ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

Group Code.:	TS/CV
EDMS No.:	440027
LHC Project document No.:	LHC-F-CI-0007

The Large Hadron Collider Project ***IT-3255/TS/LHC***

Invitation to Tender

Technical Specification for the Supply and Installation of the Underground Cooling Plant for the CMS Detector in the Experimental Area at Point 5 of the LHC

Abstract

This Technical Specification concerns the supply and installation of the cooling plant in the technical cavern USC and UXC in Point 5 of the LHC accelerator. This plant shall consist of eight complete cooling circuits with a total cooling capacity of about 3900kW, ancillary piping for 2 fire-fighting systems and 3 compressed air circuits.

Deliveries are foreseen within 4 months from placement of the Contract.

January 2004

Table of Contents

List of Tables

Terms and Definitions

Term	Definition
CDD **EDMS**	CERN Drawing Directory Engineering Data Management System
QAP	Quality Assurance Plan
CV zone	Cooling and Ventilation zone in USC55
PLC	Programmable Logic Controller
EC	Equipment Controller
ECR	Experiment Control Room
SCADA	Supervisory Control and Data Acquisition
HPGL	Hewlett Packard Graphics Language
PHE	Plate Heat Exchanger
UP	Unit Price List Document
TF	Tender Form Document
PS	Power Supply
TCR **TDS**	CERN's Technical Control Room CERN's Technical Data Server
PGCSPS	Overall Safety and Health Protection Plan
PPSPS	Special Safety and Health Protection Plan
CISSCT	Inter-Firms Health, Safety and Working Conditions Committee
AMDEC	Analysis of the Fault Modes, Effects and Criticality
LHC	Large Hadron Collider
CMS	Compact Muon Solenoid
ECAL	Electromagnetic Calorimeter
HCAL	Hadronic Calorimeter
HF	Hadron Forward Calorimeter

1. INTRODUCTION

1.1 Introduction to CERN

The European Organisation for Nuclear Research (CERN) is an intergovernmental organisation 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.

1.2 Introduction to the LHC Project

The Large Hadron Collider (LHC) is the next accelerator being constructed on the CERN site. The LHC machine will mainly accelerate and collider 7 TeV proton beams but also heavier ions up to lead. It will be installed in the existing 27 km circumference tunnel, about 100 m underground, that previously housed the Large Electron Positron Collider (LEP). The LHC design is based on superconducting twin-aperture magnets which operate in a superfluid helium bath at 1.9 K.

Several new experiments will be built for the LHC, one of which will be CMS in the Experimental Area at Point 5 of the LHC.

1.3 Subject of this Technical Specification

This Technical Specification defines the requirements for the performance, design, manufacture, and installation at CERN, inspection and testing of the cooling plant for the CMS detector and the Experimental Area in the underground caverns USC and UXC situated in Point 5 of the LHC (Cessy, France). A number of racks dedicated to the LHC machine, located in this area is also included. The cooling plant will be situated in a CV zone in the USC cavern and in UXC cavern to provide cooling for the equipment associated with this experiment.

2. SCOPE OF THE TENDER

CERN intends to put out a contract for the provision of the items described in § 2.1 “Scope of the supply”.

2.1 Scope of the Supply

2.1.1 Installation and Support Structures.

- The metal structures supporting the floor comprising the metal grating, the non-conducting fire-proof wooden tiles around the power supply cubicles and the necessary traps to access the false floor,
- the metal structures supporting the piping,

* 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.

- the rust-proofing and finishing paint-work on all the metal structures,
- cuttings in the grating and platforms for the passage of cable trays and piping,
- the drilling and fixing needed for the installation (to the walls and floor) of all the components,
- making good the sealing of all the through-wall holes provided by CERN and of those made by the Contractor for the passage of cables and cable trays, respecting the fire rating of the different buildings or rooms concerned.

2.1.2 Hydraulics

- The hydraulic design study, the sizing and selection of components, the supply of design study of the cooling plant, the supply of performance (factory tests) and conformity certificates of the different components of the plant and the design study of the pipe supports (comprising stress calculations of the piping, bellows, shock absorbers and sliding and fixed supports),
- the supply and installation of the hydraulic components of the plant (motor-pump sets, filters, plate heat exchangers, expansion vessels, air separators, control valves, stop valves, drains, air vents, gauges, etc.) and the installation and hydraulic connection of the items provided by CERN (local demineralisers by means of flexible stainless steel hoses, etc.),
- the supply and installation of the secondary piping (and lagging when required) to the connection points to the users situated in USC55 and UXC55 from the connection point inside the CV zone in the USC55 cavern,
- the supply and installation of the flexible pipes connecting cooling manifolds with supply, return and purge lines;
- the supply and installation of the piping for the high expansion foam system,
- the supply and installation of the piping for the fire-fighting systems,
- the supply and installation of the piping for the compressed air systems,
- the supply and installation for the piping for the tracker cooling circuit,
- the supply and installation of relief protection devices and differential pressure controlled by-pass valves (sized for 20 % of the total flow rate of the circuit) on the primary circuits,
- the supply and installation of the necessary balancing valves on the secondary circuits for easy adjustment of the flow rates in case of circuits with several take-offs,
- the hydraulic connection of the components on the primary and secondary sides, connection of drains and air vents to the drains of the building,
- the supply and installation of discharge lines to the building drains on every item which may be subject to leaks or where water could accumulate,
- the hydraulic (pressure) tests and overall performances tests of the different circuits of the plant.

2.1.3 Electricity

- The electrical study of the entire plant, the specification of power supply components and protections (CERN will provide the power supply cubicles according to the requirements of the Contractor) and the design study of the power supply work for the cooling plant,

- the supply of the drawings and schematic diagrams concerning the configuration of the racks of the associated equipment (both execution and as-built), in electronic and paper format,
- the supply of the technical description of all components and instrumentation, in electronic and paper format,
- the supply of the schematic diagrams of 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.

2.1.4 Controls and Local Monitoring (SCADA)

- 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 and in general, the supply of the corresponding design study,
- the conception, detailed design and coding of the PLCs and local supervision SCADA application,
- the supply of all control, regulation, monitoring and supervision application source code, along with the necessary documentation, libraries and licenses associated with the development of the control system in electronic and paper format,
- the supply of the technical files and other manuals on the organization and management of the process operation and the training for the CERN staff in charge of the operation and maintenance of the plant,
- the supply and installation of the control cubicle (UIAN) housing the programmable logic controllers (PLC), and the SCADA desktop PC, provided with its own ventilation (or air conditioning if necessary for temperature reasons),
- the supply and installation of the PLCs, the desktop SCADA PC, the sensors, transmitters and actuators, comprising all 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 TCP/IP network,
- the communication between the control PLC and the power supply cubicles by means of the local field bus (Modbus or similar),

- the communication between control PLC and the PLC dedicated to the monitoring of the chilled water production and primary cooling circuits (provided by different Contractor), via the CERN 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 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 to be used by the CERN's Technical Control Room for 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).

2.1.5 Tests and Commissioning

- The factory tests of all the hydraulic, electrical and control components,
- the on-site equipment tests and any preliminary testing before commissioning,
- the provision of the different test protocols, the test records and complete tests documentation,
- the commissioning of the plant (including balancing of circuits, calibration of actuators, etc.),
- the acceptance tests.

2.1.6 Miscellaneous

- The drilling of holes in walls for the passage of cables and cable carriers if any extra needed (it should be done under CERN's approval),
- the supply in electronic and paper format (both execution and as-built) of all drawings and schematic diagrams, and its archiving in CERN Drawing Directory (CDD),
- the supply of the technical files in English or French (three hard copies and one electronic editable form) for the maintenance and operation of the plants at the acceptance,
- the technical data of all the components and their spare parts in electronic format (MS Excel), according to the given CERN template (see Annex H), for retrieval by CERN's CAMM system, the Contractor shall enter the technical parameters of the all installations' components in accordance with the instructions given in the file,
- the labelling and panel signs of the systems and equipment (identification of all hydraulic, electrical, etc. components by means of engraved plastic labels) in compliance with CERN standards,

- the hoisting and handling gear necessary for the works, both in the surface and underground,
- the transport of all components and necessary tooling to the worksite, as described in section 2.4,
- the daily cleaning, and cleaning upon completion of the work, of the premises and all the components,
- the protection of all CERN equipment and material against wilful or accidental damage during the installation phase,
- the removal of rubbish and its discharge outside CERN,
- the drafting of documents for approval by CERN's technical services before the execution of the work and their updating in compliance with the work performed before provisional acceptance, including safety documents,
- the training of CERN's operation staff.

The Contractor shall be solely responsible for carrying out the work and for the commissioning of the various installations. CERN's responsibility will be limited to defining the scope of the required supplies and checking the factory and acceptance tests.

The Contractor shall verify the accuracy of the dimensions shown on CERN drawings and report to CERN and correct the mistakes or inaccuracies.

2.2 Items and services supplied by CERN

The items listed below fall outside the scope of the present supply and will be provided by different contractors.

2.2.1 Electric Power Supply

- the lighting inside the USC55, UXC55 and the CV zone,
- the supply of plug-in removable crate power supply cubicles, provided with their control modules following the Contractor's specification for their sizing. To that end, the Contractor shall provide the necessary information to CERN within the dates specified in the provisional schedule (Annex G),
- the supply, installation and electrical connection to the mains of the cubicles and the UIAN control cupboard main switch.

2.2.2 Controls and SCADA (local monitoring)

- The supply and installation of the CERN TCP/IP routed network infrastructure, including the physical media, connection sockets and network parameters (address, gateway, subnet mask, DNS and domain),
- The local supervision SCADA license and associate drivers.

2.2.3 Hydraulics

- the supply and installation of the primary services (pumping station and piping) from the surface, up to a connection point inside the CV zone,

2.3 Items Supplied by CERN

CERN will also provide the Contractor with the following:

- The CV zone situated in the USC55,
- the technical galleries linking the technical caverns to the main experimental cavern,
- the concrete foundations in services and experimental caverns for the plate heat exchangers and motor-pump sets,
- the necessary general site services (one connection point to a drinking water supply and electric power supply 400 V 3P+N+E, 50 Hz, from where the Contractor shall supply his own worksite supply board),
- the supply and transport of the local demineralisers provided with the ion exchange mixed-bed resins,
- the through-wall passage-ways (shown on the tendering drawings) for the passage of the Contractor's pipelines.

2.4 Work Site Location. Handling of Material

The work referred to in this Invitation to Tender is to be done at LHC Point 5 in Cessy, France. The cooling plant is to be built inside the CV zone in the underground service cavern USC55 and experimental cavern UXC55.

The cooling plant will be installed in the CERN-supplied CV zone linked to surface primary facilities via the service shaft PM54 and to the user installations in the main experimental cavern via service technical galleries. It shall contain the plate heat exchangers (PHE), primary control valves, the secondary motor-pump sets, the power supply and the control and local monitoring cubicles and all other accessories.

Personnel access to the underground in general will be via the personnel lift in PM54. Bulky material shall be lowered through the hoistway in the access shaft with the help of a surface 10 t crane. The Contractor shall provide all necessary containers for the safe and efficient handling of the material needed for the installation in the underground.

3. GENERAL CONDITIONS FOR TENDERING AND CONTRACTING

Please refer to the commercial bidding 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. MS/3255/ST/LHC. CERN reserves the right to disqualify any bidder whose reply to this Market Survey is found to have been incorrect.

3.1 Tender Procedure

3.1.1 Pre-tender Discussions

The bidder is strongly encouraged to contact CERN and discuss details of this Technical Specification before making an offer. In particular, CERN wishes to ensure that no doubt exists as to the interpretation of this Technical Specification.

To this end, all bidders' requests for clarification must be addressed to CERN in writing, by fax or by E-mail. CERN will reply to these requests and at the latest 14 days before the tender submission date. The replies will be faxed to all the bidders, together with the relevant questions, without specifying their origin. Through these measures, CERN wishes to ensure that there is no ambiguity in the interpretation of this specification.

3.1.1.1 Compulsory Bidders Conference at CERN

Before tenders are submitted, CERN will give bidders notice to attend a compulsory bidders conference 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 shall attend the bidders' conference.

Each bidder shall be represented by at least one technical 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,
- specifications related to this Invitation to Tender,
- visit to relevant CERN sites,
- questions and answers.

The minutes of the Bidders Conference (including the summary of questions raised and answers given) will be forwarded to all participants.

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 (Annex G).

3.1.3 Subcontractors and temporary personnel

Subcontracting must be limited to secondary tasks. The Bidder shall declare in the 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. If, for some reason, he wants to change any subcontractor, or the scope of subcontracted work, or the amount subcontracted, he shall obtain CERN's prior agreement in writing.

3.1.4 Documents to Submit with the Tender

The Tender and all the accompanying documents must be submitted in duplicate.

