SPECIFICATION FOR

THE PROVISION OF

FULL ENERGY BEAM EXPLOITATION (FEBE) DIPOLE MAGNETS

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Annex A Specification Document – Supplies

Title of Request:	UK SBS PR19089 Specification

1. Introduction

Introduction

This document is intended to accompany the Invitation to Quote (ITQ) documentation for the FEBE dipole magnets. It describes the deliverables for this contract and the technical specification for the magnets.

1.2 Offer Compliance

1.2.1 Complete system

It is essential that a complete system as stated in the ITQ document shall be proposed to the Contracting Authority by the Bidder.

All components plus all necessary minor and/or ancillary items shall be provided to the Contracting Authority by the Bidder in completion of any contract arising from this tender.

1.2.2 Functionality

The Bidder will propose a complete solution to the Contracting Authority including the design, selection and sizing of all components and equipment to be used, such that they will provide a working and complete installation to satisfy the stated requirements for full operational functionality in the identified working environment.

1.2.3 Responsibility

The Bidder will be responsible for ensuring the compatibility and integration of all parts of the proposed magnets.

This will include all hardware whether it is provided by the Bidder, a subsidiary or related organisation or an independent third party.

The Bidder will be fully responsible for the proposed design and liable for any mistake, inaccuracy, discrepancy or omission in their proposed solution to the stated requirements.

Nothing contained in the Bidder's design or proposal will relieve the Contracting Authority from their obligations or liabilities detailed within this document, and agreed or contained within any final contract documentation.

1.2.4 Good practice

To the extent of his obligations pursuant to the above clauses, the Bidder shall warrant to the Contracting Authority that:

- They have exercised and shall continue to exercise, both in the design of the proposal and fulfilment of any final Contract Document, all the skill that shall be expected of a professionally qualified and competent designer experienced in work of a similar nature and scope
- The tender proposal shall, unless otherwise agreed in writing, comply in all respects with the Contracting Authority's requirements and the proposed equipment shall be fit for purpose
- The Bidder's proposal has been designed using proven up-to-date good practice and to standards which are consistent with the stated requirements of the purchasing organisation
- No plant or equipment generally known to be deleterious or otherwise not in accordance with good engineering practice, has been or shall be specified or selected by the Bidder or anyone acting on his behalf
- No plant or equipment which, after its specification or selection by or on behalf of the Bidder but before being incorporated into the Contracting Authority, becomes generally known to be deleterious or otherwise not in accordance with good engineering practice shall not be incorporated into the purchasing organisation
- The design of the contracted proposed System has taken or shall take full account of the effects of both the intended use and installation methods.

1.3 Overview of project

The Accelerator Science and Technology Centre (ASTeC) at Daresbury Laboratory is currently building an accelerator test facility, CLARA – the Compact Linear Accelerator for Research and Applications.

The CLARA Conceptual Design Report (CDR) was published in May 2014, and can be found on the IOP website: https://iopscience.iop.org/article/10.1088/1748-0221/9/05/T05001/meta.

2. Aims & Objectives

2.1 Overview of procurement

FEBE (Full Energy Beam Exploitation) is an add-on to the CLARA project, taking the 250 MeV electron beam into a separately-shielded experimental hutch, providing additional resources for experiments and exploitation such as laser-plasma acceleration. The beamline requires dipole, quadrupole, and corrector magnets. This procurement relates to the dipole beamline magnets.

The Contracting Authority is looking to procure the magnets for this beamline from Bidders who specialise in design, manufacture and testing of similar magnetic systems for accelerators.

3. Background to the Requirement

The Contracting Authority is building the FEBE beamline as an extension to the CLARA accelerator. FEBE will transport a 250 MeV electron beam to a shielded experimental area. Dipole, quadrupole and corrector magnets are required to focus the beam along the FEBE transport line.

The CLARA project is split into work packages (WPs), each of which is led by a UKRI staff member. The magnet specifications are set by WP2 Magnets and Undulators, in consultation with WP9 Accelerator Physics, WP11 Mechanical Engineering, and WP13 Electrical Engineering.

