Invitation to Tender

Technical Specification for design, construction and installation of a double loop fluorocarbon 150 kW cooling plant for the CMS Tracker and Preshower detectors

Abstract
This Technical Specification concerns the design, manufacture, delivery, installation, test and commissioning of a double loop fluorocarbon cooling plant for the CMS Tracker and Preshower detectors. The installation is foreseen to start in spring 2005, and to be commissioned by the beginning of 2006.
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<td>CERN Drawing Directory</td>
</tr>
<tr>
<td>EDMS</td>
<td>Engineering Data Management System</td>
</tr>
<tr>
<td>QAP</td>
<td>Quality Assurance Plan</td>
</tr>
<tr>
<td>LHC</td>
<td>Large Hadron Collider</td>
</tr>
<tr>
<td>CMS</td>
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</table>
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 CMS Experiment, Tracker and Preshower Detectors

The Large Hadron Collider (LHC) was approved in 1994 and is now under construction. This proton-proton collider is scheduled to operate from 2007.

The CMS experiment is one of the two multi-purpose detectors that will be installed some 90 m below ground level in the new Experimental Area at Point 5 of LHC (Cessy, France), hereinafter referred to as “Point 5”.

The CMS experiment is being constructed by a worldwide collaboration involving 151 institutions from 36 countries**. The CMS Collaboration has requested TS/CV group from the TS Department to design and organize the procurement of the cooling systems for the Tracker and Preshower detectors.

The Silicon Tracker is one essential sub-system of the CMS experiment. It consists of more than 15000 silicon detector modules, assembled around the collision point in 10 cylindrical layers, co-axial with the collision axis and 24 circular disks, perpendicular to the collision axis. This arrangement is obtained through different sub-detecting systems supported and kept in a stable position by a carbon fibre sandwich cylinder, having the overall dimensions of 2400 mm in diameter and 5300 mm in length.

The inside volume of this cylinder will be kept at temperatures below -10°C during operation, but its outside surface must always be at room temperature. To this aim, several parallel circuits distribute a liquid cooling fluid at around -20°C to the sub-detecting system and the inside wall of the support cylinder is lined by an active thermal screen, divided in 32 panels.

A second fundamental tracking device is the Preshower. This is composed of two units, each one organized in a disk, facing the two ends of the Silicon Tracker cylinder. The bulk temperature of the volumes of the Preshower units must also be kept below -10°C during operation, however, due to the different geometrical constraints, their thermal screen does not

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* 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.

** CMS member States are: Armenia, Austria, Belarus, Belgium, Brazil, Bulgaria, China PR, China (Taiwan), Croatia, Cyprus, Estonia, Finland, France, Georgia, Germany, Greece, Hungary, India, Iran, Ireland, Italy, Korea, New Zealand, Pakistan, Poland, Portugal, Russia, Serbia, Slovak Republic, Spain, Switzerland, Turkey, Ukraine, United Kingdom, United States of America and Uzbekistan.
need an active cooling part. Thus, the cooling system of this sub-detector only consists of parallel circuits distributing a liquid cooling fluid at around -10°C to the sensing elements.

The CMS experiment is designed to operate for at least 10 years, typically following a yearly schedule based on 6 months of operation and 6 months of shut-down for maintenance and upgrades.

### 1.3 Subject of this Technical Specification

The subject of the work is to construct the cooling system for the CMS Tracker. This work concerns the design, construction, supply and installation of the double loop cooling plant, including hydraulic, electrical, control and regulation components, the installation and the testing. The cooling plants shall be installed at the CERN site of Cessy, France, in the underground area of the LHC Point 5.

### 2. SCOPE OF THE TENDER

This Invitation to Tender concerns the design, manufacture, delivery, installation, test and commissioning of a double loop fluorocarbon cooling plant for the CMS Tracker and Preshower, suited to operate the CMS Tracker and Preshower detectors at the required temperature of -10°C, removing some 150 kW of power produced by the electronic during its operation. The installation is expected to start at the beginning of 2005, and should be fully commissioned by the beginning of 2006.

#### 2.1 Scope of the supply

CERN intends to put out a contract for the provision of the following:

- primary circuit (herein referred to as “Main Unit”) complete of compressors,
- 7 (seven) secondary circuits (herein referred to as “Detector Cooling Units”),
- electrical (standard and emergency) distribution cubicles,
- control cubicle,
- electric/pneumatic conversion cubicle,
- all connections between these plants,
- final engineering design of the hydraulic installation including:
  - calculations,
  - execution drawings,
  - description of all the materials and components,
  - detailed description of the compressor regulation system,
- design, construction, installation and test of the related automatic regulation, control and supervision systems, as to §4.6.1 of this Technical Specification
- design, dimensioning, installation and test of the electrical system, as to §4.5.1,
- tests at the manufacturer’s works of all the equipment, as to §9.1,
- transport and installation of the plants on the CERN site,
- acceptance tests on the CERN site, as to §9.2 and §9.3,
- commissioning, as to §11,
• training of people in charge of the operation,
• supply of the complete documentation for the hydraulic, control and electrical system (as-built drawings, technical documentation, test reports etc.) together with the maintenance procedures, as to §5.7.

As a function of the CERN requirement, a document called the “Unit Price List” (UPL) has been compiled. Following this document the Contractor shall supply or carry out the above-mentioned components and work.

2.2 Items not included in the supply

The following items and installations will not be part of the supply:
• the chilled water circuit,
• the stainless steel pipes for R410A distribution between the Main Unit and the Detector Cooling Units,
• the compressed air main distribution circuit,
• the supply of UIAC-00565 power supply cubicles,
• the CERN Ethernet TCP/IP routed network infrastructure, including the physical media, connection sockets and network parameters (address, gateway, subnet mask, DNS and domain), up to the control cubicles,
• the control local supervision SCADA license and associated drivers.

2.3 Items supplied by CERN

CERN will directly supply the following installation and services:
• vertical handling and transportation of the cooling units from surface buildings to the underground caverns,
• electric power and distribution on the CERN site up to the worksite electrical cupboards, to be provided by the Contractor.

3. GENERAL CONDITIONS FOR TENDERING AND CONTRACTING

Please refer to the commercial documents for more complete information.

Tenders will only be considered from firms having been selected as qualified bidders by CERN, as a result of the Market Survey ref. MS3230/EP/CMS.

3.1 Tender procedure

3.1.1 Bidders’ Conference

Before Tenders are submitted, CERN will give bidders notice to attend one compulsory one-day joint information meeting at CERN, at which they will be given additional information on technical matters and specific work-related details. In the case of consortia, at least one person from each consortium partner but not more than five persons per consortium must attend the bidders’ conference. Each bidder must be represented by at least one technical manager and one commercial manager.
The following subjects will be covered in the course of this meeting:

- information from the CERN Purchasing Service,
- relations with the Host States,
- safety criteria,
- specific requirements to this Invitation to Tenders,
- visit to the CERN site,
- questions and answers.

Bidders will be invited, wherever possible, to send in their questions by letter or fax in advance so as to reach CERN before the compulsory bidders’ conference. A summary of questions raised and answers given during the conference will be forwarded to all participants without mentioning names.

NB: Tenders submitted by bidders failing to attend this conference will not be taken into consideration.

3.1.2 Preliminary Programme

The Bidder shall propose a preliminary design and manufacturing schedule with the Tender, based on the specified CERN provisional delivery schedule. The following milestones shall be included at least:

- compressor design,
- compressor order,
- compressor delivery,
- start of the hydraulic circuit assembly,
- completion of hydraulic circuit assembly,
- test on the assembled circuits,
- performance tests at Contractor’s premises,
- delivery.

3.1.3 Subcontractors

The Bidder shall declare in his Tender any subcontractors whose services he intends to use in the event of a Contract. Refer to the commercial documents for more details. If awarded the Contract, the Bidder shall restrict himself both to the subcontractors and the amount mentioned in the Tender. CERN reserves the right to accept or reject the subcontractors selected. If, for some reason, he wants to change any subcontractor, or the scope of subcontracted work, or the amount subcontracted, he must obtain CERN’s prior agreement in writing.

3.1.4 Document to be provided with the Tender

The Bidder’s Tender shall contain the following documents duly completed in duplicate:

- the originals of the technical descriptions and documentation issued from the manufacturers for all the proposed equipment (technical data sheets), clearly showing the results of the selection as per the list of technical documentation requested in the UPL,
a description of the working methods and protective measures that will be implemented for safety purposes (as from chapter 7 of this specification), as well as the equipment and manpower that will be used,
a detailed schedule for design production and testing of the whole installation,
the Unit Price List (UPL), completed in full,
the Tender Form, completed in full.

These documents shall be sent together in one package bearing the reference number of the Invitation to Tender and the Bidder's name and address.

The Bidder shall submit with his tender any observations or suggestions he may consider useful concerning the requirements given in the UPL or the drawings.

The costs associated with drawing up the Tender shall be met entirely by the Bidder. CERN will not contribute in any way to the expenses incurred by Bidders in connection with the tendering procedure.

3.1.5 Presentation of Tender

The Bidder may be required to make a formal presentation of his Tender at CERN at his own expense. He shall be ready to do so within one week of notification.

3.1.6 Country of Origin

Please refer to the commercial documents for specific conditions concerning the country of origin of the equipment or services to be supplied.

3.1.7 Unit Price List

The Unit Price List, hereinafter UPL, submitted by the Bidder shall be fully compliant with the original UPL document provided by CERN. The Bidder is invited to specify any reservations he may have on a different document. These reservations shall be set out in detail and substantiated by specific arguments.