In order that his Tender may be considered, the Bidder shall send CERN a parcel package, bearing the reference number of the Invitation to Tender and his own name and address, containing the following:

- Copies of the descriptions and other technical information (technical data sheet) for all the proposed equipment, clearly showing the results of the selection in accordance with CERN specifications and requirements,
- schematic drawings showing the overall dimensions and the weights of the equipment proposed,
- schematic and general assembly drawings (source files or DWG, and PLT formats, according to software used) indicating the layout proposed for the stations and dimensions of the different items and accessories,

- a strength calculation for the piping supporting structures with details of size, weight and fixing of the supports,
- a strength calculation of the concrete foundations,
- a list of the handling and lifting equipment he has available for performing the required work in accordance with the requisite general safety conditions and those applicable to the shafts and underground halls,
- a description of the working methods and protective measures that will be implemented for safety purposes, as well as the equipment and manpower that will be used,
- a detailed schedule for the various phases of the studies, internal tendering and works for each cooling plant,
- a preliminary reliability and risk analysis for the whole of the supply and breakdown analysis according to AMDEC[1] method or equivalent,
- the Unit Price List (UP), completed in full,
- the Tender Form (TF), completed in full,
- the Description and Quantity Estimate(DQE), completed in full.

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.

The Bidder shall submit with his Tender any observations or suggestions he may consider useful concerning the requirements or the drawings. No exceptions to the terms and conditions of the call for Tender documents may be made without a written order signed by CERN. Incomplete Tenders (missing documents or documents not completed in full) and Tenders which do not fully meet the specified requirements will not be taken into consideration by CERN.

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 a week of notification.

3.1.6 Country of Origin

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

3.1.7 Analysis of the Tenders

CERN will evaluate the Tenders in the light of the requirements set out in the Invitation to Tender documents and will not consider Tenders which do not fully meet those requirements, or incomplete Tenders.

3.2 Contract Execution

3.2.1 Responsibility for Design, Components and Performance

The Contractor shall be responsible for the correct performance of all items supplied, irrespective of whether they have been chosen by the Contractor or specified by CERN.

- [1] AMDEC (French): Analysis of the Fault Modes, Effects and Criticality

CERN's approval of the design and component choice does not release the Contractor from his responsibilities in this respect.

CERN assumes responsibility for the performance of items and sub-systems supplied by CERN.

The Contractor shall give proof of having subscribed to an insurance policy covering the extent of the work (see the Tender Form). In case of consortia, the group shall have subscribed to a unique policy for all the activities and members of the consortia involved.

3.2.2 Contract Follow-up

3.2.2.1 Contract Engineer

The Contractor shall assign an engineer to be responsible for the technical execution of the Contract and its follow-up throughout the duration of the Contract.

3.2.2.2 Progress Report

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 shall be sent to CERN every week until completion of the Contract.

3.2.2.3 Design Approval and Production

The detailed design shall be submitted to CERN for approval. CERN will give its approval or refusal, in writing, within three weeks. Component ordering and equipment manufacture shall not start without CERN's written prior agreement.

3.2.3 Deviations from this Technical Specification

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

During execution of the Contract, all deviations from this Technical Specification, the Tender, or any other subsequent contractual agreement, proposed by the Contractor, shall be submitted to CERN in writing for the latter's approval. CERN reserves the right to reject or accept such proposals without justification.

CERN reserves the right to modify this Technical Specification during execution of the Contract. The consequences of such modifications shall be mutually agreed between CERN and the Contractor. All amendments to the Contract shall be made via written addenda. The cost of the change orders (addenda) shall be calculated on the basis of the Unit Price List.

3.3 Factory Access

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, as stated in the Tender, may only be changed after written approval by CERN.

3.4 Site Supervision

During the work, the Contractor shall provide access to the work site to all persons appointed by CERN to supervise the work. He shall appoint a manager to represent him on the work site to supervise the personnel, equipment and the proper performance of the work. This representative shall be in a position to provide CERN with all the information it needs to monitor the work at any working hours and without prior notice. To that purpose he shall be fluent either in English or French.

3.4.1 Interruption of works

Any interruption of the works shall be immediately reported to the CERN responsible and logged by all parties. The Contractor shall prepare a written report indicating the time and description of the incident and the measures to be taken. Once all reservations have been lifted by CERN (written report indicating the consequences and duration of the interruption), work shall resume.

????? CERN cannot guarantee the continuity of the work to be realized. If civil engineering constraints or any other reasons imply a change in the installation programme, the contractor shall adapt its planning according to the new situation. This cannot give the right to the contractor for extra costs or compensations. It could also be asked to the Contractor to carry out the work in the site several times. This cannot give any rights to extra costs or to compensations.

3.5 Manpower and Tooling

Contractor's staff: The Contractor shall provide a list of all his staff working on the CERN sites and their qualifications prior to the start of the work and shall ensure that it is kept available to CERN at all times. The Contractor shall give proof, prior to the start of the works on CERN site, that his staff possess work permits and any other required authorisations, that they are properly registered at CERN's registration office and that they have attended the mandatory safety briefings by CERN fire brigade.

He shall be responsible for the specific training his personnel requires to work in the underground structures and to use the Contractor's own handling gear. The certificates corresponding to this training shall be submitted to CERN.

Replacement of staff: CERN reserves the right to demand, at any time, the immediate replacement of any of the Contractor's staff whose actions, behaviour or legal position with respect to the authorities of the Host Countries and the competent authorities, are such that they could interfere with the proper running of the worksite.

Special tooling and equipment: the Contract shall equip his assembly crew with all the necessary individual tooling and any special equipment such as: scaffolding, ladders and special hoisting gear which they may require during assembly, as well as the instruments needed for the tests. All such equipment shall comply with Host states regulations and shall be approved by a competent official body.

3.6 Assembly

The assembly work shall be done with the greatest care and attention, in accordance with the suppliers' instructions and with normal trade practice.

3.7 Waste Disposal

The Contractor shall dispose all the waste arising from the construction work in the appropriate containers. The Contractor shall mark the material discarded for proper identification. The Contractor shall bear the cost of the processing of the waste should the sorting not be done or done in an unsatisfactory fashion.

3.8 Safety

The safety matters have been presented in chapter 8.

4. TECHNICAL REQUIREMENTS

4.1 Cooling Plant Principle and layout

The cooling plant shall consist of a certain number of individual cooling circuits, each having its own heat exchanger, circulation pumps, temperature control systems and other accessories like expansion vessels, demineralisers or gas separators.

Elements not requiring frequent access for maintenance operations (like demineralised water filters or gas separators) may sit on the station concrete floor, in the false floor space, provided with the necessary access traps. The plant layout proposed by the Contractor shall optimise the different pipelines, in view of the pockets foreseen for their passage in the USC and UXC. No additional pockets on the concrete walls shall be permitted.

The replacement of all demountable elements shall be possible without draining the pipes. All the lines shall be designed to support the expected pressure conditions.

Primary circuits

The supply and return lines of each primary circuit (and the equipment connected to them) in the stations shall be protected against transient surges by means of hydraulic relief valves (discharging to return line) installed at suitable positions.

Temperature sensors (PT100) shall be provided on the primary lines (supply and return) for the monitoring of the station operation.

A number of lines shall convey the primary fluids directly to the users via connections to the primary lines inside the CV zone. These lines shall feature the same safety valves (see section 4.4.7) as the rest of the secondary circuits.

Secondary circuits

These shall consist of independent sets of plate heat exchangers, a twin set of centrifugal pumps, a common expansion vessel for the set of circuits having the same secondary fluid and the necessary filters, instrumentation, water demineralisers and other accessories.

The heat dissipated by the components and ancillary equipment of the detector will be conveyed by the secondary circuits to the primary circuits via the primary/secondary heat exchangers. These plate heat exchangers shall be located upstream, the circulation pumps, thus being subject to the lowest possible pressure on the secondary side, excepting the case of the circuit dedicated to Electromagnetic Calorimeter (ECAL).

The heat exchangers serve a second purpose in the underground cooling station. Due to the depth at the bottom of the shaft, where the service cavern has its zero level (almost 100 m underground), the pressure build-up would lead to unnecessarily high pressure ratings on the secondary circuit piping. This is prevented by the means of the secondary heat exchangers.

Air separators (fitted with air purges) shall be installed in some of the demineralised water circuits, as indicated in the hydraulic schematics of the plant. Automatic air purges (fitted with shut-off valves) shall be installed in all the high points of the secondary piping (and in the local high points of the primary circuits) and on the air separators. Drains shall be installed in all the low points of the pipework to allow the emptying of the circuits to the building drains.

Two pumps per each circuit shall be part of the basic offer for this Tender; one will be used as stand-by pump. The control system shall allow, in the event of failure of the main pump, the switching on and connection of this stand-by pump in an automatic way. The water flow in the concerned circuit shall be re-established within just a few PLC programme cycles. The pumps shall be protected against fluid flow failure, yet allow the occasional passage of air bubbles and the start up operations (by means of time relays).

In the case of circuits whose operation may create important changes in the total capacity required by the users, the Contractor shall install an automatic by-pass valve controlled by a differential pressure transmitter, designed to allow the totality of the pump's flow rate. The circuits concerned are indicated in Annex C.

Temperature regulation shall be achieved by varying the primary flow rate on the heat exchangers via two-way control (regulation) valves. The control of the circuit shall be done via temperature sensors (PT100) installed at suitable positions on both the supply and return lines of each secondary circuit. The Contractor shall calibrate these sensors according to the particular temperature ranges and the length of pipelines.

The demineralised water will be supplied from the demineralised water loop situated inside the underground LHC tunnel. Additionally, a set of local demineralisers shall be used to recycle the circuits' water during the operation, by recirculating a small percentage of the total flow rate, thus allowing to fix small particles which may detach themselves from the metallic surfaces in contact with the fluid during the operation.

The control and operation of the plant shall be completely automatic. Although it is not foreseen to have any operators in the plant, complete means for local control and monitoring of the plant shall be required for running in, the occasional check-ups and maintenance operations.

4.1.1 Characteristics of Components to be cooled

As it is indicated above the elements to be cooled by these stations are the detectors and their ancillary equipment.

The ancillary equipment consists of electronic racks, power converters, laser room, cryogenics and power supply cables, etc. These elements can be either in the services cavern USC55 or in the main experimental cavern UXC55. In the case of circuits with several distribution lines, the Contractor shall provide the necessary balancing devices to allow the correct adjustment of the different branches at the commissioning of the plant.

Table 1 shows the various estimated power requirements of each of the circuits.

Table 1 - Secondary circuits and parameters

Circuit	**Primary circuits**			**Power [kW]**	**Secondary circuits**			**Destination**	**Material**
	Temp [°C]	**Fluid**	**Flow [m³/h]**		**Temp. [°C]**	**Fluid**	**Flow [m³/h]**		
Power supply / bus bars	14-20	Mixed water	20.6	144	18–27.5	Demin water	13.1	USC55 Ground floor	Stainless steel
Yoke Barrel	14-20	Mixed water	8.4	58	18-20	Demin water	25	UXC55, underneath CMS detector	Stainless steel
ENDCAP, FORWARD	14-20	Mixed water	24.4	170	18-20	Demin water	73.1	UXC55, underneath CMS detector	Stainless steel
Muon Barrel	14-20	Mixed water	8.1	56	18-22	Demin water	12.1	UXC55, underneath CMS detector	Stainless steel
ECAL	14-17	Mixed water	119.6	417	18-19.59	Demin water	225	Cooling stations in UXC55	Stainless steel
TRACKER	5-11	Chilled water	23	154	Other call for Tender			Cooling stations in UXC55	
Racks / laser	14-20.5	Mixed water	347	2621	16-22	Mixed water	376	USC55 Counting room/ UXC55	Stainless steel
Cold box/ Cryogenics	14-18	Mixed water	4.5	20.5	No heat exchanger			USC55, UXC55 First floor	Carbon steel
HVAC	5-11	Chilled water	47.3	330	6.5-12.5	Chilled water	47.3	UXC55	Carbon steel
Foam system		Raw water	330	No heat exchanger				UXC55	Carbon steel
Fire fighting system		Raw water	27	No heat exchanger				USC55, UXC55	Carbon steel
Compressed air : -Instrumental air - Air pads - Standard air		39						Gas room UXC55 UXC55	Galvanised carbon steel or Stainless Steel

A. Sub detector cooling circuits:

The CMS detector is composed of one central barrel (YB0) and 4 moving barrels (YB+2, YB+1,YB-1, YB-2). Inside of each wheel there are several elements that need to be cooled. The parameters of the circuits are presented in table 1.

The cooling and purging manifolds will be connected to flexible pipes (passing via cable chains, see chapter 4.1.8 for more details) to which supply and return lines will be connected (see Annex C).