4. Scope

4.1 Deliverables

The deliverables for this project are as follows:

- 4 “Type 6” dipole magnets
- 1 “Type 7” dipole magnet
- Two spare dipole coils, one of each type
- Drawings
- QA documents
- Measurement data

This contract covers the:

- magnetic design
- engineering design (mechanical, thermal and electrical)
- procurement of all materials
- manufacture and assembly (including all jigs and fixtures)
- magnetic measurement
- electrical and mechanical testing, including fiducialisation
- documentation
- delivery to Daresbury Laboratory, Warrington, WA4 4AD, UK

The contract does not cover:

- power supplies for the magnets
- the supporting girders

4.2 Component labelling

Each individual magnet will be identified and numbered. The identification number will be printed on an identification plate and glued onto the magnet at an agreed position, as shown on Bidder’s drawings approved by the Contracting Authority. These serial numbers will be used for all manufacturing and test records and in all communications when reference is made to specific magnets.

5. Requirement

5.1 Dipole specification

5.1.1 Type 6

These are the detailed specifications for the Type 6 dipole magnets. The basic parameters are as follows:

- Quantity: 4
- Type: Rectangular (parallel ended)
- Pole gap: 42 mm
- Integrated field: 204 T.mm
- Field quality (maximum variation of integrated field over good field region): $\pm 1 \times 10^{-4}$
- Good field region: ±34 mm (horizontal), ±17 mm (vertical)
- Maximum length including coils (along beam axis): 290 mm
- Maximum vertical distance from magnet centre to bottom face: 210 mm
- Maximum current to generate nominal integrated field: 400 A
- Maximum voltage to generate nominal integrated field: 60 V
- Maximum inductance: 1 H
- Impedance must be such that the time constant (L/R) is less than 1 s
- Linearity of gradient versus current over range from zero to nominal: 98%
- Yoke type: Solid or laminated

5.1.2 Type 7

These are the detailed specifications for the Type 7 dipole magnet. The basic parameters are as follows:

- Quantity: 1
- Type: Rectangular (parallel ended)
- Pole gap: 42 mm
- Integrated field: 699 T.mm
- Field quality (maximum variation of integrated field over good field region): $\pm 1 \times 10^{-4}$
- Good field region: ±34 mm (horizontal), ±17 mm (vertical)
- Maximum length including coils (along beam axis): 650 mm
- Maximum vertical distance from magnet centre to bottom face: 285 mm
- Maximum current to generate nominal integrated field: 400 A
- Maximum voltage to generate nominal integrated field: 60 V
- Maximum inductance: 1 H
- Impedance must be such that the time constant (L/R) is less than 1 s
- Linearity of gradient versus current over range from zero to nominal: 98%
- Yoke type: Solid or laminated

5.4 Engineering design

The engineering design of the magnets will include the following details:

- Features for the mounting of survey monuments;
- a footplate to interface with Daresbury Laboratory's girder arrangement;
- the position of power and water connections.

These details need to comply with the Contracting Authority's layout and planning, and arrangements will be jointly agreed early during the design phase of the contract.

Preliminary designs for the kinematic mounts needed to support and align the magnets have been carried out by the Contracting Authority. The base plates of the magnets must be able to attach to these kinematic mounts. Holes for attachment are shown in drawings 256-16376-A and 256-17480-A. These hole positions are preliminary but any change must be agreed with the Contracting Authority.

Overall design of the FEBE beamline is approaching completion. The space available for components must be tightly controlled to avoid clashes. Any protrusion outside the space envelope given in this specification must be agreed with Daresbury Laboratory engineers.

The drawings 256-16376-A (Type 6) and 256-17480-A (Type 7) show the maximum space envelope and interface requirements for the magnets. Some dimensions are marked 'MIN' and 'MAX' on these drawings; these are absolute limits to make sure the magnets fit within the available space. Other dimensions are indicative and are based on an initial estimate of the size of the magnets.

The magnets shall be designed with lifting brackets that are adequate for the support of the complete magnet.

Exposed live contacts should be enclosed with a clear plastic guard, an extra 10mm is permitted on one side of the magnet.

The design shall ensure that the upper and lower halves of magnets correctly mate and align on reassembly after separation to insert the vacuum vessel.

5.5 Fasteners and fittings

All equipment shall use ISO metric A4 stainless steel fasteners, nuts and washers throughout.