CERN defines in the relevant chapter of the UPL the characteristics of each equipment (type of valves, piping size, component performances, as a way of indication). The Bidder shall quote in the UPL, the unit prices (per unit or linear metre of supply for each piping) as well as the total price for the quantity estimated by the Bidder. The Contractor cannot present any extra cost (studies, transport, installation, manpower etc.) to cover the possible difference between the installed and estimated quantities.

4. TECHNICAL REQUIREMENTS

4.1 General description

Two large underground halls house the CMS experiment at Point 5 (see LHCF35000014):

- the Service Cavern USC55 (hereinafter USC), which contains the main electrical, electronic and cooling systems to power and operate the experiment,
- the Experimental Hall UXC55 (hereinafter UXC), where the CMS detectors are located, along with the racks distributing the services to the different sub-systems
and with the power, read-out and cooling units that require to be located as close as possible to the experiment.

The double-loop cooling plant to be supplied is composed of a first loop, having its Main Unit in USC and operating an evaporative cycle based on R410A fluid, and a second loop, situated in UXC, where the R410A cools down a liquid-phase C₆F₁₄. The seven Detector Cooling Units, in UXC, transfer and distribute the cooled C₆F₁₄ liquid to the different sub-detectors of the CMS Tracker and Preshower.

A service tunnel connects USC and UXC (see drawing LHCF35000014): the pipe work connecting the Main Unit to the Detector Cooling Units pass through this tunnel, together with all the electrical and pneumatic connections between the electronic control systems and the Detector Cooling Units. The hydraulic pipes will not be included in the supply, whilst pneumatic and electrical connections together with the relative cable trays shall be part of the offer.

4.1.1 **Overall working scheme**

The general scheme of the double loop cooling plant is shown in drawing LHCF35240021. A series of compressors located in USC compress a R410A gas. This gas is then liquefied in a condenser, cooled by chilled water at around 5°C and 16 bar fed from the surface.

The liquid R410A is then transferred to UXC by means of a room temperature pipe, it evaporates inside the cooling units and finally returns to the compressors in USC, again through a room temperature pipe.

Liquid C₆F₁₄ circulates in the cooling units. This liquid, cooled down to temperatures varying between -10°C and -30°C, depending on the circuit to be served, is sent to the CMS Tracker and Preshower, in order to cool the components of the different sub-detectors.

4.1.2 **Main Unit**

In the main unit, two or three compressors compress R410A gas. The number of compressors shall depend on the chosen model: two compressors, if each one has enough power to cope with the full required capacity, or three, each one having 50% of the total required power. In both cases keeping one compressor as a back up must be possible.

The high-pressure warm gas passes through a plate condenser, where it is liquefied and stored into the reservoir. The chilled water flow rate is regulated through a regulating valve, feedback controlled by the signal of a pressure transmitter.

A strain gauge scale measures the quantity of liquid left in the reservoir. The liquid is then filtered before being transferred to UXC.

The low-pressure gas coming back to USC from UXC passes through a buffer reservoir situated upstream of the compressors.

4.1.3 **Detector Cooling Units**

Seven detector cooling units shall be installed in the UXC cavern, to serve the different sub-detectors. For the Tracker, two cooling units will serve the Silicon Strip detector, two units will serve the Thermal Screen and one unit will serve the Pixel detector. Two cooling units will be used for the Preshower.

In each cooling unit, the liquid C₆F₁₄ is stored in a reservoir kept at a low pressure, which is still higher than the vapour pressure of the liquid at 30°C, i.e. higher than 300 mbar absolute pressure. The air contained in the circuits is evacuated by a vacuum pump and an
absolute pressure transmitter controls the pressure. The amount of liquid contained in the reservoir is measured by a strain gauge scale.

A magnetic-coupling pump transfers the liquid into the evaporator through dedicated filters aiming to the suppression of any traces of acid and water. The exit pressure of the pump will be regulated via a back pressure transmitter.

The flow rate of R410A evaporated is controlled by a pneumatic expansion valve as a function of the exit temperature of the liquid C₆F₁₄. Sub-cooling of the liquid R410A is ensured via a heat exchanger placed upstream of the expansion valve and on the return line of the vapour exiting the evaporator.

The C₆F₁₄ cold liquid is transferred to the different sub-detectors through manifolds equipped with pneumatic valves and a flow rate measurement system to be activated in case of need.

All the cooling units must be insulated inside gastight boxes.

**4.1.4 Operation of a Cooling Unit**

When idle, all the liquid C₆F₁₄ is stored in the reservoir and the pressure is lowered to 500 mbar absolute, allowing for the detection of any air ingress through leaks. Then, the circuits are opened, one after the other. Each circulation pump is operated only after verification of the tightness of the connected circuit.

The amount of liquid contained in the reservoir is permanently controlled: in case of anomalous lowering of the level during operation, the circulation pump is stopped. In this way, the liquid contained in any possibly leaking circuit spontaneously returns into the reservoir. The start-up procedure is then applied, and this allows for the detection of the faulty circuit and its isolation.

**4.1.4.1 Thermal Screen and Preshower Cooling Units**

These units must operate continuously, even in case of power or water cut, and they will be cooled by an emergency refrigerator, using the available Emergency Power Supply (EPS, provided by CERN).

The standard operation is identical to the one of the other units. In case of problems, a local cooling circuit with an air condenser and an evaporator enters into operation. In this case, an electrical heater regulates the fluid temperature, the emergency refrigerator not being equipped with any power regulating system.

**4.2 Technical requirements**

In the following paragraphs, a technical description of all the component functions is given, both for the main unit running R410A and the detector cooling units running C₆F₁₄. References in brackets next to each component refer to the drawings of the single units. For some of the components, a technical file describing in full the characteristics is attached in Annex 3 of this Technical Specification. All the technical characteristics listed below and in Annex 3 are to be considered as compulsory requirements for all the components to be installed.

**4.2.1 Main Unit**

Two or three compressors shall raise the gas pressure up to 19 bar, to allow a condensation temperature above ambient temperature (R410A shall condense at 30°C). Systems of non-return valves and insulation valves allow for stopping and insulating one
compressor for maintenance purposes. Compressors (E-7 and E-10) must be oil-free, to avoid oil accumulation at the lowest part of the circuit, otherwise inevitable because of the low speed of the fluid. Please, refer to Annex 3 for more details.

Compressors inlet and outlet lines shall be equipped as follows.

At the compressor inlet:
- pneumatic shut-off valve (V-14, V-20),
- filter (E-8, E-11),
- Schrader valve (V-12, V-18),

A regulation system shall be installed on the compressors, to allow for regulation between 0 and the maximum compressor power declared by the manufacturer.

At the compressor outlet, before the condenser:
- pressure switch (I-8, I-7),
- safety valve (V-13, V-19),
- non-return valve (V-11, V-17),
- pneumatic shut-off valve (V-15, V-21): must be three pieces ball valves, full bore, butt welding, high density polyethylene seat and gland-packing with pneumatic actuator, normally open.

The plate heat exchanger (E-2) allows condensation of the R410A using chilled water, supplied in the US cavern at the point indicated in drawing LHCF35240009, at a temperature of 5°C and a service pressure of about 16 bar.

The water flow rate is regulated by means of a needle valve (V-2) with servomechanism, preceded by a filter (E-4) and a manual shut-off ball valve (V-5), nickel plated. A manual shut-off valve (V-3) is placed also at the chilled water exit from the heat exchanger. The feedback command to the regulation valve is given by a pressure transmitter (I-3) located on the reservoir (E-3) where R410A is stored after condensation. The pressure transmitter must provide a measurement range between 0 and 25 bar absolute pressure and its output signal should be 4-20 mA. The reservoir must be of stainless steel, with a service pressure of 19 bar, certified, and has to be equipped with the following components:
- a scale (I-6), which must be a strain gage measuring system,
- a safety equipment (V-8, safety valve, and V-6, three way valve),
- a manometer (I-4): reading screen diameter = 100 mm, scale -1/25 bar, stainless steel, antimagnetic needle,
- a heater (E-6), which shall be able to maintain the liquid at a temperature higher than the room one at the system start-up,
- a temperature transmitter (I-5).

To allow weight measurement by means of the above mentioned scale, flexible connections between the cooling circuit and the reservoir shall be foreseen.

At the exit from the reservoir, the high pressure R410A is filtered and dried in a stainless steel filter (E-5). A pneumatic valve (V-9) and a manual (V-4) shut-off valve allow access to the filter for maintenance, whilst a “Schrader” valve (V-7) is used for purging or for injecting Nitrogen.

After those components, R410A is sent to the underground cavern, where it evaporates on the seven sub-detector cooling unit heat exchangers.
Gas coming back from the UX cavern reaches a manual shut-off valve (V-1), at the entrance of a buffer reservoir (E-1), which is equipped as follows:

- a manometer (I-2): reading screen diameter = 100 mm, scale -1/25 bar, stainless steel, antimagnetic needle,
- a pressure transmitter (I-1), with a measurement range between 0 and 25 bar absolute pressure and an output signal of 0-20 mA,
- a Schrader valve (V-22), for service purposes.

4.2.2 Detector Cooling Units

Detector units run C_{6}F_{14} coolant. Basic components are the same for all the cooling units and are described below. References between brackets, unless otherwise state, refer to the Pixel cooling plant scheme (see drawing LHCF35240013).

