European Organization for Nuclear Research
Organisation européenne pour la recherche nucléaire

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Price Enquiry

Technical Specification
Supply of HV cables for GE1/1 and GE2/1 project

Abstract

This technical specification concerns the supply of HV power cables for CMS GE1/1 project.
The supply consists of custom cables multi conductors as described in the following.

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1. INTRODUCTION

1.1 Introduction to CERN

CERN, the European Organization for Nuclear Research, is an intergovernmental organization with over 20 Member States[1]. Its seat is in Geneva but its premises are located on both sides of the French-Swiss border (http://cern.ch/fplinks/map.html).

CERN's mission is to enable international collaboration in the field of high-energy particle physics research and to this end it designs, builds and operates particle accelerators and the associated experimental areas. At present more than 11 000 scientific users from research institutes all over the world are using CERN's installations for their experiments.

The accelerator complex at CERN is a succession of machines with increasingly higher energies. Each machine injects the beam into the next one, which takes over to bring the beam to an even higher energy, and so on. The flagship of this complex is the Large Hadron Collider (LHC) as presented below:

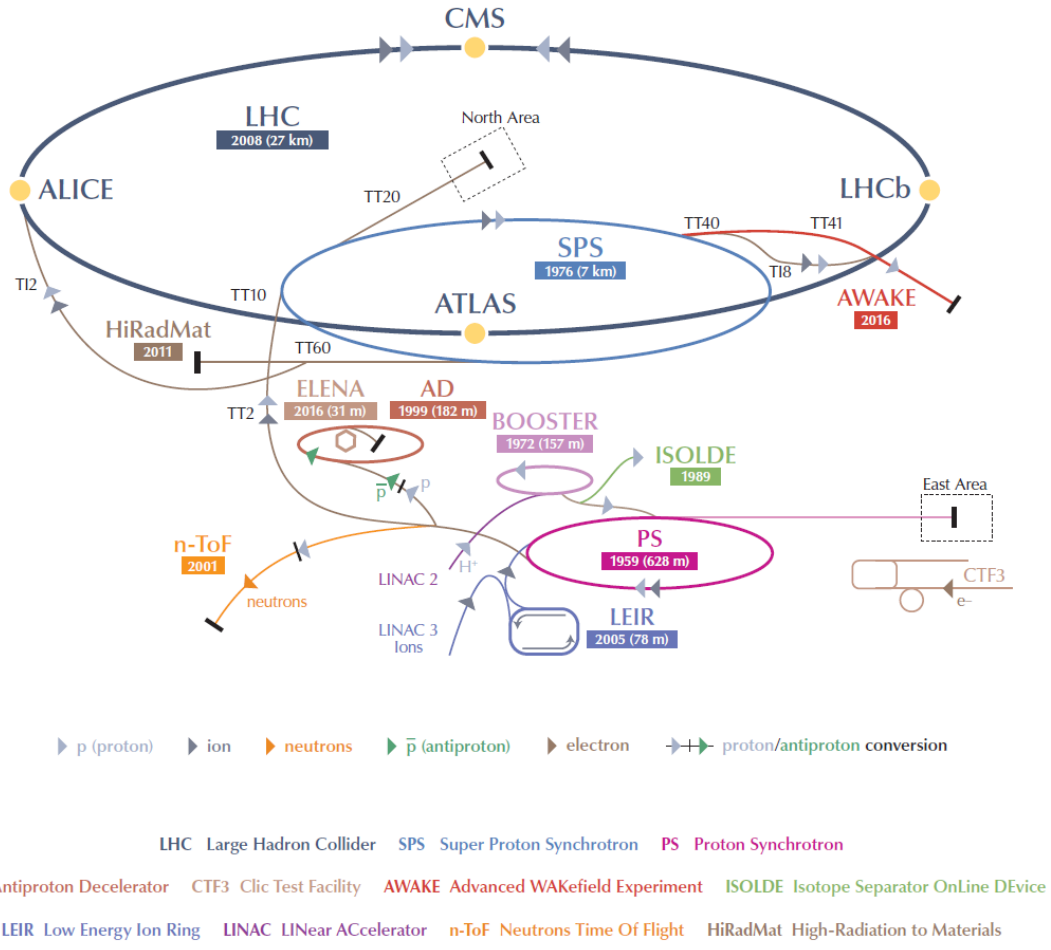

Figure 1: CERN Accelerator Complex

Further information is available on the CERN website: http://cern.ch

[1] http://home.web.cern.ch/about/member-states

1.2 Introduction to the CMS-GE1/1 Project

The Compact Muon Solenoid, or CMS (http://cms.cern.ch), is a particle physics experiment at the Large Hadron Collider (LHC) at CERN. The CMS detector is designed to study particles produced in high-energy proton-proton and heavy ion collisions to seek answers to fundamental questions such as: "understanding why the world is the way it is, why some particles weigh more than others and what constitutes the dark matter in the Universe". The CMS detector is located 100 m underground at the French village of Cessy near Geneva. The experiment is in operation and the data now being collected by CMS is distributed to institutes around the world to be analysed. The CMS collaboration involves 4300 particle physicists, engineers, technicians, students and support staff from 179 universities and institutes in 41 countries.

In the context of the CMS Muon Spectrometer Upgrade, planned for the second long shutdown of LHC (2019-2020) and subsequent upgrade, a new high resolution and high rate capable detector will be built. The GE1/1 project consists of two layers of triple-GEM detectors installed on the first disk of the CMS End Cap.