5.6 Survey and alignment

The nominal magnetic axis of the magnets will be aligned at Daresbury Laboratory by reference to fixed points on the supplied structure. The magnetic axis will be related to these fixed points by a process of fiducialisation, whereby the magnetic axis is measured in situ at the Bidder and the exact location of these reference points are then established by measuring offsets either via a coordinate measuring machine (CMM) or laser tracker type device. Offsets of the magnet axis in X, Y, Z type coordinate system in mm are then provided as part of the deliverables as a data set relative to these points.

These points are then referenced at Daresbury Laboratory using our own Leica and Faro laser trackers which – along with offset data - then allows us to align the quadrupole magnetic axis with respect to our own survey network.

An orientation vector for each data set is also required and this is likely to be best established off a machined plane of the magnet support. A complete set of survey data must be provided with each magnet upon delivery. The form of the survey data as a baseline minimum is as a tabulated list (Excel file) but preference is given for SpatialAnalyzer (SA) file (if this is capable of being generated by the Bidder). Each data set must be clearly and unambiguously identifiable with the specific magnet delivered.

The fiducial reference points on the structure will be provided by a range of precision reamed holes - that will fit standard laser tracker target mounts with minimal error – and are located into various planes of the magnet support. The provision of these holes to agreed specification is the responsibility of the Bidder.

The holes are nominally defined as 10 mm diameter with an H6/H7 precision finish (ISO 286-2) i.e. zero to 11/18 µm oversize. This hole size will fit our range of preferred laser tracker targets 0.5TH type Brunson. See this reference: https://brunson.us/0-5th-series-smr-adapter.html

If it suits the measurement process proposed by the Bidder at their premises, then the Contracting Authority may be able to supply as free issue several Brunson standard survey monument targets so that they can be incorporated into the measurement process. Otherwise it is assumed the Bidder will use their own targets (with suitable offsets stated with survey data provided upon delivery).

The fiducialisation measurements should ideally be performed at 23°C to an RMS accuracy of ±0.025 mm. If temperature at the contractors cannot be set to 23°C, then the proposed measuring temperature shall be stated and a method to compensate or provide offset for the CLARA operational temperature of 23°C specified.

If it is envisaged that the ideal RMS accuracy of ±0.025 mm tolerance between any set of target points cannot be met, then a realistic achievable RMS should be stated in the tender return.
The fiducials must be stable and repeatable to within the RMS accuracy defined after several warm-up and cool-down cycles of the structure. A check should be made on at least a test sample of finished magnets prior to delivery over a ±5°C temperature cycle.

An outline proposal of the alignment process should be provided with the tender return that includes and addresses the issues raised above. Final details must be discussed and agreed between the Bidder and STFC at the Final Design Review. We note that in this tender specification we have established what we envisage as a baseline expectation for survey. Dependent on aspects of the design of the magnets and the Bidder's own proposals - we anticipate that the final agreed measured data set and number of holes required may be streamlined to be simpler than the baseline specification.

5.7 Tooling

The Bidder should hold the tooling used in the manufacture of the magnets in a satisfactory storage area for a period of 5 years from the completion of the contract.

5.8 Magnet Yokes

5.8.1 Yoke assembly

It must be possible to split the magnets, to introduce the vacuum vessels from above.

The Bidder should determine and indicate in their tender document the method of stacking and securing the laminations they intend to use, if applicable. These methods shall be proposed as part of the engineering design, and subject to the Contracting Authority's approval.

The Bidder should give a clear explanation of how, by machining, they intend to ensure that the specified dimensions and angles required on the completed block will be achieved.

5.8.2 Steel

This section defines the steel quality that is to be used for the magnet yokes.

The magnetic performance of the magnets is the responsibility of the Bidder, who must choose steel of the correct grade to meet the required performance. However, the material used in the magnet yokes shall comply with the following magnetic properties:

Field *H* (A/m)	**Minimum Induction *B* (T)**	**Minimum relative permeability μ_r**
150	0.5	2650

320	1.0	2480
1000	1.5	1190

The material's coercivity should not exceed 100 A/m.

5.8.3 Dimensional Control

The acceptance of the yokes will be determined by measuring all dimensions shown on the specification drawings or within this specification as mandatory. No further dimensional measurements are required, as acceptance is based on magnetic performance.

5.8.4 Painting the Yokes

After assembly and control, the yokes will be protected against rusting by coating the appropriate surfaces by means of a powder coating system of minimum thickness 0.2 mm.

The following faces will not be painted:
- reference and mating faces;
- the survey monument supports.