Water will be supplied by the following cooling circuits:

- *Yoke barrel cooling circuit.*

This cooling circuit will supply water to stabilize the temperature inside the Yoke structure. The demineralised water will be supplied by a stainless steel pipe going from the CV zone to the bottom of the detector (via cable chains). There will be 2 supply and 2 return manifolds

for the central barrel and one supply and one return for each moving disk. The connection between manifolds and supply lines will be done via flexible pipes. Each barrel will have one purge manifold (it will be used to purge Yoke and Muon circuits).
This circuit is a copper system; it should not be mixed with an aluminium material.

- *Muon Barrel cooling circuit.*

In total there are 5 barrel wheels that shall be cooled by the Muon cooling system. Each barrel shall be fitted with manifolds for supply, return and purge (shared with yoke cooling circuit). In total there are 3 manifolds for each wheel. All the manifolds shall end at the bottom of each wheel, called diving board with the union with a leak tight seal. The demineralised water will be supplied from the CV zone by stainless steel pipes. The connection between manifolds and supply lines will be done via flexible pipes. This is an aluminium circuit, so it should not be mixed with copper material.

- *ECAL cooling circuit.*

ECAL cooling circuit will cool 5 barrels' wheels and two endcaps. The demineralised water will be supplied from the CV zone by the stainless steel pipe to the gallery UL 551 (see Annex C). The supply and return pipe has to be insulated to avoid temperature variations. The temperature inside the circuit should be kept with very tight precision +-0.05K.
This is an aluminium circuit, so it should not be mixed with copper material.

- *Endcap and Forward cooling circuit.*

The Endcap and Forward cooling circuit will cool 2 Endcaps (3 disks each) and two Forwards. The demineralised water will be supplied by stainless steel pipes via cable chains. There will be one supply, one return and one purge manifold for each disk The connection between manifolds and supply lines will be done via flexible pipes.

B. Other cooling circuits.

- *Power supply and bus bars circuit.*

This cooling circuit will cool power converters situated in the lower level of the USC cavern and 30m long copper bus bars (connection on upper level of the USC cavern should be foreseen by Contractor). The demineralised water will be supplied from the CV zone via stainless steel pipe. This is a copper circuit, so it should not be mixed with aluminium material.

- *Cold box and cryogenics cooling circuit.*

This system will be directly connected to the primary circuit and will cool the cold box and primary pumps situated in USC cavern and the secondary diffusion pumps situated in UXC cavern (see annex C). The water will be supplied by a carbon steel pipe to cold box and the primary pumps. There will be two supply lines and one return passing by a cryo line to UXC.

- *Racks and laser cooling circuit.*

The electronics racks to be water cooled are located in five principal areas:

-racks close to the detector, on the towers attached to the barrel and the endcaps and on the platforms attached to HF (HCAL forward detectors):
-racks situated along the balconies running on the length of the UXC experimental cavern (3 levels),
-racks located on both floors of the USC counting room,
-racks situated above the CV zone,
-racks situated close to the Power supply in USC cavern.

The water will be supplied to the racks above the CV zone, and to those situated close to the Power supply and in the counting room, laser room (booster pumps) and finally to the central part of the UXC cavern (to supply the racks situated on the towers and the balconies).
There will be two types of racks: 56u and 28u. The connection with racks will be done via flexible pipes. The Contractor shall supply those connections.

4.1.2 Secondary Cooling Fluids

Secondary cooling fluid will be demineralised, chilled or mixed water.

The Contractor shall determine the pressure head required for the circuits' pumps on the basis of the piping layout as shown in the drawings (Annex C) and the internal pressure drop of the components, given in Table 2 below, and assess on that basis the required pressure ratings of the circuits and their components. The term *internal pressure drop* refers to the pressure drop created by the end user equipment, measured between the connection flanges at the circuit's nominal flow rate. Similarly, the Contractor shall determine the volume of the expansion vessels on the basis of the internal volume of the end user equipment and that of the pipelines as shown on the drawings Annexd to this Invitation to Tender.

Table 2 Internal pressure drops required

Circuit	**Internal pressure drop (bar), (10^5Pa)**	**Internal volume (m^3)**	**Maximum temperature (°C)**
Power supply/bus bars	4	1.0	25
Cryogenics/cold box	4	0.05	18
Racks/ laser	1/ 4-7	2.6	22
Muon Barrel	5.6	1.88	22
Yoke Barrel	5.9	4.5	20
Endcap/ Forward	4/7	4.9	20
ECAL	1.5	13.5	18
HVAC	1.5		12.5

In some specific cases, for example the cold box/cryogenic circuit, the system will be connected directly to the primary circuits and shall transport the primary cooling fluids to the USC55 cavern. Those lines are shown in the Annex C.

4.1.3 Primary Cooling Circuits

Primary cooling will be made available by CERN at a point inside the cooling plant. The temperatures and naming of these circuits is explained in Table 3 below. All primary circuits use raw water. The linking pipework and accessories on the primary side will be in carbon steel, lagged in the case of the chilled water piping. All piping and accessories shall have a rating PN25.

Table 3 - Primary cooling requirements

Primary cooling	**Mixed water**	**Chilled water**
Flow rate (m^3/h)	547	72
ΔP available (bar) [10^5Pa]	4.1	3.4
ΔT range allowed	14-20 °C	5-11 °C

4.1.4 Primary Water Quality

The Contractor shall take into account the water's composition, in order to assure the correct performance of the equipment. The analysis of the water is given in Table 4, below.

Table 4 Cooling water analysis

TH	34.8 °f[2]
TH Ca	28.5 °f
TH Mg	6.3 °f
TA	0.2 °f
TAC	22.8 °f
Cl^-	20.5 mg/l
SO_4^{--}	118.8 mg/l

4.1.5 High expansion foam system.

This fire-fighting system will protect the CMS detector and its infrastructure in case of a major fire.

Water supply for this system is assured by a surface water tank (160 m^3) connected to the underground cavern by DN200 pipe (supplied by CERN). The bladder (foam) tank will be situated in USC5 cavern. The bladder tank will be connected with foam generators (12) placed in the UXC55 cavern by DN250 stainless steel pipe (L=185m). The scheme of the system is presented in Annex C. The Contractor will supply the pipes needed to connect the components of the foam system. The bladder tank and foam generators will be supplied by CERN.

4.1.6 Fire fighting system.

- <u>Hydrants</u>

There will be several points situated in USC55 and UXC55, equipped with hydrants. Each point shall have a valve with a standard CERN fire-fighting fitting capable of providing of 9 m^3/h with residual pressure 5 bar (500kPa) to be used by fire-fighters to connect to their own flexible hoses. Only the piping is in the scope of supply.

The supply lines shall be capable of supplying at least 3 hydrants at the same time (9*3 = 27 m^3/h). The scheme of the system can be found in Annex C.

- <u>Sprinkler</u>

This automatic fire-fighting system will be used for the protection of the cable ducts in UXC cavern. The scheme of the system can be found in Annex C.

4.1.7 Compressed air systems.

There will be three types of compressed air systems:

- Instrumental air,
- Standard air,
- Air pads (high pressure 30-50 bar (3000kPa – 5000kPa))

The scheme of the system can be found in Annex C.

- [2] 1 °f = 10 ppm of $CaCO_3$ equivalent

4.1.8 Flexible pipes.

Flexible pipes will be needed to connect supply and return lines with cooling manifolds. They shall fulfil the following technical requirements:

- Material: Stainless steel
- Pressure: must support the pressure 2000kPa (pressure tests), maximal work pressure 1100kPa,
- Working temperature: 16 – 25^{o}C,
- Flow speed: max 2 m/s,
- Coolant: demineralised and mixed water,
- Bending radius: about 550 mm (cable chains),

Table 5 Flexible pipes for the CMS cooling circuits.

	Approximate Diameter[3]	Number	Remarks
Yoke -central barrel -moving barrels	 DN32/DN25 DN32	 4 8	Two supply and two return manifolds in the central barrel and one supply and one return for the moving barrels
Muon -central barrel -moving barrel -purge manifold	 DN32 DN25 DN25	 2 8 5	 One supply and one return manifold for each wheel One purge manifold for each wheel (common with Yoke cooling circuit)
Endcap	DN80	6	One supply one return and one purge manifold in each Endcap disk.
Forward	DN15	6	
Racks (towers)	DN20	36	To supply and return pipes for tower racks

The cooling manifolds on the CMS barrel wheels will end with a threaded ball valve (size 2", threads BSP, stainless steel) to which the flexible pipe, fitted with the corresponding connection, will be joined.

The connection between racks and supply/return lines will be done via flexible pipes (length about 20 cm, the connection to the water manifold will be a 3/4" nut).

4.1.9 Special cooling pipes for the Tracker cooling circuit.

The Contractor shall supply the pipes needed to connect the components of the tracker cooling circuit situated in the CV zone to the cooling racks situated in the UX55 cavern. The Tracker cooling circuit is the subject of another call for Tender.

The pipes shall be properly cleaned and tested by the Contractor:

- <u>Cleaning and surface treatment of pipes.</u> The pipes for this system shall be cleaned, degreased, kept free from the contamination dirt, welding scale and oil on the inside as well as outside and capped, according to the DIN25410 grade 2.
  The proposed cleaning procedure shall be approved by CERN.

- <u>Leak tests.</u>

- [3] to verify and correct by the Contractor before realisation

All welds shall be tested with internal helium pressure and sniffers placed in plastic wraps around the welds. The leak rate of 1.10-7millibars/litres.sec will be accepted. The test procedure is subject to approval by CERN.

4.2 General Description

4.2.1 Unit Price List

The Bidder shall provide, along with the unit prices, technical descriptions of the items listed in the Unit Price List (UP).

The Unit Price List shall be used in the DQE, for information and for the costing minor changes.

4.2.2 Schematic Diagrams

The schematic diagrams of the circuits subject to this Technical Specification can be found in Annex C, Drawings.

4.2.3 Labelling of equipment

All fixed components (pumps, motors, filters, heat exchangers, valves, emergency stops, etc.) shall be identified by means of engraved plastic labels specifying the equipment ID code (see Annex C). The label shall be submitted to CERN for approval.

4.3 Mechanical Design and Requirements

4.3.1 Materials

All materials and components used in the construction shall be new and suitable for the use for which they are intended. The choice of any non-metallic material shall be in accordance with the CERN Safety Instruction IS41.

The material for the pipes shall be certified by batch and the cast numbers are to be transferred to the material used before cutting from the stock in the presence of an independent inspection authority. Inspection certificates for longitudinal welds in pipe material will be required.

The equipment and the choice of components shall be adapted to the operating conditions of the pipes, the pressure ratings and the design pressures of the fluids inside the components. Temperature variations shall not give rise to uncontrolled stresses.

Components in contact with demineralised water shall be made either in AISI 304 stainless steel or carbon steel with a suitable lining on the water side, unless specified otherwise.

Stop valves shall be designed to resist the highest pressure delivered by the pump while having no pressure on the other side.

In any case a study of the electrochemical behaviour should be performed to avoid any corrosion risks.

The specifications for the materials and equipment will be subject to approval by CERN.

4.3.2 Reliability and Risk Analysis

The Bidders shall provide with their bids, as stated in 3.1.5, a preliminary reliability, risk and breakdown analysis for the whole of the supply based on the following criteria:

- Reliability MUT[4]>10,000 h
- Repairability MTTR[5]<2h
- Availability > 99.98 %

The analysis shall identify risks and safety features to implement. The breakdown analysis shall be performed in accordance with the AMDEC method or an equivalent one.

4.4 Technical Description of Components

4.4.1 Technical Requirements for Piping (and Welding)

All the equipment supplied shall correspond to the special technical specifications set out in Annex A, "Particular Specifications –Piping and Accessories".

4.4.1.1 Welders' Qualifications

To assure the quality of the welding, the following rules and recommendations shall be respected. Welding work shall only be done by highly qualified and certified welders. They shall be authorised to work in accordance with the note TIS/TE/MI/CM 00-14 "Recommendations for on-site installation of welded pressurized pipelines".

The Contractor shall prove the good manufacture of the welds. The choice of method shall be adapted to give reliable results, see CERN TIS/TE/MI/CM 0014 and BS TIS 91-03(Specifications for X-raying welds). The non-destructive test plan shall be submitted to CERN for approval. Other tests may be required by CERN in case of doubt. Circumferential welds and longitudinal welds in pipework shall be tested at not less than 10%. If faults are discovered, CERN or the inspector may require additional analyses, up to 100%, if necessary.

The acceptance of weld flaws shall follow the European standard EN25817, except in respects of the second type (Table 1, ISO 6520 reference, requirement D), which shall not be tolerated.

The number of welds in the pipes, elbow, etc shall be minimized.

