for the duration of the project.

3.3 Deviations from this Technical Specification

If, after the contract is placed, the supplier discovers that he has misinterpreted this Technical Specification, this will not be accepted as an excuse for deviation from it and the Contractor shall deliver equipment in conformity with this Technical Specification at no extra cost to STFC.

During execution of the contract, all deviations from this Technical Specification, the tender, or any other subsequent contractual agreement, proposed by the supplier, shall be submitted to STFC in writing for the latter's consideration.

STFC reserves the right to modify this Technical Specification during execution of the Contract. The consequences of such modifications shall be mutually agreed between STFC and the Contractor. The Contractor shall not unreasonably withhold their agreement to such modifications which shall take the form of formal amendments to the contract, to be issued only by UKSBS Procurement staff.

4 TECHNICAL DETAILS

4.1 Technical Requirements

Alumina vacuum vessel is expected to be operated under the following conditions:

- Temperature: Ambient (10 to 35°C);
- External Pressure: Ambient;
- Internal Pressure: 10^{-9} mbar – Ambient.

Glazed joint is expected to be weaker than the original material. However, to maintain vessel integrity it is important for glazed joint to maintain at least 85% strength (as per Flexural Strength and Direct Tensile tests) of the original material.

4.2 Alumina Material

The Alumina Sections to be manufactured from sintered / isostatically pressed Alumina with an Alumina content between 95 and 99.9%.

4.3 Vitreous Glaze Specification

The vitreous Glaze should be selected to be compatible with the grade of Alumina used. This glaze shall be in the solid phase at normal room temperature and pressure, but shall form the molten phase at a temperature below the suitable temperature of STFC oven (1100 Celsius (1373 Kelvin)) to permit the components to be assembled by oxidation firing, on-site at STFC, in a bespoke furnace owned and operated by STFC.

The glaze shall have a high post firing strength and must be free of colourants and glaze modifiers that would weaken the joint strength.

Care must be taken in ensuring that the glaze is applied evenly and excess glaze is removed prior to firing. The contractor shall detail/specify what glaze type and application method is to be used.

4.4 Joint Strength Requirements

The supplier shall provide details of the mechanical properties of the Alumina material in its' post-fired state, indicating the test methods and standards that are complied with.

To achieve adequate strength under vacuum each individual component must be produced as per relevant drawing. The strength of joints shall be achieved by applying a vitreous glaze to the mating surfaces. In order to avoid glaze bulging during assembly and firing, glazing should be extended 5.0mm along the external surface of the sections and the internal surface of the bore. The final thickness of the glaze shall not be less than supplier specified thickness.

The joint strength shall be qualified by supply of test components as described in section 4.6. These test components will be assembled and tested by STFC. Drawings for these components are shown in Appendix A. the quantity supplied shall be sufficient to produce 16 bend test and a single vacuum leak test assemblies. STFC shall require 10 weeks to test and evaluate the test results of these samples. In the event of further time being required, STFC shall permit the bidder to amend the delivery date of 'Phase 2' such that the original delivery schedule will commence from receipt, by bidder, of test piece approval from STFC.

4.5 Tolerance Requirements

Dimensional tolerances of post fired and post machined components shall be in accordance with the relevant drawings. The contractor shall specify the predicted shrinkage of the Green State Alumina components during firing as a percentage by volume, and size the Isostatic press mould tooling appropriately.

The drawings that form part of this tender document show dimensions for components that have been fired and undergone post-firing machining. Where glaze has been removed by post firing machining the dimensions shall be adjusted, the component re-glazed, and re-fired, to achieve the final net component size within tolerance.

Post firing machining of the internal bore of the Alumina Components should not be required to maintain the indicated tolerance band but is permissible if final dimensions and surface finish are in accordance with the relevant drawings. Hand blending of radii is permissible, and where machining takes place, care should be taken to ensure that a smooth internal bore is achieved.

To achieve adequate wetting of Glaze, conformal leak-tight joints and the required angular dimensions, the end faces shall be machined flat after firing by Diamond Grinding to a surface roughness value of 0.6 Micron and an Angular Tolerance as specified on the drawing.

Glaze shall then be applied to the machined end faces to the specified thickness and the component re-fired to fix the glaze in position. A smooth surface and parallelism of adjoining components is crucial to the strength and vacuum leak tightness of the refluxed joint upon assembly at STFC.