The unpainted areas shall be protected by a light oil or other rust preventative measures.

The colour to be used for the magnets is as follows:
- Dipoles: Light Blue RAL 5012

5.9 Magnet Coils

5.9.1 Coil Construction

The coils shall be constructed using solid copper conductor, or hollow conductor with a water cooling channel where necessary.

The coil conductors shall be insulated by an enamelled surface layer which provides adequate inter-turn insulation. This enamel insulation shall comply with IEC standard 60317-8 and satisfy the requirements of Thermal Class H specifications. Additional outer-ground insulation shall be added to ensure that the coils meet the IP2X specification.

The coils of the magnets shall be designed to have the following thermal parameters when operated with nominal flow in the water cooling circuit (the inlet water temperature should be assumed to be 25˚C):

Maximum allowed coil temperature rise at nominal DC current (measured at coil surface inside magnet gap)	10	˚C
Maximum allowed coil temperature rise at nominal DC current (measured by coil resistance)	15	˚C
Maximum allowed coil temperature rise at 110% of nominal DC current (measured at coil surface inside magnet gap)	15	˚C
Maximum allowed coil temperature rise at 110% of nominal DC current (measured by coil resistance)	20	˚C

The wound coils will be mechanically consolidated by the use of an epoxy resin system applied either during the winding of the coils or present as a 'B stage' coating on the coil material. The Bidder shall ensure that the bonding process is adequate for the long-term mechanical stability and soundness of the coil and that the design used provides an adequate outer electrical insulation.

The coils shall be terminated on suitably mounted, insulated, connection panels.

After completion of winding and the curing of the resin bonding system, the resin on the coils must be fully transparent, with no colouriser or additive that would limit observation of the enamelled turns within the coil. No paint or other external coating will be allowed.

5.9.2 Conductor

The conductor shall use oxygen-free high conductivity (OFHC) copper with a maximum volume resistivity of 17.3 nΩm at 20˚C, and its properties shall be as specified in DIN 1787 OF-Cu (DE), or BS 6017:1981 Cu-OF (UK), or A 53-100 Cu-c1 (France).

The material shall be in the fully-annealed condition prior to winding, and the coil fabrication method must be such as to minimise work hardening during the winding operation.

The dimensions of the conductor shall be as determined by the Bidder's design, as approved by the Contracting Authority.

The uniformity of the conductor shall be such that the resistance of all coils constructed from it shall be equal to within ±5%.

The use of joints within the coils will not be permitted.

5.9.3 Bonding and Outer-insulation System

No material, other than those detailed in this section shall be included in the coil without the written permission of the Contracting Authority or its authorised representative. All materials must be suitable for use in a high radiation environment.

The resin bonding system shall comprise a radiation-resistant epoxy resin with an anhydride curing agent, with optional inclusion of an accelerator. The choice of the resin Bidder, the resin type and the curing agent are left to the Bidder. However, this choice is part of the offer and must be indicated within the offer, with corresponding technical documents appended.

Any addition of additives or wetting agents will be subject to written authorisation from the Contracting Authority.

The use of additives with resin systems is known in many cases to prejudice the required mechanical and electrical properties, in particular the irradiation stability. Dilutants, fillers, plasticisers and flexibilisers are therefore specifically prohibited.

Details of bonding and curing operations for the resin system must be submitted at the tendering stage. The Contracting Authority will approve all materials and processes prior to use in coil manufacture, but such approval shall in no way release the manufacturing company from any of its responsibilities under the contract.

The coil terminals, the connection posts and all metallic parts connected to them will be insulated from the yoke and able to sustain 5 kV DC without any electrical breakdown and with an insulation resistance greater than 10 MΩ.

The coil terminals, the connection posts and all metallic parts connected to them will be protected against accidental contact by an insulating, transparent cover, shielded against contact to IP2X, which can only be removed by the use of tools; the Bidder's proposals for this cover shall be described in the offer.

Magnet electrical termination connectors are to be decided in conjunction with the Contracting Authority once the overall magnet design has been finalised.

A single terminal connection post able to receive a 10 mm^2 cable shall be provided for earthing the yoke and other components. This shall be connected to all laminations (if used) in each block comprising the yoke by means of a single, resistive, conducting strip painted along the yoke block. This shall be designed so as not to create a shorted turn around the yoke laminations.

