ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
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The large Hadron Collider Project *MS-3308/AB/LHC*

Market Survey

Technical Description for the LHC Collimators

Abstract

This Technical Description concerns the supply of the primary and secondary collimators for the LHC and of the collimators for the transfer line. These collimators are used for momentum and betatron cleaning of the LHC beams and for machine protection.

This Market Survey will be followed by an Invitation to Tender in 3 months and delivery is foreseen to be completed by July 2006.

May 2004

1. INTRODUCTION

1.1 Introduction to CERN

The European Organization for Nuclear Research (CERN) is an intergovernmental organization with 20 Member States*). It has its seat in Geneva but straddles the Swiss-French border. Its objective is to provide for collaboration among European States in the field of high energy particle physics research and to this end it designs, constructs and runs the necessary particle accelerators and the associated experimental areas.

At present more than 5000 physicists from research institutes world-wide use the CERN installations for their experiments.

1.2 Introduction to the LHC Project

The Large Hadron Collider (LHC) is the next particle accelerator under construction on the CERN site. The LHC will mainly accelerate and collide 7 TeV proton beams but also heavier ions such as lead. It will be installed in the existing 27 km circumference tunnel, about 100 m underground, previously housing the Large Electron Positron Collider (LEP). The LHC design is based on superconducting twin-aperture magnets which operate in a superfluid helium bath at 1.9 K, it is scheduled to come into operation in the year 2007.

1.3 Introduction to the beam cleaning and collimation system

Each of the two LHC rings will have a stored beam energy of up to 350 MJ (at 7 TeV). This high beam intensity and the associated high protons loss rates require a powerful collimation system with the following functionality:

- Efficient cleaning of the beam halo
- Minimize the halo background in the particle physics experiments
- Passive protection of the machine aperture against abnormal beam loss

The collimators must be sufficiently robust to fulfil these tasks without being damaged. The carbon based jaw material, which absorb the beam halo under normal conditions and the entire beam under exceptional conditions, has been chosen under these aspects. Very stringent tolerances for surface flatness and straightness of the carbon jaws are required to assure the required precisions necessary for the correct functioning of the collimators with such high beam intensity and the required small beam size.

2. SCOPE OF THIS MARKET SURVEY

The aim of this Market Survey is to identify potential bidders for the supply of the collimators for the LHC.

*) CERN Member States are: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Italy, The Netherlands, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland and the United Kingdom.

This Market survey concerns the manufacture, assembly and delivery to CERN of 66 collimator units fro material delivered by CERN (see. paragraph 3.2)

Table 1: Overview of the LHC collimator types for this Market Survey

Collimator Type	Abbreviation	Quantity
Primary collimator	TCP	11
Secondary collimator	TCS	33
Injection protection collimator	TCLi/TCLp	10
Septum injection protection collimator	TCDI	12

Only firms retained by CERN after analysis of their reply to this Market Survey will be included in the forthcoming Invitation to Tender.

The selection criteria under which firms will be assessed are defined in the document entitled “Qualification Criteria”, and in the appended document “Selection and Adjudication Criteria for Supply Contracts".

3. TECHNICAL DESCRIPTION OF THE SUPPLY

3.1 General

The collimator consists of two movable graphite blocks (jaws, with length of 0.4 to 1.2 m) each mounted onto a water cooled Glidcop® support unit. These assemblies are mounted inside a stainless steel ultra high vacuum tank. The jaw support units are connected, via vacuum bellows, to movable tables actuated by high precision stepping motors. Motors and electronics are not subject of this Market Survey. The overall length of the vacuum tank for the secondary collimator (TCS), which is the most critical, is 1.5 m. (see drawing LHCTCS_P0087). Table 1 above lists the different collimator types. In table 2 you find more details.

Table 2: Overview of the LHC collimator types

Collimator Type	Abbreviation	Common feature	Specific feature
Primary collimator	TCP	Tank, cooling, motion, RF contacts	Shorter jaw length
Secondary collimator	TCS	Considered to be the reference collimator	Reference
Injection protection collimator	TCLi/TCLp	Tank, motion	Different jaw material, no cooling, no RF contacts,
Septum injection protection collimator	TCDI	Tank, motion	No cooling, no RF contacts,

A copper coating of about 5 µm is needed on the Carbon fibre reinforced graphite (CFC) jaw surface.