The perpendicularity of ceramic dowel holes to the end faces, and their positional accuracy must also be tightly controlled to ensure the internal and external bores line up accurately and fit within the Dipole magnet Aperture. It must be emphasized that ceramic dowel holes are drilled precisely perpendicular to the ANGLED end surface, NOT parallel to the nominal axis of the Ceramic Component. Any non-perpendicularity will result in interference fit of ceramic dowels, and fracture (and misalignment) upon assembly at STFC.

4.6 Test Components Design (Phase 1)

STFC has designed a test program to assess the performance of the Alumina material and Glazing.

Following tests will be performed during the 'Phase 1' of this project by the Supplier:

- Visual inspection. Refer to section 4.6.1 for detailed supply requirements;
- Crack inspection. Refer to section 4.6.1 for detailed supply requirements;

Following tests will be performed during the 'Phase 1' of this project by the STFC:

- Flexural Strength Test (Four Point Bending Test). Refer to section 4.6.2 for detailed supply requirements;
- Vacuum Outgazing Test (glazed components). Refer to section 4.6.3 for detailed supply requirements;
- Vacuum Leak Test. Refer to section 4.6.3 for detailed supply requirements;
- Direct Tensile Test. Refer to section 4.6.4 for detailed supply requirements;

The type of Glaze and Alumina used to manufacture test components shall match the type proposed as a solution for production components. STFC shall assemble test pieces using its own oven facilities and perform the vacuum tests using its own test equipment. The Bidder must provide specification on recommended joining procedure.

Should any test failure occur as a result of pre-existent sample defects, new test pieces shall be provided at Supplier's expenses and test shall be repeated.

The results of tests performed by STFC in the evaluation of alternative solutions remain the intellectual property of STFC and will not be disclosed to 3rd parties.

4.6.1 Visual Inspection and Crack Test

Visual inspection and ultrasonic examination shall be performed on each qualification part prior to delivery to STFC.

4.6.2 Flexural Strength Test

This test is based on method described in EN 843-1:2006 and is designed to determine the flexural strength of monolithic ceramic material at room temperature.

Two different test samples design have been proposed:

a. Test piece as per European Standard EN 843:1 (2006);
b. Round test piece;

Two separate tests will be performed:

a. Flexural Test of monolithic ceramic sample. This test will be used as a base line to determine material properties of the base material:
    a. Refer to drawing SI-5240-649 (4-Point Bend Cylindrical Test Piece);
    b. Refer to drawing SI-5240-643 (4-Point Bend Test Piece).

    Supplier is required to provide quote for both options. Final decision on sample will be made during technical discussion post tender.
b. Flexural Test of glazed ceramic sample. This test will measure the flexural strength of the Alumina – Glaze joint:
    a. Refer to drawing SI-5240-640 (4-Point Bend Cylindrical Test Piece);
    b. Refer to drawing SI-5240-560 (4-Point Bend Test Piece);

    Supplier is required to provide quote for both options. Final decision on sample will be made during technical discussion post tender.

The glazed joint is expected to be the weakest point. Where failure occurs within bulk Alumina either side of the glazed joint this may be followed up with proctographic examination in accordance with EN 843-6:2006.

The Supplier shall specify the price per component, and as minimum supply 15-off SI-5240-643 and SI-5240-649, and 30-off SI-5240-640 and SI-5240-560.

4.6.3 Vacuum Outgazing Test & Vacuum Leak Test

This test is designed to verify material and glazing performance under given working conditions. Test will be performed at STFC using a test arrangement SI-5240-460.

Alumina sections will be tested for outgassing after a period of evacuation of 10 hours. The outgassing rate after 10 hours shall not exceed 1 x 10^{-9} torr litre / sec / cm^2. Test piece will then be subject to vacuum leak rate testing with a vacuum leak rate not exceeding the required level of 1x 10^{-8} torr litre / second.

The Bidder is required to provide price for four glazed components as per SI-5240-461 (Alumina Vacuum Test Specimen) and four dowels as per SI-5240-406 (Alumina Test Specimen Dowel).

4.6.4 Additional Test Program

If the results of above qualification program are not sufficient to evaluate material and glaze performance, STFC reserves right to perform additional testing either by repeating one or more of the above tests, or by performing additional testing such as:

- Direct Tensile Test as per BS ISO 15490:2008;
- Interfacial bond strength as per BS ISO 13124:2011.

If required additional testing program will be discussed upon completion of the original qualification program and is outside of the scope of this Tender.

4.7 Production Components Design (Phase 2)

Supplier is expected to provide all the required components to build one complete assembly as per drawing SI-5240-007. Supplier is not expected to provide the full assembly as this component will be assembled at STFC from the individual components supplied.