In all the Detector Cooling Units, a stainless steel reservoir (E-2) is kept below atmospheric pressure by a vacuum pump (E-1). The reservoir is equipped as follows:

- a pressure transmitter (I-11),
- a security valve (V-18),
- a manometer (I-9),
- a three way valve (V-27),
- a scale with a transmitter (I-7),
- a manual valve (V-14).

<table>
<thead>
<tr>
<th>Cooling Units Name</th>
<th>Iput/output pipe</th>
<th>Inner D mm</th>
<th>Length m</th>
<th>Flow rate l/h</th>
<th>ΔP bars</th>
<th>Τ °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon Strip 1</td>
<td>90</td>
<td>12</td>
<td>35</td>
<td>33638</td>
<td>6</td>
<td>-30</td>
</tr>
<tr>
<td>Silicon Strip 2</td>
<td>90</td>
<td>12</td>
<td>35</td>
<td>33638</td>
<td>6</td>
<td>-30</td>
</tr>
<tr>
<td>Pixel</td>
<td>18</td>
<td>12</td>
<td>35</td>
<td>3564</td>
<td>5</td>
<td>-20</td>
</tr>
<tr>
<td>Thermal Screen 1</td>
<td>8</td>
<td>12</td>
<td>35</td>
<td>3168</td>
<td>4</td>
<td>-10</td>
</tr>
<tr>
<td>Thermal Screen 2</td>
<td>8</td>
<td>12</td>
<td>35</td>
<td>3168</td>
<td>4</td>
<td>-10</td>
</tr>
<tr>
<td>Preshower 1</td>
<td>2</td>
<td>30</td>
<td>56</td>
<td>6480</td>
<td>7</td>
<td>-20</td>
</tr>
<tr>
<td>Preshower 2</td>
<td>2</td>
<td>30</td>
<td>56</td>
<td>6480</td>
<td>7</td>
<td>-20</td>
</tr>
<tr>
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<td><strong>218</strong></td>
<td><strong>90136</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

At the exit of the tank, a manual valve (V-8) is used for purging. A second manual valve (V-7) serves the pump inlet and allows for pump dismantling in case of need. The pump (E-3) shall provide a pressure drop that varies from unit to unit as listed in Table 1. A safety system protecting the pump in case of overheating or overpressure shall be provided. Spare pumps shall be foreseen, as an option, in the number of 1 for each different model installed on the plant (see §9 of Annex 2). Two stainless steel filters in series (E-6, E-7) allow for C_{6}F_{14} purification from eventual acids and water. Manual valves (V-2/V-5) at the filter inlet and outlet guarantee maintenance operations. Schrader valves (V-16, V-17) at the filter outlet are used for purging and drying.

The fluorocarbon is cooled down into a plate heat exchanger (E-5), where R410A evaporates. The R410A flow rate is controlled by an expansion valve (V-10), as a function of the temperature, measured after the heat exchanger by a thermocouple (I-2). The expansion
valve shall have pneumatic actuator and positioner, allowing for a pressure of about 18 bar at the inlet and 1.4 bar at the outlet. The R410A gas exiting the evaporator passes into a heat exchanger (E-4), where it is warmed up by the R410A liquid arriving from the Main Unit. Exit temperature for the R410A gas shall be kept above the cavern dew point (13 °C).

A pressure transmitter (I-10), whose scale shall be 1-10 bar absolute pressure, measures the pressure at the distribution inlet. The pressure transducer and a manometer (I-8) measuring the distribution pressure are physically located on the control rack, next to the cold box.

Thermal Screen and Preshower cooling plants (see drawings LHCF35240012 and LHCF35240014) shall be equipped with emergency refrigerator units, which shall provide continuous functioning. Please refer to Annex 3 for technical data on the emergency fridge units. A heater placed on the distribution line shall allow for temperature regulation.

Silicon Strip and Pixel cooling units shall be equipped with an external electrical heater (E-8 on LHCF35240013), connected by flanges to the distribution lines, to allow testing and emergency operation.

4.2.2.1 Distribution circuit equipment

Different systems are envisaged to equip the distribution lines of the various cooling units.

Silicon Strip cooling units and Pixel cooling unit include, after the heat exchanger, the instrumentation shown in (LHCF35240015 and LHCF35240017). The numerous distribution lines of each plant are grouped into four sub-distribution lines. Each one of these branches is equipped with a pneumatic shut-off valve (V-19/V-26) on the distribution and on the return line. On the distribution line, a primary element (i.e. a calibrated orifice, I-3/I-6) generating a pressure drop of less than 100 mbar allows flow rate measurements. A differential pressure transducer (I-12/I-15) connected to the small pipes exiting the primary element is used to continuously acquire data. The differential pressure transducers shall read a scale of pressure between 0 and 0.1 bar.

A grouping of the distribution lines is not necessary for Thermal Screen and Preshower cooling units.

For all the final distribution lines of all the plants, the following equipment shall be provided:

- a pneumatic shut-off valve (V-11) at the circuit inlet, stainless steel, with pneumatic actuator, normally closed, with an additional metering screw, allowing for an initial manual regulation of the flow rate at a given pressure,
- a primary element (i.e., a calibrated orifice) (I-1),
- three thin instrumentation pipes (one before the orifice, one after and a third one on the return line from the detector),
- a pneumatic shut-off valve (V-13) at the circuit outlet, stainless steel, with pneumatic actuator, normally open,
- a by-pass to the shut-off valve by means of a safety valve (V-12), allowing a secure opening of the cooling circuit in case of volume variation of the fluid, whose temperature rises if the circuit is closed and the detector electronic is still dissipating heat.

A number of Schrader valves equal to the capillary exits for each cooling unit shall be installed on the outside racks to allow for connection of differential pressure transducers,
providing the flow rate measurement. The vacuum pump and a nitrogen distribution shall be installed as well on the control racks. Preshower and Thermal screen cooling unit distribution lines shall be permanently equipped with differential pressure transmitters to continuously acquire flow rate measures.

4.2.3 Instrumentation

All the readings for the detector cooling unit instrumentations shall be physically placed on some control racks, next to the cold boxes containing the cooling units. Electrical cables, pneumatic connections and small pipes connecting the primary elements to the Schrader valves shall exit the cold box from one side, in the direction of the corresponding control rack. All of these equipments and connections are part of the Tender, as from the UPL listing.

All pressure instrumentations (pressure transmitter, indicators, etc.) must be equipped with two valves: one for calibration with a known pressurized circuit and the other on the connection with the main circuit, to close the line in case of maintenance (see Figure 1).

![Figure 1: Pressure transducer and manometer mounting](image)

4.2.4 Cold boxes

Cold boxes shall be equipped with the following instrumentations (refer to drawing LHCF352400013):

- a bi-directional safety valve (V-28),
- a pressure indicator (I-18),
- a ball flowmeter (I-17),
- a light,
- a dew point transmitter (I-16).

A dew point of -40°C shall be provided by means of compressed air inside the cold boxes, to avoid condensation. CERN will provide distribution of compressed air with a dew point of -40°C. It is up to the Contractor the evaluation of the thickness of the insulation layer for the box walls, so that a minimum external temperature of 14°C is assured.

All the cold boxes shall be equipped with adequate retention bunds, in stainless steel. The external reservoirs for the two Silicon Strip cooling plants shall be equipped the same way, since thawing of ice around them is foreseen in case of emergency stop of the cooling. The connection pipes between the retention bunds and the UXC waste water network is part of this Tender.

Accessibility to the cold boxes shall be guaranteed by means of at least one door on each cold box. Doors width shall not exceed 1 m opening on the balcony passage side and their opening shall be assured independently from the inner environmental conditions. An eventual electrical heater to defreeze the door opening frame shall be foreseen in case of need.
The other sides of the cold boxes shall be equipped with removable panels, to access the inner components for maintenance purposes. The possibility of walking inside the cold boxes shall be provided by means of an adequate floor.

4.3 Overall dimensions

The primary plant, circulating R410A fluid, occupies a plane area into the Service Cavern USC, as to the drawings (LHCF35240009 and USC55_3D). The height of the whole unit cannot exceed 4.5 m. Chilled water service and compressed air services will be at disposal in the above mentioned area (see LHCF35000013 and LHCF35240009). Together with the primary plant, all the electronics controlling the cooling plants (PLCs, etc.) shall fit the Service Cavern area. Some of the control and power racks can be required to fit a dedicated area on the above floor, depending on future space reorganization.

The compressor installation into the Service Cavern area shall comply with CERN standards for noise levels (see paragraphs 6 and 7 of this Technical Specification, and Annex 7). Only the compressors functioning, the noise level shall not exceed 85 dB (A).

Piping transferring R410A between the Main Unit and the Detector Units shall pass the service tunnel between the two caverns as indicated in LHCF35000014, as well as all the electrical and pneumatic connections to control the Detector Unit cooling plants.

The seven cooling units into the UXC cavern will be placed on the first floor balconies indicated in LHCF35000014. Four of the foreseen units shall be installed on the cavern side opposite to the Service tunnel (in the following “far side”). The Silicon Strip 1, Pixel, Thermal Screen 1 and Preshower 1 cooling units shall fit the surface indicated on the drawings (LHCF35000014). On the opposite side of the cavern (in the following “near side”), three units (Silicon Strip 2, Thermal Screen 2 and Preshower 2) shall fit the surface indicated in LHCF35000014. The cold boxes external depth shall not exceed 0.8 m, and their height shall be no more than 2.3 m. A possible extension to a height of 2.8 m shall be quoted as an option (see §9 of Annex 2). The maximum external length of each cold box is given in Table 2.