4.4.1.2 Special Requirements and Installation

In addition to the requirements of the codes of practice and operating conditions specified above, the Bidder shall conform to the following special requirements:

- The inside of the pipework has to be clean, degreased and free from contamination, dirt, welding scale and oil,
- metric dimensions shall be used for bolting,
- all other requirements set out in Annex A.

4.4.1.3 Nominal Pressures and Sizes of the Pipes

All pipes and fittings and all system components (valves, etc.) shall be designed for the nominal pressure of the piping on which they are fitted or to which they are connected.

- [4] Mean Up Time
- [5] Mean Time To Repair

All water pipes and valves for which the diameter is not specified on the hydraulic diagrams shall be dimensioned by the Contractor, respecting the following maximum permissible water velocities:

	<DN20	DN20>DN50	DN65	DN80	DN100	DN125	DN150	DN200	DN250
V_{max} (m/s)	1.0	1.2	1.4	1.5	1.7	1.9	2.0	2.3	2.5

4.4.2 Technical Requirements for Motor-Pump sets

4.4.2.1 Pumps

The pumps shall be selected from the intermediate range of operation curves (head v. flow-rate), avoiding to select either the smallest (for efficiency reasons) or the largest impeller wheel (to allow the possibility of future extensions of the system).

Horizontal volute-type chemical process centrifugal monostage pumps shall be used for the secondary distribution circuits. They shall have oil lubricated ball or roller bearings housed in a sealed casing separated from the water cavity.

The discharge flange shall be oriented upwards and its design shall allow dismantling of the pump completely without disconnecting and removing the motor.

The pump/motor assemblies shall be provided with their CE conformity certificates specifying noise power emissions.

All pumps supplied shall have the same sense of rotation. The coupling section shall have an easily removable protective guard preventing accidental access to the moving parts. Pressure gauge taps on the suction and discharge flanges as well as oil cup in the oil reservoir shall be provided.

All parts in contact with demineralised water shall be made of stainless steel. Parts subject to wear, like wearing rings, may be made of zinc free bronze.

The pressure head delivered shall be calculated by the Contractor to match the circuit pressure drops for the nominal capacity. To that end, the required pressure head required for each component is given in Table 2.

What shall have negative slope all through the operation range and the difference between the discharge side head at shut-down (zero flow-rate, H_o) and the discharge side head at the nominal flow-rate (H_{nom}) shall be within 0.3 H_o.

The suction side required head (NPSH) shall be calculated by the Contractor on the assumption that the expansion/pressurisation vessel is at atmospheric pressure, and allowing a safety coefficient (NPSH available/NPSH required) of at least 2.

No strainers on the suction side of the pump will be necessary. The pumps discharge lines shall be provided with check valves, which will allow the instantaneous re-start of the pump in case of need.

Pumps for flow-rates above 50 m^3/h shall have efficiencies at least of 75 %.

The **demineralised water pumps** shall have the following characteristics:

- Standardised to EN 22858
- Entirely removable internal components, consisting of standardised sub-components
- Materials (see section 4.3.1):
  - Casing: stainless steel (AISI 316 or corrosion resistance equivalent).

  - Impeller: stainless steel (as above).
  - Shaft: stainless steel, jacketed (as above).
  - Bearing: cast iron.
  - Base: steel or cast iron.
- Curves (flow/pressure): to ISO2548 and ISO 9906 Class 2
- Plummer block bearings: C3 class aircraft-type
- Bearing lubrication: Oil sump
- Moving parts: Static and dynamic balancing, bench tested
- Mechanical seal: Burgmann (or similar) seal set
- Coupling: Escodisc (or similar) disc-and grommit flexible type
- Max. rotation speed: 1450 rpm.

The **other pumps** shall have the same specification, with the exception of the material for the pump casing, which shall be in nodular cast iron, and the type of sealing, which shall be of the packing type (fabric interbraid packing adapted to the working conditions) or mechanical sealing adapted to the quality of the raw water. The impeller material shall be bronze.

For the **laser cooling circuit,** the booster pumps or of similar type shall be used (pumps in-line will be accepted).

4.4.2.2 Motor

All pump motors shall be of the three phases, squirrel cage induction type, wound for 400 V and direct starting. They shall be compatible with the powering via variable frequency drives.

Attention must be paid to the rather high ambient temperature to which they may be subjected.

- Type: asynchronous, 3 phases
- Standardisation: to IEC
- Construction: Standard
- Rated power: Calculated for maximum permissible flow-rate + 10%
- Voltage: 400 V if nominal engine rating is < 300 kW
- Internal protection: by thermal switch
- Ingress protection: IP 55
- Starting: Direct if rated power = 160 kW (electronic starter if rated power > 160 kW).
- Max. rotation speed: 1500 rpm.
- Frequency: 50 Hz
- Insulation class: F
- Service type: to IEC 34.1 S1.

Electromagnetic pollution levels shall conform to the prescriptions of IEC 61000 and 60439 and EN 55011. Each pump shall be fitted with a local emergency stop push-button within 1 m of the motor, in a readily accessible location (e.g. on metallic posts attached to the concrete plinths, at a height of 1m -1.2 m).

4.4.2.3 Supporting Chassis

The chassis shall be made of carbon steel or cast iron. It shall be bolted to the concrete foundation block (not embedded in it). An appropriate system to reduce the vibrations shall be foreseen. The motor shall be fixed to the chassis in such a way that the correct alignment of the motor-pump set can be easily ensured (i.e. with the help of a push-screw acting on one of the motor feet). The chassis shall allow the collection of water, which shall be discharged to the drains.

4.4.3 Technical Requirements for Filters

Each secondary circuit shall be provided with filters on the return line (demineralised or mixed water), upstream the heat exchanger. The water make-up line shall also be fitted with filters. The filters shall be fitted with stainless steel woven wire screens. The mesh size shall be 20 µm for the demineralised water circuits (80 µm for the other water circuits), in order to retain metallic particles, which may have been taken away from the surface of pipes or fittings. Their pressure rating and working temperature shall be determined by the Contractor, based on the operation parameters.

The maximum pressure drop allowable shall be 50 kPa when foul (20 kPa when clean) at the nominal flow-rate. To monitor the pressure drop, they shall be fitted with differential pressure transmitters (PDSH), which shall provide an alarm signal when the pressure drop threshold is exceeded. All filters shall be provided with drains and purges.

The minimum screen surface shall be at least 100 times the free cross-section of the connecting pipework.

4.4.4 Technical Requirements for Heat Exchangers

All exchangers shall be of the plate type. All parts in contact with demineralised water shall be in a corrosion resistant stainless steel (AISI 316 or equivalent). The water passages shall be arranged in counter flow pattern for each particular heat exchange or group of heat exchangers.

The theoretical exchange surface required shall be increased by 10% at least to allow for possible fouling in service. The frame and compression system shall be of ample size to allow later increases in the initially installed number of plates of at least 30%. The compression bolts and plate shall be designed to guarantee perfect tightness at the design flow-rates and inlet pressures. It must be kept in mind that the actual service pressures on the primary and secondary sides may be quite different (Annex B, “Tests and Inspections”). The compression bolts shall be given a coat of protective grease and covered with a highly visible phosphorescent colour plastic sleeve (halogen-free material). Each exchanger shall be provided with manometers, thermometers and cleaning manhole at each water connection.

The main characteristics of these plate heat exchangers shall be:

- Counter flow type,
- all connections provided with stainless steel nozzles,
- minimum thickness of plates 0.5 mm,
- glue-free gaskets.
- Scaling factor
  - Primary circuit: in accordance with table 4.
  - Secondary circuit: none for demineralised water, in accordance with Table 4 for raw water.

- Nominal pressure: PN25
- Pressure loss: max. pressure drop 80 kPa at max. flow-rate on either side.
- Frame material: Carbon steel (painted, colour blue RAL5012).
- Plate material: AISI 316 Stainless steel.
- Seals: Nitrile.

4.4.5 Technical Requirements for Expansion Vessels and Air Separators

The expansion vessels shall be made out of cylindrical shells with dished heads welded to each end, made of low carbon steel with all inner surfaces lined with a synthetic resin. The latter requirement also applies to the construction of air separators. All the vessels shall be horizontal. Each set of circuits having the same secondary fluid shall share a unique expansion vessel (or set of vessels if required), which shall be connected to the circuit in the vicinity of the suction side of the pumps. The connection shall be provided with a calibrated check valve to prevent any major back flow but allowing the ingress of water in the vessel in case of thermal expansion of the liquid in the circuits.

The Contractor shall determine the size of the expansion vessels on the basis of the data given in this Technical Specification (volume of circuits and operation temperatures). The expansion vessels shall be pressurised with compressed air. The expansion vessels for the demineralised water circuits shall be equipped with a bladder.

The expansion vessels shall be provided with a manhole for inspection and cleaning (in accordance with Safety Code A4 Rev.- Confined spaces), and feature feet and supports, drains and purges –where applicable, connections, stop valves, pressure relief devices and, in addition, the following components which form part of the control and regulation system:

- Level transmitter for the control of the water level providing the signal which shall indicate the following levels:
  - Level too high (which shall stop the circuits served by the expansion vessel),
  - Level high, which shall stop the filling of the vessel with make-up water,
  - Level low, starting the filling of the vessel with make-up water,
  - Level too low (which shall stop the circuits served by the expansion vessel).

  The control system shall actuate the automatic On/Off make-up valve upstream the expansion vessel from the general local demineraliser.

  It shall be installed with a sight glass, of the adequate length.
- Differential pressure transmitter (4-20 mA output signal) for the control of the gas (N2) pressure, in the case of the demineralised water vessels. It shall provide two alarm signals for the low (nitrogen leak) and high pressure (safety on the closure of the make-up valve) levels.
- Level switch (On/Off signal) to provide a safety (should the level transmitter not function properly) for the “Level too low” signal
- Level sight glass.

All pressurised vessels shall be fitted with relief devices to prevent uncontrolled build-up of the pressure in the circuit. These shall be mounted on a 3-way cock which will allow the isolation and dismantling of any one of the two pressure relief devices for calibration whilst still running the plant with the due protections.

4.4.6 Technical Description of the Local Demineralisers (CERN supply)

The demineralisers will be of the cartridge mixed-bed type, contained in vertical cylinders with dished-heads welded to each end, and shall be supplied by CERN.

The cartridges shall be connected to the circuits by the Contractor via flexible stainless steel hoses (braided) via quick connectors (according to standard NF E 29 572) for normal service and regeneration. Each connection shall have its own stop valve. The cartridges shall sit on concrete plinths.

The demineralisers will treat the water from the secondary circuits ensuring that the necessary fraction of the total flow-rate of the individual circuit will be by-passed through these demineralisers..

On the discharge side of every local demineraliser, the Contractor shall install a water conductivity transmitter (4 to 20 mA output signal plus an On/Off "*Conductivity too high*" alarm signal) to monitor the quality of the demineralised water in the circuits.

4.4.7 Technical Requirements for Control Valves

The control valves shall be manufactured in accordance with ISO 5752, and fitted with flanges (or sandwich type) with normalised ISO dimensions. The use of similar valves to the makes proposed below shall be approved by CERN at its sole discretion. They shall have the necessary pressure and temperature ratings (according to the circuit) and be of a modern design for reduced vibration, noise and cavitation. The body of the valves shall be flanged. They shall have the following characteristics:

- Equal percentage characteristics, fitted with hand wheels and pneumatic actuators (the Contractor shall determine the power supply characteristics on the basis of the torque required) controlled by a 4 to20 mA input signal.
- They shall remain open upon failure of the power supply. The actuator shall be designed to close the valves against the primary circuit design pressure.
- Selected with sufficient authority (0.3 through 0.5) without creating unnecessary pressure drops.
- Installed downstream stop valves which shall allow the replacement in case of breakdown without requiring the draining of the circuit,
- Maximum noise level 80 dB(A) at 1 m. distance for any opening. Maximum leakage admissible 0.001 Kvs.
- Materials: body nodular cast iron (external epoxy paint). Seat and plug in stainless steel. All gasket material asbestos and halogen-free.
- The Contractor shall provide all necessary fittings (tapers, etc.) for their installation.

The several locations where control valves shall be required are:

- Primary side of the different circuits heat exchangers (type Masoneilan or similar),
- By-pass line of the two primary cooling circuits in the CV zone (type CLA-VAL or similar),
- By-pass line in the secondary cooling circuits HVAC, Racks and Bus Bar / Power Supply. The control valves are type CLA-VAL or similar.
- Balancing valves (TA® or similar quality) for balancing the different take-offs of the Racks circuit.

- Expansion vessels make-up water (On/Off operation),
- Emergency valves (On/Off operation).

4.4.8 Technical Requirements for other Devices

In addition to the instrumentation described for the expansion vessels and local demineralisers, the following items are required. The list of items that follows is in no way exhaustive and the Contractor shall include in his Tender any items that he deems necessary for the proper operation of the plant.