The power cables connect the commercial power supply system, which is located about 100 m away from the edge of the detectors to the chambers Patch Panel distribution.

The goal of this technical specification is to provide a set of fabrication and performance requirements for the procurement of multi-conductor cables to be used for powering the full GE1/1 upgrade system.

2. SCOPE OF THE SUPPLY

The successful bidder (hereinafter referred to as the "contractor") shall supply the HV Power Cables (hereinafter referred to, in whole or in part, as the "supply") as defined in this technical specification. The supply shall originate from CERN Member States, CMS Member States[2] and under certain conditions, from Associate Member States (as specified in the tender form).

2.1 Eligibility criteria

To be eligible for this price enquiry, the bidder shall meet the following requirements :

- The bidder shall have commercial and technical contact persons who are proficient in communicating in English or French;
- The cables shall be Low Smoke Zero Halogen compounds;
- The cable max operating temperature is 50 ˚C;
- During transport or storage of the cable, it can be expected that its temperature may vary in the range -5 ˚C to 60 ˚C. The cable shall tolerate these variations without damage or degradation;
- The cable will be operated in a radiation environment of less than 1kGy (100 krad) ionizing dose integrated over the operational lifetime. All selected dielectric materials (insulation, jacket) shall withstand this radiation level without degradation of their mechanical, electrical and safety properties.

[2] https://cms.cern/collaboration/cms-institutes

2.2 Deliverables Included in the Supply

The supply shall include:

1. The HV cables of three different kinds, as specified in Section 3, all of them shall full fill the requirement of high flexibility for cable chain insertion and application.
    a. Total length: 6800 meters of cable 1st Kind, as defined in §3.2.1;
    b. Total length: 500 meters of cable 2nd Kind, as defined in §3.2.2;
    c. Total length: 11100 meters of cable 3rd Kind, as defined in §3.2.3;
    d. Meeting all the requirements provided in Section 3.
2. Technical Documentation including: technical drawings of the cross section, weight and dimensions of the assemblies, bending radii, detailed description of the manufacturing process, characteristics of the materials used for the fabrication of the supply (i.e. their chemical composition), electrical properties and ratings and the quality assurance procedures followed to verify the conformity of the supply with this technical specification and their results.
3. Certification or Test Results proving that the cable satisfies the applicable Fire Safety and Radiation Resistance requirements of CERN IS23 https://edms.cern.ch/ui/file/335745/LAST_RELEASED/E_IS23.pdf.