<table>
<thead>
<tr>
<th>Cooling unit</th>
<th>Maximum length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon Strip</td>
<td>4500</td>
</tr>
<tr>
<td>Thermal Screen</td>
<td>2000</td>
</tr>
<tr>
<td>Preshower</td>
<td>2000</td>
</tr>
<tr>
<td>Pixel</td>
<td>2000</td>
</tr>
</tbody>
</table>

Racks containing the necessary instrumentation shall fit along the same balcony, next to the corresponding cold box. They should be accessible during all the functioning of the cooling units. One standard 19” rack is foreseen for each cooling unit, except the Preshower units, whose equipments will be placed on the Thermal Screen cooling unit racks.

4.4 Performance

The performances listed in Table 3 are those to be provided by the detector unit cooling plants.
Table 3: Detector cooling units: required performances

<table>
<thead>
<tr>
<th>Cooling Units Name</th>
<th>T °C</th>
<th>kW min</th>
<th>kW max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silicon Strip 1</td>
<td>-30</td>
<td>38</td>
<td>52</td>
</tr>
<tr>
<td>Silicon Strip 2</td>
<td>-30</td>
<td>38</td>
<td>52</td>
</tr>
<tr>
<td>Pixel</td>
<td>-20</td>
<td>9.2</td>
<td>10</td>
</tr>
<tr>
<td>Thermal Screen 1</td>
<td>-10</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Thermal Screen 2</td>
<td>-10</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>Preshower 1</td>
<td>-20</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>121.2</td>
<td>154</td>
</tr>
</tbody>
</table>

4.5 Electricity

All the electrical equipment shall comply with the safety and technological standards listed in chapter 6 and 7 of this Technical Specification.

All prescriptions covering electricity matters are provided in Annex 5.

4.5.1 Scope of the supply

The Contractor shall include in his Tender the following items concerning the electrical installations for the cooling plant:

- the electrical study of the entire plant,
- the specification of power supply components and protections (for CERN to provide the UIAC-00565 (USC55) power supply cubicle) and the design memoranda,
- the supply and installation of the UIAE-00567 (USC55) secured power supply cubicle according to chapters 2.2 and 2.4 of Annex 5,
- the supply and installation of the UIAN-00567 (USC55) control cubicle, according to §2.2 and §2.5 of Annex 5,
- as an option, the supply and installation of the UIAC-00566 and UIAE-00567 power supply cubicle in the UXC, according to §4.5.3 of this Technical Specification,
- the supply of the schematics diagrams for the plug-in removable crate power supply cubicles, (drawn on the basis of the manufacturer schematic diagrams), in electronic and paper format,
- the supply and installation of all the cables and cable carriers (sized on the basis of the equipment proposed) from the electric power cubicles to the various components, including the electrical connections and all the tests,
- the supply and installation of the power, control, bus cables and cable carriers from the instrumentation and actuators to the PLC cubicle, including connections and their tests,
- the equipotential links and the earthing of all the components of the plant including the metal structures and piping, all in conformity with CERN earthing standards.

4.5.2 Power cubicles configuration

The configuration that shall be quoted in the Tender is the following:
CERN shall provide the UIAC-00565 power supply cubicle, as described in Annex 5, §2.1, and install it in the USC cavern dedicated space (see LHCF35240009).

The Contractor shall determine the number, type and rating of each individual supply. This information shall be sent to the CERN technical responsible with the “execution file” for approval within the dates given in the Provisional schedule, in order to define the cubicle to be provided.

An indicative list of outgoing feeders is given in Table 4, where \(*P\) is the CERN estimated power in kW for the components that has to be sized by the Contractor. The Contractor shall determine the number, type and rating of each individual supply.

### Table 4: UIAC-00565 (USC55)

<table>
<thead>
<tr>
<th>*P kW</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>3x75</td>
<td>3 Compressors</td>
</tr>
<tr>
<td>2x 37</td>
<td>Pumps for SS1 and SS2</td>
</tr>
<tr>
<td>5.5</td>
<td>Pump for PX</td>
</tr>
<tr>
<td>2x38</td>
<td>Electrical heater for SS1 and SS2</td>
</tr>
</tbody>
</table>

The Contractor shall supply the UIAE-00567 power distribution cubicle, as described in Annex 5, §2.4, and install it in the USC cavern dedicated space (see LHCF35240009).

An indicative list of outgoing feeders is given in Table 5, where \(*P\) is the CERN estimated power in kW for the components that has to be sized by the Contractor.

The Contractor shall determine the number, type and rating of each individual supply.

### Table 5: UIAE-00567 (USC55)

<table>
<thead>
<tr>
<th>*P kW</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>2x7.5</td>
<td>Emergency fridge for TS1 and TS2</td>
</tr>
<tr>
<td>2x 5.5</td>
<td>Emergency fridge for PS1 and PS2</td>
</tr>
<tr>
<td>2x5</td>
<td>Electrical heater for TS1 and TS2</td>
</tr>
<tr>
<td>2x13</td>
<td>Electrical heater for PS1 and PS2</td>
</tr>
<tr>
<td>9x1</td>
<td>Vacuum pumps</td>
</tr>
<tr>
<td>10</td>
<td>UIAN-00567</td>
</tr>
</tbody>
</table>

4.5.2.1 Control cubicle

The technical details and requirements on the UIAN-00567 (USC55) control cubicle are listed in §2.2 and §2.5 of Annex 5.

The Contractor shall supply, install and power the control cubicle, housing the twin PLCs referred to in §4.6.2 and as defined in Annex 4, terminal blocs and the necessary accessories (power supplies of all sensors, transmitters and actuators) as defined in §2.2 and
§2.5 of Annex 5. This cubicle shall be located in USC55 in the area closed to the compressors. In the same place, the Contractor shall provide and install the control rack (UIAN-00568) for the electro-valves providing the conversion between electrical and pneumatic signals.

4.5.3 Electrical configuration option

With the intention of optimising the cabling, a second configuration for the electrical cubicle arrangement shall be foreseen and quoted by the Contractor as an option, as described in the following.

Also in this case, CERN shall provide the UIAC-00565 power supply cubicle, as described in Annex 5, §2.1 and install this power supply cubicle in the USC cavern dedicated space (see LHCF35240009). The Contractor shall determine the number, type and rating of each individual supply. This information shall be sent to the CERN technical responsible with the “execution file” for approval within the dates given in the Provisional schedule, in order to define the cubicle to be provided.

An indicative list of outgoing feeders is given in Table 6.

<table>
<thead>
<tr>
<th>*P kW</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>3x75</td>
<td>3 Compressors</td>
</tr>
<tr>
<td>160 kW</td>
<td>UIAC-00566 (UXC55)</td>
</tr>
</tbody>
</table>

The control cubicles (UIAN-00567 and UIAN-00568), shall be installed into the USC cavern by the Contractor, following the prescriptions already mentioned in §4.5.2.1.

In this configuration, the Contractor shall supply a second power distribution cubicle, UIAC-00566, according to Annex 5 §2.2 and §2.3, in addition to the previously described power supply cubicles. This unit shall be installed into the UXC cavern, next to the detector cooling units to be powered. The Contractor shall provide the power supply for this cubicle via the UIAC-00565 installed into the USC.

An indicative list of outgoing feeders is given in Table 7, where *P is the CERN estimated electric power in kW of the component that has to be sized by the Contractor.

<table>
<thead>
<tr>
<th>*P kW</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>2x 37</td>
<td>Pumps for SS1 and SS2</td>
</tr>
<tr>
<td>5.5</td>
<td>Pump for PX</td>
</tr>
<tr>
<td>2x38</td>
<td>Electrical heater for SS1 and SS2</td>
</tr>
<tr>
<td>1</td>
<td>Electrical heater for PX</td>
</tr>
</tbody>
</table>

The Contractor shall supply and install the UIAE-00567 power cubicle according to Annex 5, §2.2 and §2.4. In this configuration, this cubicle shall be located in UXC55 close to
the detector cooling units. An indicative list of outgoing feeders is given in Table 8, where \( \text{P} \) is the CERN estimated electric power in kW of the component that has to be sized by the Contractor. The Contractor shall determine the number, type and rating of each individual supply.

<table>
<thead>
<tr>
<th>( \text{P} ) kW</th>
<th>Component</th>
</tr>
</thead>
<tbody>
<tr>
<td>2x7.5</td>
<td>Emergency fridge for TS1 and TS2</td>
</tr>
<tr>
<td>2x 5.5</td>
<td>Emergency fridge for PS1 and PS2</td>
</tr>
<tr>
<td>2x5</td>
<td>Electrical heater for TS1 and TS2</td>
</tr>
<tr>
<td>2x13</td>
<td>Electrical heater for PS1 and PS2</td>
</tr>
<tr>
<td>9x1</td>
<td>Vacuum pumps</td>
</tr>
</tbody>
</table>

In this configuration, both UIAC-00566 and UIAE-00567 shall be installed in UXC cavern. For an adequate installation on the cavern balconies, they shall not exceed the following dimensions: 1 metre width, 2 metres height and 0.5 metres depth.

The Contractor shall also take into account the costs related to the different configuration regarding the control and power cabling.

Both configurations (i.e. with or without power supply cubicle in the UXC cavern) shall be quoted in the UPL. CERN reserves the right to define the final configuration and to inform the Contractor thereof before the works begins.

### 4.5.4 Electrical components

The Contractor shall determine the number, type and rating of each individual supply. This information shall be sent to the CERN technical responsible with the “execution file” for approval within the dates given in the Provisional schedule.