4.4.8.1 Flow Rate Measurements on Demineralised and Raw Water Lines

Flow rate measurements are required on the demineralised and raw water lines, for monitoring and control. This shall be done via a static sensor (calibrated orifice plate, Pitot tube or other), which shall be fitted on the supply line of each cooling circuit. This will be needed for calibration of any electronic measurements and initial testing. Pressure connections up to a selector manifold, provided with the necessary taps and connections (e.g. for a U-pipe type manometer or any digital device) shall be provided. The differential pressure transmitter (4-20 mA output signal) shall be provided with square root calculator.

4.4.8.2 Leak Detection Devices (WLD)

To prevent uncontrolled water spillages, which could damage the detector components, means to detect even minor leaks in a short time, shall be provided. This shall be achieved by measuring the flow (by means of a suitable device) from the expansion vessels to the circuits. The supply line connecting the common make-up water line from the vessel to the pumps suction side shall be fitted with a leak detection device (0 to 3 m^3/h range rotameter fitted with a magnetic float and adjustable contact with On/Off output signal to control system).

4.4.8.3 Emergency Valves

Automatic emergency valves shall be installed in both the supply and return lines of each cooling circuit, close to the exit of the CV zone. These are intended to stop leaks when detected by the leak detection devices by closing and shutting off the circuits.

They shall close in the event of failure of any kind. Both manual and automatic operation shall be provided, and they shall not give rise to pressure surges themselves due to a too fast closure. They shall be provided with limit switches to indicate the correct opening and closure of the valves.

4.4.9 Technical Requirements for Steel Structures

The Contractor shall supply and install all the supports necessary. The studies for the sizing of the structure are the responsibility of the Contractor. The weight of the supports shall be minimized. The grating boards shall be attached to the structure by means of the necessary brackets. The sizing and installation of the whole shall take into account the build up of stresses due to the loading or thermal expansion of the assembly.

The steel profiles used for the construction of the structure shall be, after cutting, properly ground and smoothed to avoid sharp edges. Cutting by flame in underground caverns is excluded. After installation, the structure shall be given an anti-rust paint and a final coat of aluminium paint.

All drilling into the concrete walls for fixing the structure shall be the responsibility of the Contractor.

The grating boards shall be made of hot dip galvanised steel, of dimension 1320 mm x 1000 mm x 25 mm. The mesh size shall be 33 mm x 33 mm and the load capacity 500 kg/m^2, (except for an access path for trolleys to roll on, from the CTR entrance to the location of the motors and cartridges, where the capacity shall be 1,500 kg/m^2). Boards needing cutting on the work site shall receive a cold galvanisation treatment afterwards. The fire resistant non conducting floor tiles around the power supply boards shall also have a load capacity of 500 kg/m^2.

The Contractor shall also supply and install the local monitoring station in the CV zone.

4.4.10 Technical Requirements for Electrical Components

The equipment shall comply with the safety and technological standards listed in § 5. "Applicable Documents". All prescriptions covering electricity matters are provided in Annex D. Information on the general power supply by CERN and the way to fix cable trays to the concrete plinths in the station is given in the schematics in Annex C.

4.4.10.1 Power Supply Cubicles

The low voltage cubicles shall be of the plug-in-rack type and will be supplied to the Contractor by the CERN electrical service. 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 Annex G. It is of the utmost importance that this deadline is respected in order to meet the contractual manufacturing delay of the cubicles.

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

- Sizing the 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.

Power supply cubicles shall conform to the prescriptions given in Annex D.

An indicative list of outgoing feeders is given in Table 6, where *P* is the CERN estimated power in kW for the components that have to be sized by the Contractor.

Table 6: UIAC-00565 (USC55)

P	*Component*	*Circuit*
2x7.5	pumps	Power supply
2x7.5	pumps	Yoke Barrel
2x37	pumps	ENDCAP, FORWARD
2x7.5	pumps	Muon Barrel
2x132	Pumps	ECAL
2x55	pumps	Racks
2x7.5	pumps	HVAC

4.4.11 Technical Requirements for the Control Cubicle

The Contractor shall supply and install the control cubicle, housing the twin PLCs referred to in §4.4.13 and the SCADA PC, as well as the terminal blocs and the necessary accessories (power supplies of all sensors, transmitters and actuators). The control cubicle shall conform to the prescriptions given in Annexes D and E.

4.4.12 Technical Requirements for Instrumentation

All the sensors and actuators required to operate the process shall be included in the Tender. For a complete list and their naming, see the "Instrumentation Schematic", Annex C and the Unit Price List –UP. The pressure ratings, materials and temperature operation range shall be adapted to the particular use of each transmitter and its environment. The use of similar instrumentation to the makes proposed shall be approved by CERN at its sole discretion. The electrical characteristics shall meet industrial standards. In particular, this equipment shall have excellent vibration resistance and be designed to operate in the following extreme conditions:

- Temperature 0 to 50 °C
- Humidity 0 to 90% without condensation.

On/Off sensors/switches

CERN proposes material from Khrone®, Endress+Hauser® or of similar quality. The control and electrical racks shall be dimensioned and fully equipped to integrate the zero-potential contacts. These shall include:

- Level switches (e.g. pressure sensor or probe for conducting liquids) for the "level too low" safety function in the expansion vessels,
- Level switches for the raw water expansion vessels with four output signals (too high, high, low and too low),
- Leak detection devices, (0 to 3 m^3/h rotameters) provided with adjustable magnetic float contact,
- The thermostats for all motors,
- The fault status switches associated to the motors,
- The hand-operated equipment security stop push-buttons,
- The flow, pressure, temperature, …, switches,
- All the applicable "power on" switches,

Electro valves

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

Analogue sensors/transmitters

Voltage 24 V - D.C. with electrical isolation

Conventional 4 to 20 mA output signals.

Precision is required to be > 0.5% of the scale measured. Easy calibration and configuration. Process quality.

CERN proposes material from Khrone®, Endress+Hauser® or of similar quality.

These include:

- Level transmitters (e.g. of the capacitive type) or differential pressure transmitter for the level in the demineralised water expansion vessels,
- Pressure transmitter for the nitrogen pressurisation system of the expansion vessels, with two On/Off output signals for the too high and too low pressure alarms,

- Differential pressure transmitters with one On/Off output signal for the pressure drop alarms in filters, with local display,
- Water meters for overall water consumption on the expansion vessels, with local display,
- Conductivity transmitters giving in addition an On/Off alarm signal for the too high conductivity alarm (special attention is to be paid to the proper cabling of this transmitters for adequate shielding, etc.),
- Orifice plate flow-rate measurements with differential pressure transmitter with square root calculator,
- Temperature probes PT100 suitable for use in pipe wells in piping for the control of the temperature setting of each circuit, allowing for line compensation (4 leads), provided with signal converters.

Other instrumentation

- Bourdon Tube manometers, fitted with stopcocks are to be installed at the discharge and suction side of each pump, on each connection of the heat exchangers and on the single body filters,
- Liquid in glass thermometers, for use in pipe wells on each connection of the heat exchangers.

ECAL cooling circuit specific requirements

The ECAL cooling circuit presents specific requirements in terms of temperature measurement at its secondary circuit. The Contractor shall consider these restrictions when selecting the sensor and transmitter.

- A relative precision in the measurement of ±0.01 K over the operating range (15 to 25 ºC) is required.

The Contractor shall consider these restrictions when selecting the sensor and transmitter.

4.4.13 Technical Requirements for Control Systems and Local Monitoring (SCADA)

Programmable Logic Controllers (PLC), Schneider shall be used to comply with CERN internal recommendation, to 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). A redundant PLC solution (composed of two sets of CPU and power supply) with Modbus Plus decentralised I/O modules shall be installed for availability reasons.

All prescriptions covering control and monitoring matters are provided in Annex E.

ECAL cooling circuit specific requirements

ECAL cooling circuit presents specific requirements in terms of temperature regulation at its secondary circuit.

- The operating point must be maintained with a precision of ±0.25 K.

The Contractor shall consider these restrictions in the design and implementation of the regulation loop, including the calculation, simulation, tuning and validation of the PID regulation parameters.

4.5 Technical Requirements Regarding Noise

The levels of noise pressure at any point inside the CV zone shall not exceed 85 dB, under any operating condition. The level outside the CV zone, measured at 1 m from any point of the room shall not increase by more than 10 dB when the cooling plant is running, under any operating condition. The Contractor shall take all necessary precautions to meet these values when selecting the equipment. Should the maximum values indicated by CERN be exceeded, the Contractor shall propose alternatives measures to CERN for approval (palliative measures such as sound-proof casings around noisy equipment, like pumps, will not be accepted). If these measures are found unsatisfactory by CERN, the Contractor shall, at his own expense, replace any items necessary to meet CERN specifications.

The same limitations apply to the transmission of noise or vibrations through the pipework. The Contractor shall install the necessary vibration and shock absorbers as to insure that none is transmitted outside the CV zone to the rest of the USC55 or the UXC55.

4.6 Information and Documentation Management

4.6.1 Manufacturing Drawings

Manufacturing drawings prepared by the Contractor for the execution of the contract shall comply with the procedure defined in chapter 8 of the LHC QAP document No LHC-PM-QA-306, “Drawing Process-External Drawings”.

4.6.2 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". The Contractor shall take into account on site the regulations of CERN’s Host States in what regards working hours regulations and the working calendar.

4.6.3 Quality Control Records

All specified tests and measurements carried out during all stages of production, from raw material procurement up to delivery and installation must be recorded in specific files, collected in the MTF (Manufacturing and Test Folder), according to the procedure defined in the LHC QAP document No LHC-PM-QA-309.00, "Fabrication and Inspection of Purchased Equipment".

5. APPLICABLE DOCUMENTS

Please refer to the cover letter or Instructions to Bidders for the complete list of enclosed documents, which form part of this Invitation to Tender.

Please note that the quality assurance documents, CERN standards and Purchasing documents referred to in this Technical Specification are on the enclosed CD-ROM entitled "CERN Official Documents".

The supplies and assembly work shall comply with international (ISO, IEC) 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.

5.1 Standards

The applicable standards shall be the ISO international standards or the EN European standards; should the above not exist, the standards of the CERN Member States shall be taken into consideration.

5.1.1 CERN Safety regulations

CERN expects the Contractor to attach great importance to compliance with the safety regulations, by which he is bound, and to implementing, without restriction, all the appropriate safety measures to prevent personnel suffering accidents and professional illnesses, to avoid damage to equipment and to protect the environment. He shall take account of these considerations in his Tender. If new regulations come into force during the work, the Contractor shall be required to refer them to CERN in writing.

Attention is drawn to the fact that CERN has specific rules concerning safety regulations applicable to works of Contractors at CERN, access to and activities on the CERN site, occupational health and safety on the Organisation's site and special health and safety matters.

- The safety regulations, ref. CERN/TIS/GS/98-10, dated May 1998,
- PG: General requirements (ST/IE, December 1994),
- Safety code A2 - Reporting of accidents to the TIS Division,
- Safety code A3 - Relating to safety colours and safety signs,1992,
- Safety code A4 - confined space,
- Safety code A6 - The two-person rule of working,
- Safety code A8 - Relating to protection against noise,1993,
- Safety code C1 - Electrical safety,
- Safety code D1 - Relating to lifting equipment,
- Safety code D2 - Relating to pressure equipment,
- Safety code E - fire protection, 1995,
- Recommendations for on-site installation of welded pressurized pipelines and welders qualification, TIS/TE/MI/CM 00-14, June 2000,
- Organisation of the installation work of the LHC and its experiments, LHC-PM-IP-0001, rev. 1.1, 2002 edition,
- Safety instruction IS 5 relating to emergency stops, 2001,
- Safety instruction IS23 Rev. 2 relating to criteria and standard test methods for the selection of electric cables and equipment from the point of view of fire safety and radiation resistance (1993),
- Safety instruction IS24 Rev. covering regulations applicable to electrical installations (1990),
- Safety instruction IS37 Rev. 2 covering regulations applicable to alarms and alarm systems (1998),
- Safety instruction IS41 relating to the use of plastics and other non-metallic materials at CERN from the point of view of fire safety and radiation resistance, 1995.

The safety codes and instructions can be found at:
http://tis-div.web.cern.ch/tis-div/TIS-site/tis_pages/frame_documents.html

5.1.2 International Standards

- 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,
- IEE 802.3 concerning Ethernet,
- EN 22858 on centrifugal process pumps,
- EN 25817 on welding,
- ISO 9660 CD concerning the writing of information on CD ROM,
- ISO 10628 "flow diagram for process plants – general rules",
- ISO 1127 on stainless steel tubes,
- ISO 4200 concerning stainless steel piping,
- ISO 9906 on pump performance,
- ISO 3744 on noise power measurements,
- ISO 5251 on stainless steel butt welding
- ISO 5252 on steel tubes tolerances,
- ISO 2604-5 on steel products for pressure purposes,
- ISO 5752 on metal valves in flanged pipe systems,
- Eurocode 3 concerning the design of steel structures.