Refer to the following drawings for individual components' design details:

- Angled Segment – SI-5240-008
- Chamber Bell End – SI-5240-009
- Square End Segment – SI-5240-010
- Profile Flange – SI-5240-097
- Bell End Flange – SI-5240-012
- Ceramic Dowel – SI-5240-406

Note: Supply quantities are as per top level assembly drawing SI-5240-007.

Note: Part SI-5240-406 is required for both Phases of the project. However, Supplier is requested to quote them for each Phase separately based on a quantity required for corresponding phase.

5 PRODUCTION COMPONENT QUALITY ASSESSMENT

Each individual component must be checked prior to delivery to STFC. The contractor must supply details of the testing procedures to be carried out to meet the specification requirements within their tender response.

STFC require that all the production components to be tested, and the contractor must include an itemized cost for complete testing of all sections in the tender response.

Any component that fails testing (both prior (section 5.1) and post-delivery (section 5.5) testing) shall be replaced by Contractor with equivalent components that passed testing. All the costs associated with components replacement shall be sole responsibility of the contractor.

5.1 Inspection of Components for Defects

Following test must be performed by the Supplier for each individual component as a last step prior to delivery to STFC. Components must be initially subjected to a visual inspection to ensure they are free of visual defects. This shall then be followed by a full dimensional check. The contractor shall detail the inspection equipment available for measurement of surface and through-thickness dimensions.

5.1.1 Visual Inspection

To be performed on each component to ensure they are free of visual defects (e.g. chips, discolorations, inclusions).

5.1.2 Dimensional Inspection

Dimensional tolerances of post fired and post machined components shall be adhered to in accordance with the relevant drawing. Dimensional reports to be supplied to STFC together with the components.

All the required thickness measurements shall be made following manufacture on individual Alumina Sections at the locations indicated on the individual drawings.

All individual Alumina sections are to be tested for thickness at these locations prior to supply to STFC. Documented test results are to be provided for components supplied to STFC.

5.1.3 Testing for Cracks

To ensure components are crack free, ultrasonic or similar tests shall be carried out. As a minimum these should be undertaken at the locations specified on the individual drawings and along the whole length of each component.

5.2 Additional Items

Please supply individual costings for any other items that may be required. Prices for these items should be listed separately from the Alumina component prices.

5.3 Quality Assurance Plan

The Contractor must plan, establish, implement and adhere to a documented quality assurance program that fulfills all the requirements described in this Technical Specification.

5.4 Certificate of Conformity

The contractor shall provide a certificate of conformity to show that the appropriate tests have been undertaken to ensure material conformance, component's quality and adherence to dimensional and thickness tolerances.

5.5 Vacuum Tightness Testing

Following tests will be performed by STFC upon receipt of the individual components. These tests are designed to provide vital information about components' performance under working conditions.

Testing will be undertaken at the STFC facilities. Supplier may request that its' representative is present to witness these tests.

5.5.1 Cleanliness of Components

Upon delivery and prior to testing components will be cleaned accordance with the original cleaning specification SNS/VAC/SPEC/SPEC 1/78 or ISIS/TS/N5/05.

5.5.2 Leak Rate Testing

Each individual section will be subject to vacuum leak rate testing. Individual sections shall not exceed a vacuum leak rate of $1x\ 10^{-8}$ torr litre / second.

5.5.3 Outgassing Requirements of Manufactured Components

Alumina sections will be tested for outgassing after a period of evacuation of 10 hours. The outgassing rate after 10 hours shall not exceed 1×10^{-9} torr litre / sec / cm^2.

6 DELIVERY

6.1 Delivery Dates

The Bidder shall as a minimum specify the expected lead time for the following items:

a. Solution development phase (if required)
b. Test samples tooling design;
c. Test samples tooling manufacturing;
d. Test samples manufacturing/delivery;
e. Production items' tooling design;
f. Production items' tooling manufacturing;
g. Production items' manufacturing/delivery;

6.2 Packaging

The Bidder shall propose and cost the provision for packaging for the individual components, and provide information regarding any specific handling requirements for STFC to follow (if any).

6.3 Transportation

Arrangements for transportation and delivery should be made by the contractor to ensure the specified delivery schedule. Each coil should be suitably insured against damage whilst in transit to an appropriate value to allow for complete replacement should the need arise.

6.4 Delivery

Deliveries to the RAL site shall be between 08.30 and 15:30 Mondays to Thursdays, and 08:30 to 14:30 pm on Fridays only, unless prior written agreement from STFC has been sought.