5.9.4 Water Connections

Magnets should be supplied with an inlet manifold and outlet manifold mounted on the magnet. The manifold should be manufactured from metric stainless steel tube, grade 304/316 and conform to ASTM A269, suitable for connection to the supply and return water system via a single Swagelok metric compression fitting onto each manifold. The manifold pipe will be mounted vertically on the mechanical services panel and the connection point will be at the bottom end of the tube.

All hoses and pipes located on the magnet should be metric Swagelok except the Inlet and Outlet manifold connections, these should be Rp1/2" (Female). Swagelok American Standard Pipe Thread (NPT) is NOT to be used.

The Bidder shall, during initial design, avoid locating any organic based material in the median plane of the magnet centre where it would be subject to long-term radiation damage from the electron beam.

Water connections to the manifolds should be well above and below the beam-line. Where water conduits cross the beam-line horizontal plane, pipe work should be metallic.

The Bidder shall ensure that there is adequate electrical connection between the earthing post, the manifolds and other components so that all the exposed metallic parts of the magnet are safely earthed by this terminal post.

5.9.5 Inspection and Tests of Coils at Works

The Contracting Authority or its authorised representative shall inspect and approve all tooling, fixtures, materials and processes prior to their use in fulfilment of the contract.

Inspection and approval shall not release the Bidder from any responsibilities under the terms of the contract.

All coils shall bear an identification number stencilled in a position as shown on Bidder's drawings approved by the Contracting Authority, as described above.

The programme of tests to be carried out shall be as specified in the section below.

All tests shall be undertaken using equipment and procedures which have been agreed by the Contracting Authority. The Bidder must specify the methods which it is proposed to use to carry out the test programme.

The Contracting Authority reserves the right to reject any material or coil not fulfilling the conditions laid down in this specification.

No conductor or coil failing any test shall be used or repaired without the written permission of the Contracting Authority or its authorised representative.

5.9.6 Test Schedule for Coils at Works

Test certificates shall be available relating to tests undertaken by the copper Bidder, to include dimensions, resistivity and Brinell hardness.

All coils shall be visually inspected, and must be free from cracking, voids and other flaws or defects. The bonding insulation must not exhibit resin-rich areas, and the thickness of resin on the coil surface must not exceed 0.5 mm. Coils failing to satisfy any of these criteria shall not normally be accepted.

The electrical resistance of all coils shall be measured with a DC bridge. The values shall be corrected to 20˚C and must be within ±5% of the mean value for all coils.

Each coil shall be energised until the coil temperature increases to 55˚C, as measured by the change in electrical resistance. On attaining the required temperature, the current shall be interrupted and the coil allowed to cool until the conductor again assumes the ambient temperature, as measured by the conductor resistance. This cycle shall be repeated ten (10) times. Any coil exhibiting evidence of cracking or delamination shall be rejected. The Bidder may wish to undertake this procedure on several coils simultaneously.

Each coil shall be immersed in tap water at ambient temperature, but with the terminals exposed above the water level. Any other part of the coil body not then completely immersed shall be covered with wet cloths, the ends of which are in contact with the water.

The following test sequence shall then be carried out:

- Record insulation resistance between coil terminals and water bath, at a voltage of 500 V.
- Apply direct voltage of 5 kV between coil terminals and water bath for one minute and record the leakage current.
- Repeat the insulation resistance measurement.

Any coil exhibiting evidence of breakdown or significant changes of insulation resistance during these tests shall be rejected.

Immediately after the test described above the coil shall be tested by using it as the secondary winding of a transformer. A maximum voltage of 2.5 kV RMS shall be induced across the coil terminations for a period of one minute, and the corresponding primary current recorded. Any indication of short-circuiting between turns shall result in rejection of the coil.

5.10 Testing and Measurement

5.10.1 Mechanical Test and Measurement Programme

The Bidder shall give details of their normal test procedure for routine mechanical tests during manufacture with the tender. Details of the specific tests which will be used in this contract shall be agreed at the Design Review.

5.10.2 Electrical Test and Measurement Programme

A direct voltage of 2 kV shall be applied between the terminals of each coil and its magnet yoke for one minute. Any coil showing evidence of breakdown, indicated by a leakage resistance of less than 10 MΩ, shall be rejected.