CERN will take care of the connection of the power supply cubicles to the mains. The Contractor shall be responsible for:

- Sizing components and protections of each cell,
- Connecting the power cables to the terminals of each motor or power component,
- Calibrating and setting all protection devices,
- Laying and connecting the control and monitoring cables needed to each of the components of the cells.

#### 4.5.4.1 Cables and cable trays

The Contractor shall be responsible for all the cables and cable trays downstream from the power and control cubicles. The technical details and requirements are listed in Annex 5.

#### 4.5.4.2 Connections

The Contractor shall be responsible for all the power and control connections of the equipments and their sensors and actuators.

All the local and remote controls and the control connections shall be provided by the Contractor.
4.5.4.3 Earthing

All metal parts shall be earthed by the Contractor at the connectors provided by CERN in the CV area of the USC and on the balconies of the UXC cavern.

4.6 Control System

All prescriptions covering control and monitoring matters are provided in Annex 4. The whole control system for the double-loop cooling plant shall comply with the requirements indicated in paragraphs 1 to 3, and paragraph 7 of Annex 4. The complete plant control system, achieving the performances listed in paragraph 3, shall be included the offer.

4.6.1 Scope of the supply

For the control system and the local monitoring system, the Tender shall supply:

- the study of the PLC-based regulation and control system and of the local supervision SCADA of the plant, including the calculation, simulation tuning and validation of the parameters for each regulation loop,
- the supply of process flow-charts and the function and malfunction analyses together with the corresponding design memoranda,
- the conception, detailed design and coding of the PLCs and local supervision SCADA application,
- all the control, regulation, monitoring and supervision application source codes, along with the necessary documentation, libraries and licenses associated with the development of the control system in electronic and paper format,
- the supply and installations of the power supply and control cubicle (UIAO) housing the programmable logic controllers (PLC), and the SCADA desktop PC,
- the supply and installation of the PLCs, the desktop SCADA PC, the sensors, transmitters and actuators, including all the necessary items for their operation (power supply, converters, signal conditioning devices, etc.),
- the integration of PLCs and PC to CERN’s Ethernet network and the dialogue according to the TCP/IP protocol within this network,
- the communication between the control PLC and the local supervision SCADA PC, by means of the CERN Ethernet TCP/IP network,
- the communication between control PLC and the power supply cubicles control cubicles by means of the local field bus (Modbus or similar),
- the communication between control PLC and the PLC which is dedicated to the chilled water production and primary cooling circuits monitoring (provided by different Contractor), via the CERN Ethernet TCP/IP network,
- the dialogue between the control PLC and the Experimental Control Room (ECR) control system, including the handling of remote commands and set points from the ECR, and the reporting from the PLC to the ECR of the progress status data, via the CERN Ethernet TCP/IP network,
- the dialogue of the local supervision SCADA PC with the CERN’s Technical Control Room (TCR). A software interface, the SCADA Equipment Controller (EC) will be supplied by CERN for this purpose (the Contractor shall be
responsible for the installation, configuration, testing and validation of the configuration parameters),

- the Web-based serving of the local supervision mimic diagrams for the use of the CERN’s Technical Control Room remote monitoring,

- the provision of the WIZCON® tag names corresponding to the data to be integrated in the TCR at least eight weeks in advance to the date foreseen for the acceptance test of the complete monitoring capabilities. These data tag names will be delivered using the predefined TCR data integration form (Excel file table),

- training.

### 4.6.2 Generalities

Programmable Logic Controllers (PLC), Schneider in accordance with CERN internal recommendation, shall control and monitor the plant. This automatic system shall control the cooling plant, handle the safety functions and the control and monitoring systems of the ancillary components and subsystems (i.e the Modbus of the power supply cubicles) and the modular electrical/pneumatic automation system for the command of the process pneumatic valves). A redundant PLC solution (composed of two sets of CPU, communication modules, and power supply) with FipIO decentralised I/O modules shall be installed for reliability reasons.

Paragraphs 4 to 6 of Annex 4 concern the requirements for an eventual upgrade to an advanced regulation system. Optional advanced regulation systems shall be quoted separately for each cooling unit, allowing the single unit upgrade if required later.

### 4.6.3 Instrumentation

All the sensors and actuators required to operate the process shall be included in the tender. The pressure ratings, materials and temperature operation range shall be adapted to the particular use of each transmitter and its environment. The electrical characteristics shall meet industrial standards. Please refer to §4.7 for environmental conditions to be sustained by all the instrumentation.

#### 4.6.3.1 Analog transmitters

Transmitters’ electronics shall be located on the control cubicles in the USC cavern in order to avoid radiation effects on the electronic devices. Galvanic isolations shall be foreseen for all the connections between the control cubicle and the detector units local control racks. As a way of indication CERN proposes material of the makes Khrone®, Endress+Hauser® or of similar quality.

The following characteristics are required:

- Voltage 24 V - D.C.
- Conventional 4 to 20 mA output signals.
- Precision > 0.5% of the scale measured.
- Easy calibration and configuration. Process quality.

#### 4.6.3.2 On/off switches

The control and electrical racks shall be dimensioned and fully equipped to integrate the zero-potential contacts. These shall include:

- the thermostats of all the motors,
the fault and status switches associated to the motors,
the hand-operated equipment security stop push-button of each detector cooling unit,
the flow, pressure, temperature,…, switches,
all the applicable “power on” switches.

4.6.3.3 Electrical/pneumatic valve blocks

As a way of indication CERN proposes material of the makes Bosch type VTS type 2x3/2, Burkert block assembly type 5470 MP05 2x3/2, or of similar quality.

Voltage 24 V – D.C. with electrical isolation.

4.7 Environmental conditions

During operation, a strong magnetic field and a high level of radiation will be present in the cavern. They both will be reduced at the level of the balconies of UXC, where the detector cooling units will be situated. Magnetic and radiation levels into UXC are given in Table 9 and Table 10. The origin of the cylindrical reference system used in these tables is placed into the UXC centre, indicated in the drawing LHCF35000014. The z axe is placed along the cavern length. Sensitive equipment installed in UXC will be minimized and it shall be fully compatible with this environment.

4.8 Materials recommendations and requirements

The above mentioned environmental conditions cause specific requirements on the materials employed in the plant components. For a complete list, please carefully read the following instructions on the attached CD-ROM: “CERN Official Documents”.

- IS 23 on the selection of electrical cables and equipment with respect to fire safety and radiation resistance
- IS 41 on the use of plastic and other non-metallic materials with respect to fire safety and radiation resistance

<table>
<thead>
<tr>
<th>Table 9: Magnetic field into the UXC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from the CMS geometrical center</td>
</tr>
<tr>
<td>R</td>
</tr>
<tr>
<td>&gt; 8 m</td>
</tr>
<tr>
<td>10 m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 10: Radiation level into the UXC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance from the CMS geometrical center</td>
</tr>
<tr>
<td>R</td>
</tr>
<tr>
<td>10 m</td>
</tr>
<tr>
<td>10 m</td>
</tr>
</tbody>
</table>

Both the USC and the UXC caverns will be kept at an ambient temperature of approximately 20°C.
The use of cryogenic fluids is regulated by the CERN safety instruction IS47, whilst special directives on the compatibility of the fluorocarbons (C\textsubscript{6}F\textsubscript{14}) with different materials are listed in Table 11.

<table>
<thead>
<tr>
<th>Material name (commercial name)</th>
<th>Manufacturer data</th>
<th>CERN IS 41</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acrylic (Acrylite / Acrysteel / Aristech / Cyrolite / Diakon / Kamax)</td>
<td>Good</td>
<td>Possible</td>
</tr>
<tr>
<td>Buna-N-Nitrile rubber (NBR=Acrylonitrile butadiene rubber -Perbunan-NT/ Hyca/ Butacrill/ Chemigum/ Isr-N/ Stansolv/ Sol-Vex)</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Nalgene-Polyurethane (PU/PUR=Polyurethane rubber - Vulkollan / Adiprene)</td>
<td>Good</td>
<td>Possible</td>
</tr>
<tr>
<td>Neoprene W (CR=Polychloroprene rubber - Baypren / Neox / Stanzoil)</td>
<td>Good</td>
<td>Prohibited</td>
</tr>
<tr>
<td>Silicone (SIR=Silicone rubber - Silastic)</td>
<td>Good</td>
<td>Possible</td>
</tr>
<tr>
<td>Polyurethane (PUR=Polyurethane rubber - Vulkollan / Adiprene)</td>
<td>Good</td>
<td>Possible</td>
</tr>
<tr>
<td>Neopren W (CR=Polyurethane rubber - Baypren / Neox / Stanzoil)</td>
<td>Good</td>
<td>Possible</td>
</tr>
<tr>
<td>PVC (PVC=Polyvinyl chloride – Betaglas / Darvic / Fiberlok / Trovidur / Hostalit / Vestolit / Tygon)</td>
<td>Bad</td>
<td>Possible</td>
</tr>
<tr>
<td>Teflon (PTFE=Polytetrafluoroethylene - Flubriflon / Fluon / Teflon TFE / Valflon F / Hostaflon TF / Furon / Gortex / Tfm / Rulon)</td>
<td>Bad</td>
<td>Prohibited</td>
</tr>
<tr>
<td>Tygon (PVC)</td>
<td>Bad</td>
<td>Prohibited</td>
</tr>
<tr>
<td>Viton (FKM=Fluoroelastomer - Fluorel)</td>
<td>Bad</td>
<td>Prohibited</td>
</tr>
<tr>
<td>EPDM (Ethylene propylene rubber - Keltan / Nordel / Vistalon / Buna-AP / Pyrofil)</td>
<td>Bad</td>
<td>Possible</td>
</tr>
</tbody>
</table>

5. **CONTRACT EXECUTION**

5.1 **Responsibility for the Design, the Equipment and its Performance**

The Contractor shall be responsible for the correct performance and working order of all items supplied, irrespective of whether they have been chosen by the Contractor or suggested by CERN. The Contractor shall be liable for any information prepared by him or on his behalf, and shall apply professional standards in using any information provided to him under the contract.