2.3 Activities at the Contractor's Premises

The contractor shall perform the following activities at his premises:

- Design of the cables compatible with this technical specification and CERN IS23;
- Procurement of the raw material for the cable;
- Tests on a sample basis of the final cable;
- Packing, and shipping if required by CERN (see § 4.4);
- Production of Technical Documentation.

Before the production of the supply, the production drawings shall be approved by CERN in writing. The production of the supply shall only begin after the written approval by CERN.

2.4 Options

CERN reserves the right to increase the order quantity of the series batch of the supply until up to 10 weeks after the placement of the contract, from a minimum of 3 km to a maximum of 5 km additional length for cables 1st and 3rd kind and from a minimum of 500 m to a maximum of 1 km for cable 2nd kind

3. TECHNICAL REQUIREMENTS

3.1 General Description

The supply shall include and be compliant with the following parameters and conditions:

Design parameters, dimensions and tolerances, operational conditions, interfaces, including references to technical drawings and documents to be appended to the price enquiry.

The supply consists of a custom round multi-core cable with outer diameter smaller than 30 mm for 1st kind, less than 25 mm for the 2nd kind and less than 35 mm for the 3rd kind of cable.

The target application is the distribution of dc power at high voltage to custom equipment. The cable has no special safety functions.

3.2 Cables specifications

3.2.1 1st kind of cables

Cables for power distribution on GEM detector chambers:

- 2 x 10 conductors x AWG 22;
- The two cables must be laid up together with filler for roundness;
- The two cables must be of different colours and the wire inside each cable must be numbered (1 to 10) ;
- The cables must full fill the High Flexibility for cable chain application;
- Outer diameter smaller than 30 mm;
- Bending radius static condition not above factor 4 with respect to the diameter of the cable;
- Bending radius dynamic condition not above factor 6 with respect to the diameter of the cable;
- Expected cable lifetime: >25 years;
- Weight less than 900 g/m;
- External cable colour RED, label reporting “GEM” have to be marked with the standard cable marking every meter.

3.2.2 2nd kind of cables

Cables for power distribution from GEM Power System backend:

- 2 x 10 conductors x AWG 26;
- The two cables must be laid up together with filler for roundness;
- The two cables must be different colours and the wire inside each cable must be numbered (1 to 10);
- The cables must full fill the High Flexibility for cable chain application;
- Outer diameter smaller than 25 mm;
- Bending radius static condition not above factor 4 with respect to the diameter of the cable;
- Bending radius dynamic condition not above factor 6 with respect to the diameter of the cable;

- Expected cable lifetime: >25 years;
- Weight less than 600 g/m;
- External cable colour RED, label reporting "GEM" have to be marked with the standard cable marking every meter.

3.2.3 3rd kind of cables

Cables for power distribution from CMS service cavern (USC) to the CMS experimental cavern (UXC):

- 4 x 10 conductors x AWG 22;
- The four cables must be laid up together with filler for roundness;
- The four cables must be different colours and the wire inside each cable must be numbered (1 to 10)
- The cables must full fill the High Flexibility for cable chain application;
- Outer diameter smaller than 36 mm;
- Bending radius static condition not above factor 4 with respect to the diameter of the cable;
- Bending radius dynamic condition not above factor 6 with respect to the diameter of the cable;
- Expected cable lifetime: > 25 years;
- Weight less than 1400 g/m;
- External cable colour RED, label reporting "GEM" have to be marked with the standard cable marking every meter.

3.3 Manufacturing and Tooling

The contractor shall have available all the necessary tooling for the proper execution of the contract including assembly, testing and characterisation of the cables.

The testing setup shall be capable of measuring the resistances of the different conductors and between conductors in order to exclude openings and short circuits as well as to provide the resistances of the different conductors in the assembly.

3.4 Safety Design Requirements

The supply shall comply with CERN Safety Rules (available at the link: https://hse.cern/content/rules) and the Swiss and/or French and European legislation.