On each magnet, the coils shall be powered for a period of at least two hours at the nominal current specified and with the nominal water flow rate. During this test the temperature of coil surfaces and all coil interconnections and terminals will be checked with contact thermometers; the coil voltage and current shall be monitored with an accuracy that will allow the average coil temperature rise, measured by resistance, to be assessed. Results shall be judged with respect to the appropriate magnet thermal specifications.

During this time, the mechanical, electrical and thermal stability of the magnet will be monitored.

Any magnet showing evidence of any of the following shall be rejected:

- electrical discharge in the coils, at the terminals between laminations or parts of the yoke and other fittings;
- overheating of the coils;
- a terminal voltage which is more than 5% lower than the mean for that type of magnet (evidence of low inductance due to a shorted turn around the yoke).

The inductance of each magnet should be measured and recorded.

5.10.3 Magnetic measurements

The following magnetic tests must be completed successfully at the Bidder's premises before shipment. The tests consist of in-situ magnetic field measurements by means of suitable probes and should show that the magnets meet the magnetic specifications detailed above.

The magnetic axis of each magnet must be accurately determined and referenced to the magnet's fiducials.

The results of the measurements must be analysed and compared directly to the specification. Measurement errors and reproducibility must also be evaluated.

The integrated field produced by the dipole magnets, and the field quality inside the specified good field region, must be measured. This can be either a rotating coil or Hall probe measurement.
The central field produced by the dipole magnets must be measured using a Hall probe.

The above measurements must be carried out at the nominal dipole current, and in steps of 10% from zero up to 110% of the nominal current.

5.10.4 Acceptance Tests after Delivery

After delivery, each magnet will be visually inspected for mechanical damage suffered in transit. Any such damage will be reported to the Bidder. Possible repair will be the subject to the agreement of the Contracting Authority. Where the damage has resulted in alteration to the magnet iron geometry or to the soundness or shape of coil conductor, insulation or terminals, the magnet shall normally be rejected.

Mechanical, electrical and magnetic tests shall be carried out by the Contracting Authority's staff at Daresbury Laboratory after delivery. The Bidder has the right to be represented during these tests but shall notify the Contracting Authority in writing if this right is to be exercised. Likewise, the Contracting Authority will endeavour to provide the Bidder with adequate notice concerning the timing of such test sequences.

A direct voltage of 2 kV will be applied between the terminals of each coil and its magnet yoke for one minute. Any coil showing evidence of breakdown, indicated by a leakage resistance of less than 10 MΩ, shall be rejected.

Each magnet will be energised with a direct current of value equal to the nominal current specified in the appropriate magnet parameters, for a period of at least two hours. Any coil showing evidence of breakdown, local hot spots or other faults during this period shall be rejected.

5.11 Project Management

5.11.1 Contract Engineer

At the start of the contract the Bidder should nominate a Contract Engineer who will be responsible for all reporting and contact with the nominated Contracting Authority's point of contact.

5.11.2 Reviews and reporting

Start of contract

Within two weeks of the start of the contract, the Bidder should issue a detailed programme covering the design, procurement, manufacturing, testing and assembly phases in sufficient detail to allow regular progress monitoring.

At this time, the Bidder should also produce a QA plan, listing all certification, supporting documentation and procedures that will be implemented within the contract, and which will form the basis of the final QA dossier.

Kick-off meeting

The kick-off meeting should take place after the programme and QA plan have been issued, either at the premises of the Contracting Authority or the Bidder or via videoconference. It should establish a good working relationship between the successful Bidder and the Contracting Authority.

At the meeting:
1. The Contracting Authority will present an overview of the project.
2. The successful Bidder will carry out a walk-through of its initial proposed solution.
3. The Contracting Authority and the successful Bidder will firm up what is required for the final design review.

Throughout the contract, the Contract Engineer should supply a written report to the Contracting Authority every month (or at significant milestones), detailing progress with respect to the programme. A videoconference meeting should be held after the report is received by the Contracting Authority.

Preliminary Design Review

Within one month of the start of the contract a Preliminary Design Review (PDR) will be held with the Bidder, either at the premises of the Contracting Authority or the Bidder or via videoconference. At this review the Bidder will present their proposed design solution for the magnets. UKRI STFC and the Bidder must agree that the solution proposed is suitable and that it should proceed to a full design. The Bidder will also present a plan for the execution of the contract and a Quality Assurance plan.