Where the Contractor seeks any approval or agreement by CERN or any other party, the giving of such approval or agreement shall not release him from his obligations or liabilities under the contract.
5.2 Contract Follow-up

5.2.1 Contract Engineer

The Contractor shall, within two weeks from the confirmation of the contract, notify CERN in writing of the person appointed to represent him for the daily follow up of the work. He/she shall give to CERN prior notification in writing of any change.

5.2.2 Progress Reports

The Contractor shall supply, within one month of notification of the Contract, a written programme detailing the manufacturing and testing schedules. The programme shall include preliminary dates for inspections and tests. A written progress report, containing the status of the work and the detailed schedule for the two following months, shall be sent to CERN every two months until the completion of the Contract.

5.2.3 Design Approval and Production

The detailed design shall be submitted to CERN for approval within two months from the Contract signature. CERN will give its approval or refusal, in writing, within one month from the submission. Component ordering and equipment manufacture shall not start without CERN’s prior written agreement.

5.3 Factory Access

During the Contract period CERN and its representatives shall have free access during normal working hours to the Contractor's manufacturing or assembly sites, including any subcontractor’s premises. The place of manufacture, as stated in the Tender Form, may only be changed after written approval by CERN.

5.4 Packing and transport to CERN

The Contractor is responsible for the packing and the transport to CERN. He shall ensure that the equipment is delivered to CERN without damage and any possible deterioration in performance due to transport conditions.

The Contractor shall include in his Tender all the transport, off-loading and installation of the supply. A special procedure shall be implemented for the transport of the material in the pits because in this phase of work the handling of the material must be done under CERN responsibility. The Contractor shall:

- store the material on his container at CERN site,
- deliver the said material in a dedicated surface building (SD) on the top of the access pits,
- complete a transfer sheet for the material,
- carefully inspect the material before and after transfer,
- any damage must be immediately checked and reported jointly by the Contractor and CERN representative to the CERN ST/CV work section leader.
5.5 Handling at CERN

All handling material employed by the Contractor has to be done with equipment conforming to CERN Safety Code D1 "Lifting Equipment", see the attached CD-ROM containing the CERN standards and rules.

5.5.1 CERN supplied items and services

CERN will make available:
- space and civil engineering structures (buildings, galleries and ducts),
- site services, such as electricity 400V / 50Hz / 63A three phase power (see LHC document LHC-PM-IP-0001),
- the vertical handling of all the Cooling Plants and the related equipments in the CERN shafts.

5.5.2 Contractor’s installations at CERN

Contractor’s installation at CERN and work during the contract period are regulated by CERN Standards listed in the attached CD-ROM “CERN Official Documents” (see §6 of this Technical Specification).

5.6 Deviations from this Specification

The Contractor shall not implement any deviations from this Invitation to Tender without CERN's prior written approval which it can give or withhold at its sole discretion.

CERN reserves the right to modify the conditions set out in this Invitation to Tender including but not limited to the Technical Specification during execution of the Contract. The consequences of such modifications shall be mutually agreed between CERN and the Contractor it being understood that any additional costs shall be calculated on the basis of the unit prices quoted in the UPL.

All amendments to the contract shall be in writing.

5.7 Information and documentation management

5.7.1 Documents to be provided

The Contractor shall submit the following documents to CERN. CERN reserves three weeks time for approval of any of the submitted documents.

5.7.1.1 During the contract period
- intermediate progress report,
- written report on any problem that might affect the schedule shall immediately be sent to CERN.

5.7.1.2 Four weeks before work starts
- detailed working schedule, including the preliminary tests
- detailed design calculations for the various components of the installations and for each technical drawing,
- all the documents, notes, circuit diagrams and descriptions concerning the components and materials,
• detailed specification and data sheets for components, in particular those to be supplied by subcontractors,

• prior to the functional and malfunctional analysis phase, the description of the general process, set up in a document called “General Description of the Operation of the Process”. This document corresponds to the User Requirements Definition Phase (2.2.1 of Annex 4),

• within 4 weeks after CERN approval of the document “General Description of the Operation of the Process”, the Contractor shall submit for approval the “Function and Malfunction Analysis” document, showing, in particular, the complete and detailed description of the process control system proposed. This document shall correspond to the Software Requirements Definition Phase (2.2.2 of Annex 4),

• the hydraulic, electrical, control and regulation management and monitoring schematic drawings,

• calculation notes regarding the sizing of the power supply cables and their protections,

• the complete list and composition of power supply cells required for CERN to order the power supply cubicles, please refer to §4.5,

• the control and regulation flow-charts, the electrical wiring and regulation loop diagrams, the SCADA (local monitoring) system mimic diagrams, and a detailed list and structure of all the software functions and data blocks. This document shall correspond to the Architectural Design Document (2.2.3 of Annex 4),

• all relevant information on subcontracted equipment, such as manuals, drawings, etc.

5.7.1.3 One month before tests on the contractor’s premises

• detailed testing schedule

• description of the measurement procedure for the tests

5.7.1.4 Four weeks prior to provisional acceptance:

Three paper copies and an electronic copy of the final revision of the complete as-built documentation including:

• the test records,

• the materials certificates,

• all the components operating instructions specifying the various settings, the operations to be performed, the timing and type of maintenance inspections and all the information needed to manage the installation,

• all the drawings and the technical documents up-to-date,

• the complete technical data of the components in electronic format (MS Excel), according to CERN templates (see annexed template “Equipment_template.xls”),

• all the software and programmes, source and object files, fully documented and detailed (comments in the programmes) with documentation and licences, in accordance with the state of programming when in service. For each item of software and programme installed, a glossary, with comments of all the variables and cross-references and I/O to which they are connected. This documentation shall correspond to the Detailed Design Document (2.2.4 of Annex 4),
• for each item of software installed, a “quick reference guide” in which each page shall contain a description of a particular function, a definition of the menu commands involved and an example by way of illustration. This document shall correspond to the Software User Manuals (2.2.4 of Annex 4).

5.7.2 Documentation management

CERN will create and maintain a specific website for the contract as a means of coordinating information between CERN and the Contractor, and to be used for the documentation management. CERN Engineering Data Management System (EDMS) shall be used for storing the documents.

5.7.2.1 Archiving of drawings and internal approval on the CDD

The drawings shall be submitted to CERN for archiving in duplicate, in addition to the paper copies, in the form of printer files (HPGL) and source files (DWG and DXF) on CD-Rom.

Following an initial check by CERN, the Contractor shall archive his drawings in CERN’s CDD via Internet. The procedure to obtain access to the CDD and to store documents is given in the LHC-PM-QA-609.00 (see CERN Official Document annexed CD-ROM).

The Contractor may consult the CDD via Internet on his own initiative in order to check the approval or rejection status of his documents. He must take account of any comments made, amend his drawings accordingly, index them and put them back in the system until all his drawings have been fully approved. This procedure shall apply to drawings submitted for approval prior to the start of the work and to the as-built drawings submitted prior to provisional acceptance for final archiving.

5.7.2.2 Planning and scheduling

Planning and scheduling activities shall be performed according to the procedure defined in the LHC QAP document No LHC-PM-QA-301.01, "Planning and Scheduling Requirements for Institutes, Contractors and Suppliers”.

5.7.2.3 Document format

All the text, instructions and notes appearing on the drawings and in the documents shall be in English or French. Please refer to LHC-PM-QA documents in the annexed CERN Official Document CD-ROM for:

• document types and naming conventions,
• glossary, acronyms and abbreviations,
• naming conventions,
• drawings,
• design standards,
• document standards.

All the documents drawn up by the firm shall be sent to CERN in both paper and electronic format, and stored by the Contractor on the EDMS. The Contractor must draw up his design memoranda using Microsoft Word4 or Microsoft Excel and his schedules using Microsoft Project. He shall provide CERN with a source version (DOC, XLS, MPP, etc.) and a PDF version.

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4 Microsoft Word, Excel and Project are registered trademarks of Microsoft Corporation.
The mechanical drawings and diagrams shall be made using the AutoCAD\textsuperscript{5} 2002 system. The Contractor shall model all the equipment in three dimensions. For each drawing and diagram he shall supply a paper copy, a DWG drawing source file, a DWG 3D object file and an HPGL plotter type file. The drawings shall comply with the QAP document, ref. LHC-PM-QA-306.00, Drawing Process External Drawings.

The electrical wiring diagrams shall be made on a commercial package imposed by CERN (Trace-Elec\textsuperscript{®}). The sheets shall be supplied as source files and printer files.

The contractor shall supply with his technical documentation the technical data of all the components and their spare parts in electronic format (MS Excel), according to the given CERN template (see the annexed document “Equipment_template.xls”). For retrieval by CERN’s CAMM system, the Contractor shall enter the technical parameters of all the installations’ components in accordance with the instructions given in the file. The documents (qualifications, technical documentation, etc.) not fulfilling the above-mentioned standards requirements shall be scanned by the Contractor and supplied in PDF format.

Within two weeks after receipt of a document for approval by CERN, one copy will be returned to the supplier marked for approval or showing the modifications, which may be required. If no copy is received in due time, tacit approval can be assumed. Approval given by CERN does not release the supplier from the responsibility of fulfilling the requirements stipulated in this Technical Specification.