3.2 Materials supplied by CERN

All raw materials for the construction of the collimator assemblies will be delivered by CERN.

The main materials are:

1. Stainless steel TYPE X2CrNi19-11 (1.4306, AISI 304L) after CERN's specification N° 1004 - Ed. 3 for the vacuum tank
2. OFE Copper after CERN's specification N° 2000 - Ed. 3 for the cooling circuit
3. Carbon fibre reinforced graphite (CFC) for the collimator jaw. The jaw material is premachined, the final pass must be given after the final assembly of the jaw/support unit. This requires specific machining equipment (milling and polishing) for graphite/CFC. Copper and tungsten are used for the jaws of TCLi/TCLp, graphite for the TCDI collimators.
4. Dispersion strengthened Copper UNS-C15715 LOX (GlidCop® AL-15) for the jaw support bar.
5. Material for Radio-Frequency contacts (silver coated Copper-Beryllium alloy)
6. Conflat® Vacuum flanges DN 100 and DN 40 and UHV bellows.
7. Rack and pinions, stainless steel springs.
8. Temperature and position sensors.

3.3 Drawings

All necessary drawings will be supplied by CERN. The company must produce their drawing valid for fabrication.

3.4 Manufacturing

The manufacture of the above material consists of:

- Machining of stainless steel for the vacuum tank assembly
- Preparation for brazing by machining of GlidCop® and copper tubes and sheets
- Final machining of the Carbon-carbon surface after the jaw assembly
- Machining of additional parts and tools used for the assembly and for handling

3.5 Assembly

The different steps in production must be followed by dimensional control and alignment procedures. The very tight tolerances of position (10 µm), angle (100 µrad) and surface flatness (25 µm) need to be assured by appropriate measurements

As the collimators are part of the LHC, which functions under ultra high vacuum, the critical steps of the assembly must be carried out under clean conditions. The most critical operations are the brazing of the support bar to the cooling unit, the assembly of the clamped jaw and the mounting and welding of the vacuum tank. All parts have to be ultra high vacuum cleaned before assembly.

3.6 Tests

Each component part shall be checked for tolerances and the final assembly will be tested on vacuum leak tightness and a water pressure test and a series of dimensional controls will be performed before the final acceptance.

3.7 Quality

In order to be able to align, via the plug in system, each collimator with an accuracy of 0.1 mm in the accelerator tunnel, traceability of all components for each collimator is crucial. A logbook ("traveller") for each unit must be delivered with all intermediate and final positions and measurements. An in-house 3-dimensional measurement device with a precision of better than 5 µm, and a range of at least 1500 mm is required.

3.8 Transport

The high precision and fragile collimator assemblies need to be shipped with special precaution. Acceleration must be limited to a maximum level of 0.1 g. During transport a device must be added to monitor the movements of the components during the voyage of the collimators.

3.9 Responsibility

CERN has the responsibility for the functionality of the design and the quality of the material delivered by CERN. The company winning the contract is responsible for the machining of the raw material within the required tolerances, the application of the adequate techniques for welding and brazing including the surface preparation, the assembly under clean conditions with respect to ultra high vacuum applications, all measurements for mechanical tolerances and vacuum leak tests and water pressure tests. The shock free shipping to CERN falls also under the responsibility of the company. The final acceptance of the collimator will be subject to a successful final control at CERN.

4. SCOPE OF THE SUPPLY

In total there are 66 collimators to be built. The collimator, aligned and leak tested, consists of an assembly complete with: Two assembled blocs equipped with Cu-Be RF contacts and temperature sensors, a vacuum tank including four bellows, four movable tables equipped with linear guideways. CERN requires an option for the supply of 10 fully machined and assembled assemblies.

CERN has produced 2 collimator prototypes. More information and drawings are available on demand.

5. DELIVERY SCHEDULE

The call for tender will be sent out in August 2004 with the aim to award a contract in January 2005. Starting from June 2005, batches of up to 6 collimators per month shall be sent to CERN. The last batch shall arrive at CERN not later than end of July 2006.