5.1.3 National Regulations

- Standard NF C 15-100: Standard used by the Office of Controls and Inspections prior to acceptance,
- Standard NF E 29-572 concerning Guillemin® system symmetrical connectors,
- Standard NF S 31-010 concerning the characterisation and measurement of noise,
- Articles R48.4 and R48.5 of the public health code,
- DIN 2633 as above, PN16
- DIN 17440 concerning delivery conditions for stainless steel parts,
- DIN 1626 on welded circular unalloyed steel tubes,
- DIN 1629 on seamless circular unalloyed steel tubes.

5.1.4 Other Documents

- The assembly and maintenance instructions provided by the manufacturers,
- ESA-PSS 05 Software Engineering standards, ESA Board for Software Standardisation and Control, 1994,
- H. Laeger, P. Ninin, "TDS Tagnaming Convention (Annex 1 to TDS ICD)", CERN ST/MC/96-12A1
- D. Blanc et al., "Recommendations for the Use of Programmable Logic Controllers (PLCs) at CERN", 1998,

- L. Guerrero, "Guidelines for Integration of PLCs in CERN Services Network", 2000,
- M. Batz, "TCR Control Strategy and Alarm Integration Procedure", CERN ST/MO/99-18, 1999,
- E. Lienard, “TCR Control Desk Procedure”, CERN ST/MO (2000-10), 2000,
- P. Sollander, “ST User Interface Conventions”, CERN ST EDMS 366286, 2003.

6. QUALITY ASSURANCE PROVISIONS

The Contractor shall 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.

Please note that the quality assurance documents, CERN standards and Purchasing documents referred to in this Technical Specification are on the enclosed CD-ROM entitled “CERN Official Documents”.

The list of relevant topics covered by the LHC Quality Assurance Plan, together with the corresponding documents, is given in Table 5 below.

Table 7 - LHC QAP topics and documents

Topic	Document Title	Doc. Number
Policy and Organisation	Quality Assurance Policy and Organisation	LHC-PM-QA-100.00
	Glossary, Acronyms, Abbreviations	LHC-PM-QA-203.00
Planning	Planning and Scheduling Requirements for Institutes, Contractors and Suppliers	LHC-PM-QA-301.01
Design	Quality Assurance Categories	LHC-PM-QA-201.00
	Design Process and Control	LHC-PM-QA-307.00
	Drawing and 3D Model Management and Control	LHC-PM-QA-305.02
	Drawing Process-External Drawings	LHC-PM-QA-306.00
Change Control	Configuration Management – Change Process And Control	LHC-PM-QA-304.00
Manufacturing and Inspection	Manufacturing and Inspection of Equipment Handling of Non-conforming Equipment	LHC-PM-QA-309.00 LHC-PM-QA-310.00
	LHC Part Identification	LHC-PM-QA-206.01

7. DOCUMENTS TO BE PROVIDED

7.1.1 Before Starting Work

The Contractor shall send CERN, for approval, two paper copies and one electronic copy of the documents listed below:

General documents:

- An organizational chart detailing the staff seconded to execute the contract covered by this Invitation to Tender,
- the procurement programme for the raw materials (pipes) and sub-contracted equipment,
- a detailed schedule of the submission of documents, manufacturing, factory tests, deliveries, assembly, tests, commissioning and acceptance, in accordance with CERN's provisional schedule,
- 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 E),
- the request for approval of sub-contractors, where applicable,
- the methods for installing and assembling the components of the installations,
- the Special Safety Plan (PPSPS),
- 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 E)

Drawings, diagrams, design study:

- The working drawings, manufacturing drawings, general and detail isometric drawings of the planned installations,
- the complete technical documentation of the proposed equipment (including noise reduction equipment if foreseen),
- the weight and dimensions of each of the components of the supply,
- the complete list and layout of concrete foundations including dimensions and loads,
- the design study (hydraulics, pumps sizing, pipelines supports, power supply cubicles, PLCs, etc.) drawn up by the Contractor. The Contractor is required to supply all the design study needed for installation,
- the presentation of the materials certificates to be approved by CERN,
- 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,
- 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 E),
- the network connections and field-bus cabling drawings showing the position of the connection sockets

The Contractor shall supply the working drawings in the form of AutoCAD files containing all the equipment in 3D so that CERN may check that there is no interference with the work of the other trades involved. Electrical drawings shall be supplied in Trace-Elec ®.

7.1.2 Approval of Drawings and Other Documents

CERN will be responsible for co-ordinating the documents provided by the Contractor from the point of view of links with the other trades.

Where appropriate, it will inform the Contractor of any amendments needed.

Two paper copies and one electronic copy of the amended drawings shall be submitted four weeks before the equipment is delivered.

For the purposes of manufacture and work on the site, the Contractor shall use only documents stamped "*approved*" and signed by the CERN engineer in charge.

Approval of these documents in no way releases the Contractor from his responsibility to ensure that his installations meet all the requirements.

7.1.3 Prior to Acceptance

For each cooling plant, the Contractor shall send CERN, three weeks prior to acceptance, four paper copies and two electronic copies of the following amended as-built documents:

- The updated versions of the above-mentioned documents,
- the results of the hydraulic tests, performance tests, etc.,
- the materials certificates of the various components,
- the commissioning report, including all the regulation parameters,
- the list of equipment, including the reference numbers of the spare parts and suppliers' addresses,
- the operating, maintenance, emergency repair and preventive and systematic maintenance instructions,
- the complete technical data of the components in electronic format (MS Excel), according to CERN templates (to be provided at a later stage), for storage in CERN's CAMM system,
- the Contractor shall enter the technical parameters of the installations' components on Excel-type templates supplied by CERN for CERN's CAMM software in accordance with the coding system of CERN's quality assurance plan,
- 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 E),
- the document called "On site Installation (Static and Dynamic) Tests", along with the tests schedule, the list of hardware and software components concerned and the necessary schematic diagrams,
- 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 E),
- for each control cubicle, all the documents showing how the automatic unit and the input/output modules are organised, reference to the various functional sub-units, the type of signals used, the various power supplies and associated protective devices.

A laminated diagram in the conventional colours code stuck on a rigid board shall be fixed on each control cubicle supplied by the Contractor, pinpointing all the components to facilitate understanding of the installation's operating handbook.

7.1.4 On Completion of the Work (lifting of reservations)

The Contractor shall submit four paper copies and two electronic copies of the following final documents:

- The updated versions of the above-mentioned documents with all the regulation parameters,

- the last test records,
- 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,
- copies of the manufacturers' guarantee certificates.

7.1.5 Archiving of Drawings and Internal Approval on the CDD

The drawings shall be made using a CAD system complying with ISO standards. They shall be submitted to CERN in duplicate, in addition to the paper copies, in the form of printer files (HPGL) and source files (DWG) on CD-ROM.

Following an initial check by CERN, the Contractor shall archive his drawings in CERN's CDD via Internet (directions for the archiving are given in Annex F).

To this end, the Contractor shall be put in contact with CERN's CDD technical support team in order to obtain rights of access to the CDD Web server (registration of the firm, obtaining of a user name and password, etc.).

For each drawing, the Contractor shall enter all the information relating to his drawing in the relevant fields on the site's Web pages from his own Internet browser. He shall then download the files (source files and HPGL) of the drawing in question onto a directory of the CDD server via Internet.

An automatic procedure generated by the CERN server will check the drawing entries and will send all the correctly formatted drawings for approval to the various CERN services concerned. Every person receiving a drawing will be able to accept or reject it and will make comments in textual format.

The Contractor shall 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.

7.1.6 Document Format

All the text, instructions and notes appearing on the drawings and in the documents shall be either in English or bilingual (French and English).

All the abbreviations and codes used shall comply with CERN's coding systems.

All the documents drawn up by the firm shall be sent to CERN in both paper and electronic format. The contractor must draw up his design study using Microsoft Word[4] 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.

The mechanical drawings and diagrams shall be made using the AutoCAD[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.

---

[4] *Microsoft Word, Excel and Project are registered trademarks of Microsoft Corporation.*
[5] *Autocad is a registered tradmark of Autodesk Corporation.*

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

The other documents (qualifications, technical documentation, etc.) not available on the above-mentioned software shall be scanned by the Contractor and supplied in PDF format.

As a general rule, the various documents, drawings and diagrams shall be sent to CERN in both paper copy and electronic format, as source PDF files.

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.

8. SAFETY

The term "safety" covers health, safety, and working conditions. The work covered by this call for Tenders is subject to compliance with all the safety regulations in force as per the provisions set out in the document: *Safety regulations applicable to the work of contractors at CERN*, ref. CERN/TIS-GS/98-10, dated May 1998, hereinafter referred to as "Safety Regulations".

The LHC project is the subject of a safety coordination operation established from the design stage. For the work on the installation of the LHC and its experiments, CERN has made the group GTD/APAVE responsible for Coordination in matters of Safety and Health Protection.

The Safety Coordinators appointed by the group with CERN's approval are responsible for ensuring the proper conduct of the Coordination in matters of Safety and Health Protection procedure. They are, in particular, required 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 are also required to integrate the preventive arrangements in the structures and equipment to ensure their fully safe use and maintenance.

One of the tasks of the Health and Safety co-ordinators is to draw up a *Overall Safety and Health Protection Plan*, ref CERN/TIS-GS/IR/98-04-A, March 2000 (PGCSPS). This document, which was drawn up during the design phase of the project, is Annexd to the call for Tender documents. The preventive, organisational and co-ordination measures recommended therein shall be observed by Bidders when submitting their Tenders.

It must be noted that the PGCSPS and the CERN document "Organisation of the Installation Work of LHC and its experiments" are a contractual documents (Doc Ref: LHC-PM-IP-000rev. 1.1., EDMS 323972)

Before any work begins, the Contractor (main contractor and/or sub-contractor) shall draw up a Special Safety and Health Protection Plan (PPSPS) and submit it to the Safety co-ordinator and Project Manager for their opinion and comments.

This document shall be supplemented by a brief but adequately clear and complete description of the working methods and the protective measures to be implemented. The equipment and staff used shall be specified. A timetable for the performance of the various stages in the work shall also be attached.

The PPSPS must take account of the provisions of the PGCSPS and must be drawn up after the join inspection of the premises organised by the Safety co-ordinator and in the presence of the Project Manager. It shall be submitted to CERN at the latest 30 days before work commencement.

In addition, it should be pointed out that an Inter-Firms Health, Safety and Working Conditions Committee (CISSCT) is set up for work on the LHC. The committee will meet, when called upon, at least every three months and, in accordance with its regulations, the contractors concerned must be represented on it.

All these provisions are described in detail in the GHSCP and in the specific addendum relating to the work covered by this Invitation to Tender.

8.1.1 Additional Stipulations

Participation in the LHC project implies *de facto* involvement in the safety co-ordination operation. Furthermore, CERN expects the Contractors to attach great importance to the observance of the safety regulations and to implement all the necessary measures without restriction to prevent accidents and occupational illnesses.
The Contractors are required to be involved and meet all the obligations arising there from. In this context, they shall, in particular:

- Take account of all the safety rules and apply them to prevent occupational accident and illnesses,
- Take steps to ensure environmental protection,
- Take part with the safety co-ordinator in the inspection of the working areas,
- Draw up and provide the safety co-ordinator with a Special Safety and Health Protection Plan (PPSPS),

Contractors shall take all the necessary precautions for installation work, especially:

- All the necessary signs shall be set up,
- The hoisting and handling methods and gear shall be clearly defined and agreed by TIS,
- All the protective measures required for the performance of work at height shall be implemented.

The Contractor shall also ensure the presence of a safety officer on the work site and shall take account of all these provisions in his Tender.

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 intend to implement and of their proposed equipment, manpower 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 Contractor in the Special Safety and Health Protection Plan.

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

The Bidders shall nevertheless be deemed to be familiar with the provisions of the regulations applicable to them and may under no circumstances plead a lack of information from CERN to justify failure to implement safety measures.

9. CONTRACTOR'S OBLIGATIONS

The contents of all the documents referred to in this section shall be applicable throughout the execution of the contract.

9.1.1 General

The requirements set out in this specification shall be regarded solely as the minimum conditions to be met. They shall, by no means, relieve the Contractor of his responsibility for the proper selection of the supply components, their perfect compatibility with the equipment to which they will be connected and the proper completion and operation of the installations.

The data in the Invitation to Tender documents and any characteristics and dimensions shown on the drawings or in the texts are provided only as a guide. All the working documents shall be drawn-up by the Contractor. Similarly, CERN's approval of the Contractor's study and drawings shall in no way relieve the latter of any responsibility.