The materials used and the supply shall be in compliance with CERN Safety Instruction IS23 "Criteria and Standard Test Methods for the Selection of Electric Cables and Wires with Respect to Fire Safety and Radiation Resistance" and references therein (including IEC 60332-3-24 amongst others), available at https://edms.cern.ch/ui/file/335745/LAST_RELEASED/E_IS23.pdf, and with CERN Safety Instruction IS41: "The use of plastic and other non-metallic materials at CERN with respect to fire safety and radiation resistance" and references therein, available at https://edms.cern.ch/ui/file/335806/LAST_RELEASED/IS41_E.pdf

The cable shall be flame retardant as for the provision below.

The cable must be compliant with CERN electrical safety code C1 available at https://espace.cern.ch/Safety-Rules-Regulations/en/rules/byDomain/Pages/EL.aspx.

The wire insulations and sheath(s) shall be made of low smoke, halogen free and sulphur free materials. Taping and fire barrier, if present, shall meet the safety specifications above.

Suggestions of compatible materials are provided in IS23. Examples of materials for the insulation of conductors are Polyethylene, Cross-linked polyethylene, Ethylene Propylene Rubber, EPDM. Examples of materials for taping and fire barriers (if present) are: Polyester, PETP. Examples of materials for the outer sheath: Low Smoke Zero Halogen compounds, Polyethylene, Ethylene Propylene Rubber, EPDM, EVA, Polyolefin.

3.5 Operational Conditions

The supply conductors will be operated at DC Voltage within a range of 0 V to 5 kV.
The maximum operating current will not exceed 10 mA in each conductor under normal conditions.
The nominal conductor-conductor operating voltage will be 4 kV and the loop current 0.1 mA.

3.6 Environmental Conditions

The area of operation for the cables is in air and at room temperature. The nominal operating ambient temperature is 18 ˚C and the maximum ambient temperature will be below 35˚C. The operational environment will have well-controlled relative humidity, between 40 % and 60 %. The cable max operating temperature is 50 ˚C.
During transport or storage of the cable, temperature may vary in the range -5 ˚C to 60 ˚C. The cable shall tolerate these variations without damage or degradation.

The cable will be operated in a radiation environment of less than 1kGy (100 krad) ionizing dose integrated over the operational lifetime. All selected dielectric materials (insulation, jacket) shall withstand this radiation level without degradation of their mechanical, electrical and safety properties.

3.7 Information and Documentation

3.7.1 Detailed Design File

The contractor shall submit to CERN a detailed design file containing production drawings for the cable with submission of the tender form.

The submitted design documentation shall contain the dimensions as well as the specifications of the material for conductors, insulation, taping (if present), sheath(s); mechanical characteristics and properties, an estimate of the cable weight, allowed bending radius and corresponding bending force; electrical characteristics.

3.7.2 Documentation Handling, Quality Control and Quality Assurance

The contractor shall plan, establish, implement and adhere to a documented quality assurance program that fulfils all the requirements described in this technical specification.

The contractor shall be certified according to ISO9001.

In addition to the requirements of § 3, the contractor may propose any internationally recognised design standard, subject to prior written approval by CERN. The contractor shall state its intended method of design including applicable codes as part of his bid. CERN reserves the right to veto the use of certain codes or norms if it is considered that their application will not ensure compliance with this technical specification.

The contractor shall submit all documents produced in electronic format:

- Drawings in CATIA®, AUTOCAD® or HP-GL® format and additionally in PDF® format;
- Text documents in Microsoft Word® or OpenDocument or RTF and in PDF® format.

4. PERFORMANCE OF THE CONTRACT

Unless specifically mentioned otherwise, the contractor shall apply the most restrictive clause in case of ambiguity between the clauses of the contract, including its annexes.

All deliverables and activities that are not explicitly mentioned in the technical specification but are essential for the execution of the contract shall be considered an integral part of the technical specification and therefore subject to clause 3.1 of *General Conditions of CERN Contracts*.