All the final documents shall be sent to CERN in both paper and source electronic format (3 copies) and stored on the EDMS.

The support medium for the electronic versions shall be CD-Rom, with files written in accordance with the ISO standard 9660 CD. Each CD-Rom supplied shall be accompanied by a delivery slip and shall also comprise a Word-type file indicating the contents of the files and inventories of the information contained in them.

5.7.2.4 Internet access

With a view to optimising the exchange of information, the Contractor shall have Internet access. He shall in particular use Internet for:

- exchanging e-mails and files,
- archiving documents on CERN’s Intranet system,
- consulting CERN’s databases to monitor progress with the work.

6. APPLICABLE DOCUMENTS

Please refer to the cover letter for the complete list of enclosed documents which form part of this Invitation to Tender. In particular the Contractor shall comply with the documents or standards listed below.

6.1 Standards

6.1.1 CERN standards

The following CERN regulations, which are also applicable to the performance of the contract, are included in the CD-ROM “CERN Official Documents” joined to this Invitation to Tender. All standards apply to this Contract. Please pay particular attention to the following:

\textsuperscript{5} Autocad is a registered trademark of Autodesk Corporation.
• the “Organization of the installation work for LHC and its experiments”, ref. LHC-PM-IP-0001,
• PG: General requirements (ST/IE, December 1994),
• the safety regulations applicable, ref. CERN/TIS-GS/98-10, dated May 1998,
• safety code A3 Rev, 1992, relating to safety colours and safety signs,
• safety code A8, 1993, relating to noise protection,
• electrical Safety Code C1, 1990 edition,
• safety code D1 Rev, 1997 edition, relating to lifting equipment,
• safety code D2 (Rev, 2, 1998) relating to pressure equipment,
• safety code E (Rev, 1995) relating to the fire protection,
• safety instruction IS37 Rev, 2 covering regulations applicable to alarms and alarm systems (1998),
• safety instruction IS41, 1995, relating to the use of plastics and other non-metallic materials at CERN from the point of view of fire safety and radiation resistance,

Further information on the safety regulations applicable at CERN may be obtained from the TIS-GS, TIS-TE and ST-CV groups.

6.1.2 International Regulations

The supplies and assembly work shall comply with international (ISO) or European (EN) standards or, where these do not exist, the most recent standards in force in the country where the installation is to be located.

• IEC 60204 concerning electrical equipment of industrial machines,
• IEC 61069 concerning industrial-process measurement and control, evaluation of system properties for the purpose of system assessment,
• IEC 61506 concerning industrial-process measurement and control documentation of application software,
• IEC 61512 concerning batch process control,
• International standard: FDX 07-21: Fundamental standards metrology and application of the statistics. Help to the process for the estimation and the use of the measurement and test results uncertainly.

6.2 Other references

6.2.1 On-site work regulations

For work to be carried out on the CERN site, attention is drawn to the fact that CERN has specific rules concerning e.g. safety regulations applicable to works of Contractors at CERN, access to and activities on the CERN site, occupational health and safety on the Organization's site and special health and safety matters (see chapter 7 of this document).

For companies which are not established in France, particular attention is drawn to the fact that the site installation work requires obtaining of the relevant permits from the French authorities and that the work will have to be carried out in accordance with French law.
6.2.2 Hydraulic and Electrical Works

Where not otherwise stated into this Technical Specification, electrical and hydraulic works should achieve the requirements stated in Annex 5 and Annex 6 of this Technical Specification.

7. SAFETY

7.1 Contractors and Safety at CERN

The term "safety" covers safety, health protection and working conditions. The works covered by this call for tenders are subject to the observance of all the applicable safety rules set out in the document: Safety regulations applicable to the work of contractors at CERN, ref. CERN/TIS-GS/98-10 dated May 1998 and attached to this specification (hereinafter referred to as "Safety regulations").

7.2 Co-ordination in Matters of Safety and Health Protection

The LHC project is the subject of a safety co-ordination operation established from the design stage. Safety Co-ordinators have been appointed by CERN and are responsible for ensuring the proper co-ordination in matters of Safety and Health Protection procedures. They have the mandate to ensure the application at all the stages in the project (design and completion) of all the measures needed for the performance of the work in accordance with the safety regulations in force at CERN. They also have the duty to integrate the preventive arrangements in the structures and equipment to ensure their fully safe use and maintenance.

One of the tasks of the safety co-ordinator is to draw up the Overall Safety and Health Protection Plan (PGCSPS). This document, which was drawn up during the design phase of the LHC Project, is appended to the tendering documents sent to firms. The preventive, organisational and co-ordination measures recommended therein shall be observed by bidders when submitting their tenders. Take note that the PGCSPS is an integral part of the contract.

Before any work is started, the Contractor (main contractor and/or sub-contractor) must draw up a Special Safety and Health Protection Plan (PPSPS) and submit it to the CERN Safety Co-ordinator and Project Engineer for their opinion and comments.

The PPSPS must take account of the provisions of the PGCSPS and be drawn up after the joint inspection of the premises organised by the Safety co-ordinator and in the presence of the Project Engineer.

In addition, it is pointed out that a Inter-Firm Health, Safety and Working Conditions Committee (CISSCT) is established for the LHC work. This board will meet when called, at least every three months and, in accordance with its rules, the Contractors concerned must be represented on it.

All these provisions are described in detail in the PGCSPS and the specific addendum for the work covered by this call for tenders.

7.3 Additional Stipulations

Taking part in the LHC project stipulates de facto involvement in the safety co-ordination procedure. In addition, CERN expects the Contractors to attach great importance to the observance of the safety regulations and implement all the necessary measures without restriction in order to prevent accidents and occupational illnesses.
Contractors shall also ensure the presence of a safety officer on the work site, and shall take account of all these provisions in their tenders.

In support of their tenders, bidders shall provide a brief but sufficiently full and clear description of the working methods and means of protection, which they are going to institute, and of the equipment, staff and work site installations at CERN. These important details will be taken into account in the assessment of the tenders and shall be set out in detail by the successful bidder in the Special Safety and Health Protection Plan.

Any further information on the safety regulations applicable at CERN may be obtained from the Safety Co-ordinator and the CERN group in charge of the work.

Contractors will nevertheless be deemed to be familiar with the provisions of the regulations applicable to them and may in no circumstances plead a lack of information from CERN to justify a failure to apply safety measures.

8. QUALITY ASSURANCE PROVISIONS

The Contractor must plan, establish, implement and adhere to a documented quality assurance program that fulfils all the requirements described in this Technical Specification and drawn up according to the Quality Assurance Plan for the LHC Project.

The list of relevant topics covered by the LHC Quality Assurance Plan, together with the corresponding documents, is given in Table 12.

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<tr>
<th>Topic</th>
<th>Document Title</th>
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<td>Quality Assurance Policy and Organisation</td>
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9. TESTS

The cooling plant installations shall undergo a complete series of tests, on both the Contractor premises and after installation at CERN. All the tests described in the following represent a compulsory condition for final acceptance of the cooling plant.

The cost of all tests, inspections, commissioning, measurement campaigns, acceptance, the supervision, the specialist manpower and the services of the official bodies needed to meet these requirements shall be included in the tender. Consumables and instrumentation as well must be provided by the Contractor and will be part of the offer, unless otherwise stated. The Contractor shall provide all the calibration certificates for his equipments.

The Contractor shall at his own expense replace all appliances and equipment or parts thereof that, during the inspections and tests, fail in their role or do not perform as specified in this document or as guaranteed in the bid. Once these repairs have been completed, a further test shall be conducted, at the Contractor’s expense, under the same conditions as specified above. CERN reserves the right to reject any work which, in its opinion, does not meet the requirements set forth in this Technical Specification and to have it redone at the Contractor’s own expense.

For each test, the Contractor shall compile and submit a report covering the following information:

- serial number of the test,
- test conditions (pressure, temperature, etc.),
- values specified and results obtained, stating the difference between the two,
- duration of the test, results obtained,
- decisions relating to any repairs required,
- conclusions.

This report will be signed by the representatives of the Contractor and CERN.

9.1 Inspections and tests at the Contractor’s premises

The tests described in the following shall be performed at the Contractor’s or any subcontractors’ premises. CERN reserves the right to present, or to be represented by an organization of its choice, to witness any of these tests. The Contractor shall give at least 10 working days notice of the proposed date of any such tests.

In the event of failure to meet the conditions set out in the Contract and after the Contractor has ensured the required level of compliance, a further series of tests shall be made in the same conditions until the defects and faults discovered during the tests have been rectified. If the Contractor is unable to meet the standards of performance set out in the Technical Specification, the unit will be rejected by CERN. The Contractor shall replace the components which fail the performance test by new ones which are able to meet the standards of performance needed. A new series of performance tests shall be organized by the Contractor.

9.1.1 General tests

The Contractor shall carry out a series of tests to confirm the performances of specific components (pumps, compressors, pressure vessels) before assembly, in accordance with this
CERN Technical Description. After these test, the cooling units (both the Main Unit and all the seven Detector Units) must be assembled and should separately undergo specific tests on piping tightness and overall leak performance as described in the following.

9.1.1.1  **Pumps functionality and regulation**

The tests shall include:

- determination of the head vs. flow-rate characteristics, NPSH and absorbed power for each type of pump (ISO 2548 et ISO 9906 class 2),
- verification of required materials (foundry certificates),
- adjustment of components such as motors and coupler line alignments,
- pressure tests (1.5 times the operating pressure).