An agreed set of minutes will be produced following the PDR recording the state of the design work as well as all decisions and actions.

Final Design Review

The Final Design Review (FDR) will be held in an agreed location (or via videoconference) with the presentation of the final design for the quadrupole magnets and all supporting systems. The review must be successful for the project to continue.

Before the FDR takes place, the successful Bidder should send the following information:
1. Detailed technical design including a list of all components used in the design and a full CAD model
2. Project plan
3. Manufacturing plan
4. Assembly plan
5. Test and measurement plan

An agreed set of minutes will be produced following the FDR accurately recording whether all aspects of the design have been completed, as well as all decisions and actions. The final design must be approved by the Contracting Authority before manufacture begins.

Unforeseen delays

In the case of exceptional events or delays in the project, the Bidder will immediately inform The Contracting Authority to assess the situation and discuss the steps to be undertaken.

5.11.3 Communication

Throughout the project, the Bidder and The Contracting Authority will communicate regarding the interfaces between their work areas by email, telephone or videoconference.

5.11.4 Deviation from the specification

During the construction, all proposed deviations from the specification must be submitted to the Contracting Authority in writing; the Contracting Authority will give its approval or refusal also in writing.

5.11.5 QA system

The Bidder shall maintain and apply a Quality Assurance (QA) system compliant with ISO9001:2000 for the design, manufacture and testing of all systems and equipment provided by them.

The Bidder shall ensure that all subcontractors have a similar QA system and shall take all the necessary actions to guarantee the quality of the subcontractor's delivery.

5.11.6 Documentation and file formats

Before completion of the contract the successful Bidder will provide electronic copies of the following documentation relating to the project and the completed system:
- Preliminary Design Review (PDR) documents
- Final Design Review (FDR) documents
- Factory Acceptance Test procedures
- Factory Acceptance Test reports
- Full set of manufacturing drawings for all equipment supplied
- Safety report
- Electrical safety test certificates

- QA documents, certifying that the equipment conforms to the specification and the supplied engineering drawings, and containing all certificates, relevant documents and results of test procedures
- Magnetic measurement results in spreadsheet format

In addition to the sets of final drawings, the successful Bidder shall make drawings available as soon as possible throughout the term of the contract, for the Contracting Authority's inspection and/or approval.

Monthly and milestone reports should be submitted in PDF format.

The Bidder will be required to produce a full set of engineering drawings showing all components and enough assembly details to allow complete construction of the magnets. Drawings should be submitted in a format compatible with the Contracting Authority's CAD systems – STEP or Creo is preferred. Electrical drawings showing all agreed cabling and connections should be supplied in AutoCad DWG or DXF file format. The Contracting Authority will provide a batch of drawing numbers at the start of the project so that drawings can be integrated into our drawing registry.

Measurement data should be sent in Excel-compatible format.

All reports should be in English.

5.11.7 Safety and Hazard Management

The successful Bidder shall carry out a safety assessment of the equipment and its operation. This shall be fully documented in the corresponding manuals. Any safety and risk assessments carried out shall be supplied to the Contracting Authority.

The Contracting Authority requires successful Bidders to employ hazard management techniques to reduce the risk of personnel becoming injured as a result of interaction with their equipment.

Consideration should be made of hazards that exist at all stages of the life of the equipment, including installation, commissioning, operation, maintenance, repair, decommissioning and disposal. The analysis should include hazards that may occur during fault conditions and should include all potentially hazardous materials.

The hazard management system should:
1. Identify hazards
2. Reduce severity
3. Mitigate likely hazards
4. Predict casualty rates.

5.12 Delivery

5.12.1 Packaging

All items to be delivered should be protected during transport from damage due to dirt, weather and rough handling.

5.12.2 Delivery timescales

All magnets to be delivered between 1st April 2020 and 31st July 2020.

5.13 Warranty

5.13.1 Warranty period

The Bidder shall include 12 months warranty from point of installation, including preventative maintenance and servicing, to guarantee the delivered equipment against defects due to either faulty components or faulty manufacture.

6. Timetable

Key milestones for this project are:

- The Final Design Review between The Contracting Authority and the successful Bidder.
- Delivery of all materials and components to the successful Bidder.
- Final delivery of all magnets to the Contracting Authority.

UKRI are not permitted to make any prepayments, submitted invoices need to match the accumulated value of the work completed.