The Contractor shall visit the site to inspect the state of the premises, the access facilities and the conditions for the performance of the work.

9.1.2 Quality Control Records

All specified tests and measurements carried out during all stages of production, from raw material procurement up to delivery and installation shall be recorded in a specific file, called "the traveller", according to the procedure defined in the QAP document No LHC-PM-QA-309.00, "Fabrication and Inspection of Purchased Equipment".

9.1.3 Location of the Contractor's Premises

The volume of the work being done for the LHC Project requires that the Contractor sets up an organisational structure able to guarantee that the installations are properly completed in terms of quality, cost and schedule. In this context, the Contractor shall set up an administrative and technical support structure near CERN, which shall remain effective for the entire duration of the work.

9.1.4 Subcontracting

Subject to CERN's prior authorisation, the Contractor may, if necessary, sub-contract part of the work.

9.1.5 Planning and Scheduling

The Contractor shall prepare and submit to CERN for approval a detailed schedule, which complies with the provisional schedule set out in Annex G. This schedule shall comprise milestones for the following:

- Provision of documents requiring CERN approval, as defined in chapter 7 of this Technical Specification,
- the delivery of the material, a mid-point during the installation phase, the completion of the installation work and the tests for each particular work lot (steel structures, electricity, piping, controls or mechanical installation lots).

On the basis of the milestones specified in this schedule, CERN and the Contractor will set any other necessary schedules (like the one for the use of the SDX1 crane).

CERN reserves the right to amend the schedule before the start of the work, especially for reasons connected with the work of other companies in the same premises or because of the actual date of the contract's adjudication. This could result in changes in the dates or order in which work is to be performed and the Contractor shall undertake to adapt himself in accordance with them.

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

9.1.6 Manufacturing Drawings

Manufacturing drawings prepared by the Contractor for the execution of the Contract shall comply with the procedure defined in chapter 8 of the QAP document No LHC-PM-QA-306.00, "Drawing Process-External Drawings".

9.1.7 Checking of Data Provided by CERN

At the time of drawing up this call for Tenders, some of the buildings referred to have yet to be built, and certain parameters have yet to be confirmed by the future users of the premises.

CERN therefore reserves the right to amend certain parameters and to inform the Contractor thereof before the work begins, particularly with respect to:

- The work schedule,
- the positions and routing of the piping,
- the positions of the wall openings (pockets),
- the positions of the electrical power supply boards,

Before any work begins, the Contractor shall satisfy himself of the correctness of the dimensions and information shown on the drawings provided by CERN for information, failing which he shall bear sole responsibility for the consequences. This shall also apply to the civil engineering structures.

9.1.8 Missing CERN Documents

The Contractor shall request in writing, and sufficiently far in advance, any drawings, written instructions or documentation needed to execute the work that CERN may not have provided.

9.1.9 CERN Approval and Performance of the Work

Work may begin only when CERN has approved the entire project in writing on the basis of the requested documents.

9.1.10 Protection of Equipment

The Contractor shall be required to make provision for all the protective devices needed to prevent the installations and equipment made by other tradesmen being damaged by his work.

The Contractor shall be responsible for protecting his own structures until acceptance.

To this end, he shall take all the measures needed to prevent any damage or deterioration. Should any installations suffer damage or deterioration due to defective protection measures or any other negligence on the part of the Contractor (or his sub-contractors), the Contractor shall be required to compensate CERN for any loss or damage resulting therefrom. He shall also be responsible for guarding his installations and the equipment being stored on the site.

Furthermore, every precaution shall be taken to prevent any indentation of the roof covering when the equipment is being installed (temporary platform for walking on and for storage shall be compulsory). Any damage occurring shall be repaired at the Contractor’s expense.

9.1.11 Type of Materials

All the materials installed shall be new, free of any flaw or alteration (by oxidation or otherwise), fire-resistant and halogen-free (see Safety Instruction IS41). The chosen equipment, which shall comply with this specification, shall have been manufactured in one of CERN's Member States. The Contractor shall, at his own expense, replace any item of equipment or part of the installation that does not comply with this specification and with the official CERN documents.

All the adjustment, balancing, control and safety equipment supplied shall have certificates proving their performance levels issued by an approved body.

9.1.12 Cleaning

The Contractor shall be responsible for cleaning his worksite on a daily basis.

Prior to acceptance, all the premises and all the equipment shall be carefully cleaned ready for use.

The Contractor shall supervise or shall himself perform this very careful cleaning, for which he shall bear full responsibility. Should he fail to do so, CERN will have the premises cleaned by a third party. The cost of it shall be borne by the Contractor.

Furthermore, the Contractor may not store any material, such as combustible packaging, inside CERN buildings and underground structures.

9.1.13 Training of CERN's Operating Staff

As soon as CERN has taken possession of the installations the Contractor shall appoint one of his qualified representatives to train, on the site, CERN operating staff (10 people maximum) on the operation and maintenance of the plant, at a date agreed upon between CERN and the Contractor.

9.1.14 Guarantee of the Installations

The installations shall be guaranteed for *two years,* starting from the date of provisional acceptance.

The Contractor shall guarantee the design and layout of the installations, as well as the dimensions of the equipment given in his own drawings (see General Conditions). During this period, any part of an installation recognised as faulty shall be replaced by the Contractor at his own expense. The replacement equipment shall be guaranteed for a new two-year period.

If the Contractor considers the equipment specified by CERN in this specification or its Annexes to be defective or unsuitable, he shall submit his reservations in writing before the order is placed, failing which he shall not be entitled to disclaim responsibility for poor workmanship.

The Contractor shall point out any item of CERN's specifications or project, which seems incompatible with proper operation.

The Contractor may not disclaim responsibility for any malfunction of the installations on the grounds of CERN's specifications or project.

9.1.15 Internet

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 (CDD),
- consulting CERN's databases to monitor progress with the work.

10. INSPECTIONS, COMMISSIONING, TESTS AND ACCEPTANCE

Following CERN's written approval of the documents submitted by the Contractor, the latter may begin manufacture of the system components. The cost of all tests, inspections, commissioning, measurement campaigns, acceptance, the necessary instrumentation, its use and fitting-out, the supervision, the specialist manpower and the services of the official bodies needed to meet these requirements shall be included in the Tender. The Contractor shall provide all the calibration certificates for his equipment.

10.1.1 Factory Tests

The preparation of the factory tests shall be the subject of a document to be submitted to CERN for approval. This document shall set out in detail the procedure for the tests, their nature and all the operations to be performed.

They shall include:

- A visual check of the assembly (type of equipment, construction method, compliance with specifications),
- measurement of the power consumption values,
- hydraulic (pressure) tests (1.5 times the nominal pressure) for heat exchangers (with the exception of those which shall be assembled on the CERN site), filters, vessels and valves (all items shall be tested),
- performance tests for pumps (flow-rate, head, NPSH, efficiency) and motors. All pumps shall be tested.

The control cubicles containing the programmable logic controller (PLC), the local monitoring and the supervision systems shall also be factory-tested in the presence of CERN's representatives. Each functionality shall be checked, and each control loop tested independently. The communication tests shall be done by simulating the system.

These inspections and tests shall take place at least six weeks before the date on which the equipment is to be shipped to CERN.

All costs entailed by these tests (supply, manpower, apparatus, instrumentation, etc.) shall be borne by the Contractor and shall form an integral part of his Tender.

The Contractor shall set out the results of all the tests in a document, which must be approved by CERN before shipping or installation on the site, as appropriate.

The Contractor shall propose a date for delivery to the site.

10.1.2 Tests Performed on the Contractor's Premises

CERN reserves the right to be present or to be represented by an organisation of its choice at all the tests performed on the Contractor's premises or those of his sub-contractors. To this end, the Contractor shall keep CERN informed of progress with the manufacture and of the programmed test schedules. CERN shall be given at least ten working days' notice of the date of such tests.

10.1.3 Inspections Performed by the Contractor

Throughout the execution of the work the Contractor himself shall be required to monitor all his installations for both the quality of workmanship and operation.

As soon as the installation has been assembled on the CERN site, the Contractor shall check the following:

- The mechanical assembly of the systems (construction method, type of material, modularity, etc.),
- all the documentation,
- the identification labels (each component, circuit with flow indication arrows, electrical components and regulation devices, servo-motors, etc.),
- the command components, the protections of the electrical equipment, the safety devices, the remote controls, the transfers of the signals and alarms,
- all the cables, without exception, and their marking,
- the measurement of the insulation of the power systems between phases, neutral and earth,
- phase balance and the equipotential links.

Any defects in equipment damaged in transport or during assembly (metalwork, paint-work, etc.) shall be repaired.

The work-site (buildings, approaches and storage areas) shall be cleaned up and all rejects, trimmings and materials unused by the Contractor shall be removed.

The various operations needed for the tests shall be performed by the Contractor, who shall assume full responsibility for them. If any defects are discovered, they shall be corrected as a matter of urgency. The Contractor shall be responsible for redoing any work not complying with the specifications.

All the tests and inspections shall be entered on a test certificate appended to the general work completion file.

The Contractor and CERN shall make a joint inspection to verify that the assembly work has been duly completed.

10.1.4 Commissioning

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.

The commissioning procedure shall consist of several phases:

- Commissioning of all the safety devices,
- commissioning of the electrical systems (operation),
- commissioning of the hydraulic systems,
- commissioning of the control system,
- commissioning of the local monitoring and central monitoring systems.

It is to be noted that the performance tests will not be performed until some time after the completion of the station, once the users equipment will be installed and commissioned. The foreseen dates and time scale of these performance tests is shown in Annex G.

10.1.5 Testing by the Contractor

A detailed programme of tests will be drawn up by CERN in collaboration with the Contractor. All the measurements taken will be reported in test reports to be Annexd to the technical file for submission to CERN.

The tests will be carried out in the presence of a CERN representative. They will cover at least the following items:

- Measurement of the flow rates and available head,
- noise measurements,
- measurement of the electric current and power consumed,
- check of the quality and quantity of the materials,
- check of the assembly work: positions, directions, quality of connections, accessibility, securing, finishing, insulation, marking, compliance with the working drawings,
- safety inspections: electrical circuits, earthing, mechanical guards for pump couplings, etc.,
- checking of compliance between markings, drawings, diagrams and descriptions,
- checking of control and command functions,
- checking of dynamic behaviour: checking that the regulation process of the circuits takes less than 1 minute to stabilise after start-up; testing the stability of the automatic settings, etc.,
- checking the supervisory functions,
- checking the operating and maintenance instruction manual and the other documents.

The operating points for the different settings referred to above will be shown on the characteristic curves and Annexd to the test reports.

The current and power consumption values measured shall be compared with the ratings given on the motor identification plates.

10.1.6 Checks by CERN

All the test reports will be checked by CERN in the Contractor's presence. The following checks will be performed:

- Verification of the quality and quantity of the materials,
- verification of compliance of the installations with the documents and regulations in force and with normal trade practice,
- verification of compliance of the installations with the design study and the working drawings,
- verification by the technical control office (Office of Controls and Inspections appointed by CERN for electrical installations). Changes to the installations as a function of the comments by the Office of Controls and Inspections shall be the Contractor's responsibility,
- verification and control of the accuracy and speed of response of the measuring equipment,
- verification of the noise measurements.

10.1.7 Noise Measurement

CERN attaches particular importance to reducing the noise pollution from its equipment in the outside environment to the minimum. Checks on noise damping shall therefore include various kinds of noise measurement.

The noise measuring instruments and specialised manpower shall be provided by the Contractor. The measurements taken shall be appended to the test reports.

The noise level measurements shall be taken by the Contractor in the presence of CERN's Acoustics Service and in accordance with its instructions. They shall be carried out on each structure in different locations and at different phases of the work.

The measurement campaigns shall comprise the following stages:

- Measurement of the background noise spectra (before work, equipment switched off), which shall be used as reference values,
- measurement of the noise limits of the cooling plants alone (pumps operating at their design points, valves open, etc.),

The noise limits shall be measured at the following locations:

- Inside the CV zone and on the different floors of the Service and Experimental caverns,
- inside and outside the CV zone by the piping and cabling openings (verification of the attenuation measures installed by the Contractor).

10.1.8 Acceptances

Acceptances shall be granted in accordance with the contract documents.

Comments and reservations made by one of the parties shall be entered in the acceptance reports. At acceptance, test checks shall be made on the basis of the test reports (listing the measured and rated characteristics) supplied by the Contractor. The necessary resources for all these tests (instruments like thermometers, flow-rate meters, manometers, water resistivity/conductivity meters, etc. plus the staff) shall be supplied by the Contractor, together with their calibration certificates issued by an approved body. If recordings of the tests of the installation need to be made, the Contractor shall provide the recording devices.