6. CERN CONTACT PERSONS

Persons to be contacted for technical matters:

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7 ANNEXES

Drawing Number	Title
7.1 :Schematic view, Figure 1	Schematic view of LHC collimator
LHCTCS_P0087	Collimator tank, RF contact assembly

7.1 Schematic view

- Blue: Jaw material
    - Red: Cooling pipes
        - Light blue and green: Clamping system

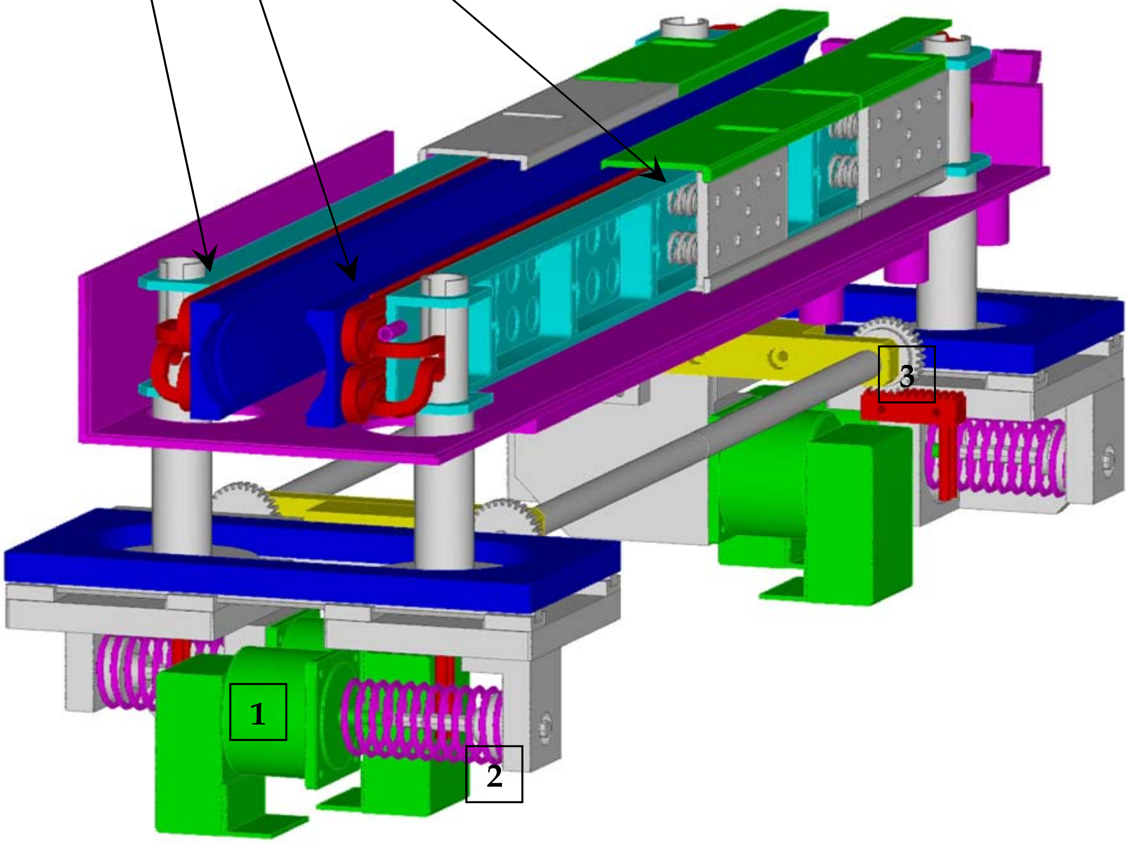

Figure 1: Schematic view of LHC collimator

- 1. Each jaw actuated by 2 step motors (not part of this Market Survey)
- 2. Return spring for automatic pullback in case of motor failure
- 3. Rack-pinion system to prevent excessive misalignments
- Lateral translation and angular correction (tilt) allowed
- Automatic recovery of mechanical plays.
- Jaw advancement per motor step: 5 µm