4.1 Delivery Schedule

Once the contractor is awarded the contract (estimated: August 2018), it shall deliver the supply according to the following delivery schedule from the award date (T0):

Deliverable	Maximum deadline
Certification or Test Results proving that the cable satisfies the applicable Fire Safety and Radiation Resistance requirements of CERN IS23	T0+ 2 weeks
Detailed schedule	T0+ 2 weeks
3rd kind of cables	T0+ 8 weeks
1st kind of cables	T0+ 10 weeks
2nd kind of cables	T0+ 12 weeks

CERN reserves the right to amend this delivery schedule before the start of the installation works. In such case, CERN will inform the contractor in writing about the definitive date to start the on-site installation two weeks before such date.

At the beginning of the contract and before the start of material procurement, the contractor shall submit for CERN's approval a detailed schedule defining the processes and methods, which he intends to implement. At CERN's request, he shall provide for information, in writing, a detailed account of the arrangements, which he intends to make, and the equipment and installations to be provided.

CERN and its representatives shall have free access during normal working hours to the manufacturing or assembly sites, including any subcontractor's premises, during the contract period. The place of manufacture may only be changed after written approval by CERN.

The schedule shall make provision for CERN's official holidays and take into account weather and other conditions related to the execution of the contract.

4.2 Tests

4.2.1 Tests Carried Out at CERN

Upon reception of the supply and technical CERN will perform the following acceptance tests and checks:

- Visual inspection of the cable;
- Measurement of the resistances of the conductors on a sample basis;
- Dimensional inspection of cable (diameters of conductors, insulations, cable);
- Compliance of the materials and supply with this technical specification, IS23 requirements and all other applicable safety requirements.

4.3 Contract Follow-Up and Progress Monitoring

The contractor shall assign a person responsible for the technical execution of the contract and its follow-up, as well as a person responsible for the commercial follow-up, throughout the duration of the contract. They shall be able to communicate in one of the official languages of CERN (English or French).

The contractor shall send a written progress report to CERN on a bi-weekly basis until completion of the contract. All communications and documents shall be in English or French.

This report shall include all the necessary information, in particular:

- Actual progress in comparison to scheduled progress;
- Any major issue encountered or important information related to the project.

4.4 Packing and Shipping

The contractor is responsible for the packing and, where specified by CERN (see tender form document), for the transport to CERN. In all cases, it shall ensure that the equipment is delivered to CERN without damage and any possible deterioration in performance due to transport conditions.

The contractor shall comply with professional regulations in matter of packing and shipping.

The cable shall be delivered segmented in reels with maximum total weight of 1000 kg, maximum flange diameter of 1200 mm, maximum total reel width of 1100 mm. The length of cable segment in each reel shall not be larger and not smaller than 300 m.

4.5 Acceptance and Warranty

Acceptance of the supply shall be given by CERN only after the delivered supply is deemed to be in conformity with the contract including documentation referred to in this technical specification, all tests specified have been successfully completed and all tests or other certificates have been submitted to CERN.

After reception of the supply including the documentation at CERN, CERN will carry out a detailed acceptance test as described in § **Error! Reference source not found.** within four weeks.

The warranty shall be as defined in the tender form.

The contractor shall fix not conform supply or replace the discarded supply, within four weeks from the written notification of the not conformity by CERN.

5. CERN CONTACT PERSONS

Persons to be contacted for technical matters:

Name/Department/Group	Telephone	Email
Dr. Michele Bianco EP/CMX/DA	Tel: +41 75 411 0307	Michele.bianco@cern.ch
In case of absence:		
Dr. Archana Sharma EP-CMX-DA	Tel: +41 75 411 4875	Archana.Sharma@cern.ch

Persons to be contacted for commercial matters:

Name/Department/Group	Telephone	Email
Ms Floriane Brouillat IPT/PI	Tel: +41 22 766 4205	Floriane.Brouillat@cern.ch
In case of absence:		
Mr Joshua Davison IPT/PI	Tel: +41 22 766 4458	Joshua.Davison@cern.ch

6. ANNEXES

The annex is:

- CERN IS23: Fire Safety and Radiation Resistance.