6.5 Storage at STFC

After delivery to STFC the Alumina components will be kept in secure storage. Access to the delivered components in storage will only be possible during standard working hours unless prior arrangement is made.

The supplier shall indicate any specific storage requirements for STFC to follow upon reception of the components.

7 TENDER DOCUMENTATION SUMMARY

7.1 Quotation

The quotations should include the following items as detailed above.

a. Quote for a complete set of Alumina Ceramic components.
b. Quote for additional items as described below:

- Isostatic Press and Mould Tooling – Where the supplier has to include the purchase costs of an isostatic press and / or mould tooling in the production of the Alumina Ceramic components the isostatic press shall remain the property of STFC. Any mould tooling that is manufactured to fit in the press shall also remain the property of STFC and shall be returned to STFC on completion of the contract. Said press and tooling shall not be made available to any other customer. STFC shall at its' discretion permit the supplier to store any Mould Tooling on their premises without incurring any associated charges, should STFC consider orders for further vessels of the same design necessary. In this eventuality the supplier shall be required to satisfy STFC or its' representative that said tooling is kept in a secure, dry and 'bonded' storage facility.
- Green Machining – any additional tooling, jigs or fixtures that have to be manufactured during the Green machining process shall remain the property of STFC. STFC shall not require these items to be returned to STFC, but shall expect the supplier to store any such fixtures securely in the event of repeat orders.
- Post Firing Machining – all consumable tooling that will be required for the post fired machining of components shall be purchased at the discretion of the supplier. The cost of all tooling shall be included as part of the component fixed price.
- Glazing equipment – all the specific tooling made to glaze STFC components shall remain the property of STFC. STFC shall not require these items to be returned to STFC, but shall expect the supplier to store any such fixtures securely in the event of repeat orders.
- Quality control equipment – all the specific tooling made to quality control STFC components (e.g. bespoke gauges, or fixtures) shall remain the property of STFC. STFC shall not require these items to be returned to STFC, but shall expect the supplier to store any such fixtures securely in the event of repeat orders.

All quotes are to be itemized, and should include delivery to the Rutherford Appleton Laboratory site. The tender responses must include:

- Sufficient information to describe the manufacturing process used.
- Expected manufacturing tolerances of Alumina sections.
- Alumina grain size, consolidation process, % content and any additive used to assist machining.
- Quantities of vessels sections that will be delivered.
- Expected outgassing of Alumina under vacuum.
- Specification and application process of Vitreous Glaze.
- Expected fracture toughness of the supplied Alumina.
- Time-scales for delivery from receipt of order, including outline project plan.
- References, where possible, of customers previously supplied with similar components.
- Alumina and Glaze trade name.

7.2 Testing Procedures and Reports

The tender response should include details of all testing procedures and reports that will be carried out and supplied to prove conformity with the specification as outlined in section 5. The Bidder shall provide an inventory of test equipment and procedures to be used. Copies of test reports shall be delivered alongside components and originals will be required to be retained by the Supplier for a period of not less than 4 years from delivery of components, whereupon they shall be offered to STFC for archiving.

7.3 Deliverables

The following table summarizes the minimum supply required by STFC.

Item	Description	Quantity required (min)	Phase
SI-5240-560 or SI-5240-640*	4-Point Bend Test Piece	30	**Phase 1**
	4-Point Bend Cylindrical Test Piece		**Phase 1**
SI-5240-643 or SI-5240-649*	4-Point Bend Test Piece	15	**Phase 1**
	4-Point Bend Cylindrical Test Piece		**Phase 1**
SI-5240-461	Vacuum Test Specimen Part	2	**Phase 1**
SI-5240-406**	Ceramic Dowel	4	**Phase 1**
SI-5240-008	Angled Segment	17	**Phase 2**
SI-5240-009	Chamber Bell End	1	**Phase 2**
SI-5240-010	Square End Segment	1	**Phase 2**
SI-5240-097	Profile Flange	1	**Phase 2**
SI-5240-012	Bell End Flange	1	**Phase 2**
SI-5240-406**	Ceramic Dowel	40	**Phase 2**

*Supplier is required to provide quote for both options

**Part is required for both Phases of the project. Supplier is requested to quote them for each Phase separately based on a quantity required for corresponding phase.

Please Note: - Phase 2 of this project will only be awarded after STFC accepts Phase 1, in addition STFC reserves the right to place an additional order as per Phase 3, discussed in this document (refer to section 2).