9.1.1.2  **Pressure Vessels (Condensers and Evaporators)**

The constructor shall provide all the documents specified in CERN Safety Code D2, Chapter 6. In particular, all pressure vessels shall be subjected to a hydraulic test at 1.5 times the nominal pressure or to a pneumatic test at 1.25 times the nominal pressure before being fitted on the cooling set.

9.1.1.3  **Control Cubicle**

The control cubicles containing the programmable logical controller (PLC), the local monitoring and the supervision systems shall be factory-tested in the presence of CERN’s representatives. Each functionality shall be checked and each control loop tested independently.

9.1.2  **Assembled circuit tests**

Once the circuit assembled, pressure test on the pipes, cleaning procedures and leak test shall be performed as indicated in the following paragraphs.

9.1.2.1  **Piping inspections and pressure tests**

- Welding inspections: 5% of all the welds shall be inspected as defined in Appendix D, reporting the CERN document TIS/TE/MI-CM-00-14 attached to this Technical Specification. CERN may require other non-destructive tests in the event of negative results at the Contractor’s expense.
- Pressure tests: each circuit shall be subjected to a pneumatic test at 1.5 times the operating pressure.

Each test shall be conducted in the conditions required for accurate examination of the section of pipe being tested, particularly all seals. The Contractor shall be responsible in particular for the supply and installation of the stops, electrical connections and all other additional equipment (gases, consumables, etc.) needed to carry out the test in accordance with the set conditions, as well as the hardware required for these tests.

9.1.2.2  **Cleaning of the Cooling Circuits**

The piping for cooling fluids shall be cleaned and degreased and be made free from contamination, dirt, welding scale and oil on the inside as well as the outside, according to DIN norm 25410 grade 2. The proposed cleaning procedure shall be approved by CERN.
9.1.2.3 Leak Tests on the Cooling Circuits

Having undergone the pressure test described above, each cooling circuit shall be subjected to a Helium leak test. This test shall be carried out by the Contractor after the assembly of all the cooling components.

The overall leakage rate shall not exceed $10^{-5}$ mbar/l/s. Measurements shall be done by means of a mass spectrometer. The test procedure is subject to approval by CERN. The report on these tests shall include the same information as the report on the pressure test.

9.1.3 Cooling Unit Performance Tests

The Contractor shall carry out a series of tests to confirm the plant performances indicated by him in his description, in accordance with CERN's specification. These tests are to be performed on the assembled circuit configuration. They shall be conducted using C$_6$F$_{14}$ fluid, which has to be provided as part of the offer. The fluid shall be stored into the cooling plant tanks and delivered at CERN for the final tests.

9.1.3.1 Compressor functionality and regulation

Main Unit functionality test has priority with respect to Detector Unit test. The fully assembled circuit, with slight modification to the final configuration, as explained in the following, shall be installed (see drawing LHCF35240019).

The pipe containing the liquid R410A exiting the tank (E-3) shall be connected to the heat exchanger (E-2). In this way, a closed circuit is created, where the heat exchanger runs R410A on both directions, as from the scheme (LHCF35240019). The heat exchanger will indeed be used both to condensate the gas at the compressor outlet, as well as to evaporate the liquid coming from the tank and expanded in the temporary expansion valve. Superheated vapour exiting the heat exchanger will then be cooled by means of a chilled water circuit, whose flow rate is controlled by a regulating valve (V-2). In the circuit final configuration, the same control valve will be installed at the inlet of the condenser (running, in this configuration, R410A and chilled water, as explained in paragraph 4.2.1 of this Technical Specification).

Cooled vapour exiting the heat exchanger will be sent to the buffer reservoir (E-1).

With respect to the final layout configuration, some instrumentation will be added for test purposes. In particular:

- a gas flowmeter, installed immediately after the chilled water heat exchanger,
- two temperature gauges, with recordable output, at the heat exchanger inlet and outlet,
- two temperature gauges, at the compressor suction line, after the buffer reservoir, and at the compressor outlet.

The flowmeter and the temperature gauges, together with the related acquisition system, shall be part of the offer. CERN reserves the right to bring its own equipment to perform test at the Contractor’s premises, in substitution of those proposed by the Contractor.

Each compressor shall be tested individually for a range of power between 0 and the maximum value given by the constructor to verify the compressor characteristic. A continuous data acquisition shall be provided for a cyclic variation of the compressor flow rate between 0 and 100% of its nominal value, by means of the regulation of the expansion valve. Pressure
and flow rate functioning limits shall be determined as well. For this purpose, the following parameters must be continuously recorded during all the tests:

- pressure and temperature at the compressor inlet,
- temperature at the compressor outlet,
- flow rate
- pressure at the storage reservoir (E-3).

The compressor regulation system shall be validated on the full functioning range of pressure and temperatures of the fluid.

A complete report including the test results shall be provided for approval to the CERN contact persons.

9.1.3.2 Detector Cooling Units

All of the seven detector cooling units shall be tested separately on the Contractor’s premises, after approval of the Main Unit implant.

Each unit must be connected to the completed and tested R410A plant. Test must be performed using C₆F₁₄. The thermal load shall be applied by means of the fridge unit heaters for Thermal Screen and Preshower, whilst Silicon Strip and Pixel units will be equipped with portable heaters, which shall be part of the offer. In drawing LHCF35240020, the heater installation is shown for the Silicon Strip cooling unit test.

The following instrumentation must be installed on the cooling unit for testing purpose:

- a flowmeter, at the outlet of the heater,
- two temperature gauges, at the inlet and the outlet of the heating unit.

Both the flowmeter and the temperature gauges, together with the dedicated data acquisition system, will be provided by CERN.

Measurements of the following parameters will be required for each cooling unit test:

- pressure at the pump inlet (by the pressure gauge on the reservoir),
- pressure at the distribution manifold,
- temperature at the pump outlet,
- temperature at the distribution manifold

All measurements must be recorded in continuous for all the different tests.

The distribution fluid temperature shall be continuously varied between +20°C and -35°C for at least 20 complete cycles. The same test shall be repeated at different load levels, i.e.1/3, 2/3 and 3/3 of the maximum dissipated power.

9.1.4 Preparation of the cooling sets for dispatch

The cooling plant circuits shall be delivered in air overpressure. The overpressure will be checked at the arrival. The connecting flanges shall be plugged with metal stoppers. All the valves of the cooling circuits shall be closed.
9.2 **Acceptance test at delivery**

The Contractor shall assume full responsibility for the physical checks described below. A certificate will be issued confirming safe delivery of the all equipment of the supply. In the presence of a CERN representative, the Contractor shall check:

- the condition of the hydraulic and cooling circuits,
- the condition of the various components (any damage, leaks etc.).

Before provisional acceptance, a record will be made of any defect discovered, which shall be rectified by the Contractor at his own expense.

9.3 **Tests to be carried out at CERN**

After delivery, the cooling units will be installed into the USC and UXC caverns and connected to the services.

9.3.1 **Functionality test**

The final acceptance tests shall include:

- a leak test, following the same procedure as described in 9.1.2.3,
- a pressure test for all the piping, as described in 9.1.2.1,
- a complete electrical functionality test,
- a complete regulation, control and monitoring test,
- a pneumatic functionality test, as to Annex 4.

10. **PROVISIONAL SCHEDULE**

10.1 **Provisional delivery schedule**

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<td>Design Meeting</td>
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<tr>
<td>February 2005</td>
<td>Complete installation at contractor premises</td>
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<td>Commissioning</td>
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<tr>
<td>End 2006</td>
<td>Detector activity starts</td>
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</tbody>
</table>

11. **COMMISSIONING AND ACCEPTANCE**

After final acceptance test, the whole plant shall be commissioned. Once the Contractor has completed his own tests, he may inform CERN that the installation is ready for commissioning. CERN shall send him confirmation of the date of commissioning.

All the following tests must be performed to fully commission the cooling plant:

- calibration of all the transducers and instrumentation systems,
- performance test on the complete plant installation as from paragraph 11.1,
- commissioning of all the safety devices.
11.1 **Performance test for commissioning**

The whole plant will be equipped with the electrical resistances already used for testing at the contractor’s premises. Each cooling unit shall be tested separately, repeating the test already done at the contractor’s premises. All the instrumentation interfaces must be checked for accessibility and functionality.

Once each cooling unit has passed its performance test, all of them shall be operated at the same time, for three different tests at 1/3, 2/3 and 3/3 of their power. Moreover, the full power test shall be repeated varying all the functioning temperature between +20 and -35°C.

The plant will be considered commissioned only after complete fulfilment of the demanded test.

11.2 **Training**

The Contractor shall train the CERN staff to correctly operate the installations and structures to be supplied hereunder. Training shall take place at CERN. The cost of training shall be included in the Tender.

11.3 **Acceptance and guarantee**

Provisional acceptance will be given by CERN only after all items have been delivered in accordance with the conditions of the contract including documentation referred to in this Technical Specification, all tests specified have been successfully completed and all test or other certificates have been supplied to CERN.

The guarantee period is defined in the commercial documents.
12. **CERN CONTACT PERSONS**

Persons to be contacted for technical matters:

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<th>Name/Department/Group</th>
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</tbody>
</table>

Persons to be contacted for commercial matters:

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</tbody>
</table>
Annex 1  List of Drawings
Annex 2  UPL
Annex 3  Technical files
Annex 4  Regulation, control and monitoring
Annex 5  Electricity
Annex 6  Hydraulic works
Annex 7  CD-Rom "CERN Official Documents"