10.1.8.1 Partial Acceptance

CERN may freely make pre-acceptance tests to formalise the progress of certain phases of the work (in the case of the piping, this shall correspond to the hydraulic tests, subject to payment according to article 5 of the TF).

10.1.8.2 Provisional Acceptance

Once the installation has been fully completed, commissioned and adjusted in accordance with CERN's specifications, CERN and the Contractor will agree on a date for provisional acceptance, within the date given in Annex G, provisional schedule.

The Contractor shall first send CERN all the "as-built" documents.

Provisional acceptance cannot be granted until all the equipment supplied fully complies with the specification and the approved documents and until all the requested documents have been submitted in full.

10.1.8.3 Final Documents

Once the Contractor has made any necessary alterations and/or provided any further information requested, CERN's reservations will be lifted following an additional partial acceptance procedure.

10.1.8.4 Final Acceptance

Final acceptance will take effect upon expiry of the two-year guarantee period, provided that the Contractor has met all his obligations.

11. DELIVERY AND COMMISSIONING

11.1 Packing and Transport to CERN

The Contractor is responsible for packing, transport to CERN and the work-site, off-loading and installation of the equipment and shall include it in his Tender. He shall ensure that the equipment is delivered to CERN without damage and any possible deterioration in performance due to transport conditions.

Persons technically responsible at CERN :

Name	**Tel-Fax**	**Email**
Guillermo Peon In case of absence: Philippe Pigne	**Fax: + 41 22 767 87 67**	guillermo.peon@cern.ch philippe.pigne@cern.ch

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

Group Code.:	TS/CV
EDMS No.:	440027
LHC Project document No.:	LHC-F-CI-0007

The Large Hadron Collider Project *IT-3255/TS/LHC*

Technical Specification for the Supply and Installation of the Underground Cooling Plant for the CMS Detector in the Experimental Area at Point 5 of the LHC

ANNEX A TO THE TECHNICAL SPECIFICATION

Technical Prescriptions

Pipework and Accessories

January 2004

1. CARBON STEEL PIPE WORK

Pipes

All pipes shall be seamless. In order to keep the pipes clean during transport and storage, they shall have their ends adequately protected.

All the pipes shall be of ST37-2 carbon steel and comply with standards ISO 559 and ISO 4200. For reasons of accessibility the maximum length of pipe shall not exceed 6 m. The tolerance system shall follow standard ISO 5252 (class DT on the external diameter, T3 on the thickness).

All piping in contact with demineralised water shall be in stainless steel. Chilled water pipelines (HVAC, TRACKER) should be insulated to avoid condensation on the cold surfaces, ECAL cooling pipelines shall be also insulated to avoid temperature variations.

Parts such as drain, top-ups etc. shall be made of galvanised steel, while the bleed valves and the air vents should be completely stainless steel.

The secondary circuits conveying raw water shall be provided with tapings (supply and return lines) fitted with stop valves (1”) for the maintenance operations (chemical treatment) of the circuits. The pipes shall be fitted flanged expansion joints wherever needed to allow the free expansion or contraction during operation.

All the pipes shall be supplied cleaned and capped. All pipework shall be fitted by welding, performed in accordance with the note TIS/TE/MI/CM 00-14 “Welder’s qualification for welding works on pressurised or vacuum pipes and vessels at CERN”.

Welds must be of the electric arc type or using oxy-aceteylene torch. For pipes diameter up to DN 150 or thicker than 3 mm electric arc shall be obligatory. Pipes of DN 25 shall be welded with external bushing round the pipes. Similarly bends, tapers, T-junctions, etc, of DN 25 shall be connected using weldable bushing. Bending shall not be permitted, even for small diameters.

Bends

3D bends shall follow standard ISO5251. Their outside diameter and wall thickness shall be the same as those of the pipes to which they are welded. Bends composed of several welded sections shall not be accepted. The material used for bends shall be the same than that used for the piping proper.

Flanges

The flanges mounted on the pipework shall be of the welded collar type and comply with DIN 2633 for diameters below DN 150, and DIN 2632 for diameters above DN 200.. They shall be neck flanges with raised seal beds. The material of the flanges shall be that of the pipe they belong to. The dimensions of the flange for each nominal diameter can be find on drawing LHCF99900015-3.

Blank flanges

They shall be of form B as defined by DIN norm 2527. They shall be covered on the fluid side by a washer of 2 mm thickness of the same material as the pipe they belong to. This washer shall have the same outer diameter as the gasket. Any part of the blank flange which is not made of stainless steel shall be galvanised.

Gaskets

The gaskets shall be of the Klingerit® [1] type or equivalent. Whatever their diameter, they shall be 2 mm thick. The outer diameter shall be such that during assembly the gasket is centred by the flange bolts.

Bolts, washers and nuts

[1] Klingerit® is a registered Trade Mark of Klinger

The nuts and bolts shall be calculated to withstand the specified pipework test pressures. The bolt lengths shall be perfectly adapted to the connections for which they are to be used. A washer shall be placed under each nut. The bolts, nuts and washers shall be zinc coated and passivated for assembly.

Tapers and dished ends

These may be forged or standard commercial items. Whatever their source, their outside diameters shall be the same as those of the pipes to which they are to be welded. The wall-thickness of the tapers shall be that of the larger-diameter pipe. The length of their frustum cone shall never be less than three times the difference between the end diameters.

2. GALVANISED CARBON STEEL PIPEWORK

Pipes

All the pipes shall be of the drawn seamless type and their dimensions shall meet recommendation ISO.R.65, "medium series". They shall be threaded in accordance with the recommendation ISO.R.7. With regard to the equipment and delivery conditions, the contractor shall comply with standards DIN 1629 - sheet 2 (commercial quality pipe ST 00) and 2440 where these do not conflict with the specified ISO standards.

All the pipes shall be hot-dip galvanised.

Accessories

All the pipework accessories, i.e. bends, sleeves, nipples, unions, plugs, T-pieces and reducers, shall be of galvanised malleable cast steel and meet the ISO.R.49 recommendations.

The threads shall be to recommendation ISO.R.7.

The flanges shall be of the round type, threaded to DIN 2665 and 2566. They shall be galvanised.

The plain flanges shall comply with standard DIN 2527 shape B. They shall be galvanised. In general, standard commercial bends shall always be used.

Where the change of direction of the pipe is less than 20°, an already galvanised pipe may be machine bent provided that:

- The outer surface of the pipe exhibits no visible corrugation on the inside of the bend
- The galvanisation does not flake
- The radius of curvature measured along the pipe axis is at least four times the pipe's outside diameter.

Fixings

These shall be of cadmium-plated steel and tallowed or graphited before fitting.

Seals

Seals of the Klingerit type, 2 mm thick, shall be used for assembling flat flanges.

The product used to seal the threads shall be chosen using the recommendation IS41 and shall be submitted to CERN for approval.

Whatever the sealing products used, all the connections shall remain easy to dismantle.

3. STAINLESS STEEL PIPEWORK

3.1 Raw Material

The material for the pipes and the connections is AISI 304L stainless steel with a low carbon content. The composition of the steel shall correspond to the national standards quoted in the table below.

USA	GERMANY	FRANCE	UK	ITALY	SWEDEN
AISI	DIN 17006	AFNOR	BS	UNI 4047	SIS
304 L	X2CrNi 18.10	Z03CN18.10	801 grade C	X3CN19.11	2352

or equivalent.

Their chemical composition shall be as follows:

% C	% Si	% Mn	% Cr	% Ni
≤ 0.03	≤ 1.0	≤ 2.0	17 ≤ 20	10 ≤ 12.5

3.2 Pipe Manufacture

The Bidder may propose pipes which are longitudinally welded.

They shall be made from hot or cold rolled sheet. After welding, they shall undergo descaling followed by passivation. This treatment corresponds to procedure dl or kl of the DIN Norm 17440. The guaranteed welding coefficient must be at least 0.8. In order to keep the pipes clean during transport and storage, they shall have their ends adequately protected. The delivery conditions shall be those specified by standards ISO 2604-5 and ISO 1127.

One test sheet per pipe shall be issued. Each pipe shall bear a distinctive and indelible marking that does not alter its thickness or shape and records:

- the pipe supplier,
- the grade of steel,
- the number of the pipe and/or test sheet number, including the reference of the pipe, the cast number, the chemical composition and charateristics of the steel, the treatment procedures undergone by the pipe and the tests conducted on the pipe,
- the pipe dimensions (external diameter x thickness).

The test sheets shall be made available to CERN on request

3.3 Pipe Dimensions

All pipes shall follow the ISO 4200 recommendations for outside diameters and wall thickness, and ISO 5252 and ISO 1127 for tolerances on dimensions.

The thickness specified shall not be applicable at points where later insertions or junctions are planned for manifolds. In such cases the Contractor shall be free to strengthen those by means of a skirting ring at the point of insertion. The strengthening element shall be a stainless steel band of the same grade as the pipe, shaped to fit the drilled pipe. See the drawing LHCF999000116-3. The dimensions shall be those laid down in AD-Merklatt B9.

For reason of accessibility to the various structures the maximum length of pipe shall not exceed 6 m.

3.4 Bends

The bends shall follow the ISO 5251, model 3D. They shall have the same outer diameter as the pipe to which they are joined. Their wall thickness shall be as close as possible but in no case less than that of the pipe to which they are joined. The material used shall be as defined in paragraph 3.1. The elbows shall undergo the same surface treatment as the pipes. The guaranteed welding coefficient shall be 0.8. The material used shall be the same as for the pipes. They shall be marked in a similar fashion to that prescribed for the pipes, except for the reference to the test sheets.

3.5 Tapers

The tapers may be either eccentric or concentric according to their use. Their largest outer diameters shall be the same as the outer diameters of the pipes to which they are to be joined. The should follow the ISO5251.

The wall thickness of the reducer shall be that of the pipe having the largest diameter. The length of the frustrum cone shall never be less than 3 times the difference of the end diameters.

The reducer material shall be that defined in paragraph 3.1. The reducers shall undergo the same surface treatment as the pipes. The guaranteed welding coefficient shall be at least 0.8. They shall be marked in a similar fashion to that prescribed for the pipes, except for the reference to the test sheets.

3.6 Flanges

Flanges and collars

The flanges mounted on the pipework shall be of the welded collar type. The loose flanges shall be hot galvanised. The material of the collar is that defined in paragraph 3.1.

The collars will be identical like on drawing LHCF99900014-3.

Blank flanges

They shall be of form B as defined by DIN 2527. They shall be covered on the fluid side by an stainless steel 18/8 washer of 2 mm thickness. This washer shall have the same outer diameter as the gasket. The blank flange shall be galvanised.

Bolts, washers and nuts

The nuts and bolts shall be calculated to withstand the specified pipework test pressures. The bolt lengths shall be perfectly adapted to the connections for which they are to be used. A washer shall be placed under each nut. The bolts, nuts and washers shall be cadmium plated and graphite coated for assembly.

Gaskets

These shall be of the Klingerit[1™] type or equivalent. Whatever their diameter, they shall be 2 mm thick. The outer diameter shall be such that during assembly the gasket is centred by the bolts of the flanges.

4. WELDING

Welding shall only be done by qualified and certified welders. They shall be approved by CERN (see Document TIS/TE/MI/CM 00-14). The welding shall be done in an inert or slightly reducing atmosphere both inside and outside the pipe. The composition of this atmosphere shall be 80 to 85 % argon and 20 to 15 % hydrogen.

[1™] Klingerit is a registered Trade Mark of Klinger

All welds shall be carried out in accordance with the ISO standard Handbook n° 19. The shielding gas inside and outside the pipe shall correspond to DIN 32526 or equivalent. The filler metal for gas shielded arc welding shall follow the DIN 8559 or equivalent.

Before welding, the pieces to be welded shall be very clean, free from grease and dampness and have been stored in a very dry inert gas. In addition, the welds shall be brushed with a stainless steel brush on the outside of the pipe so as to remove all trace of oxidation on the seams.

A chamfer of the pipe is compulsory for a wall thickness of 2.9 mm or greater. Welding must be done in such a way that neither descaling nor passivation shall be necessary on site.

The number of welds and cuts in the pipes, elbows, etc. must be minimized.

4.1 Inspection of Built-Welds on Pipes for Pressurized Systems

The inspection shall be in accordance with the note TIS/TE/MI/CM 00-14.

4.2 Special Remarks on the Construction

Except where shown otherwise, all pipework shall be welded The flanges needed for the construction of the system are clearly shown on the drawings accompanying the Technical Specification.

At a change of direction, the bends specified in paragraph 3.4. shall always be used. Only, if there is a small change in direction and the distance between the two welds is less than 13 mm, measured on the inner part of the bend, then the bend may be replaced by a bevelled cut on the pipes. Minimal distance between the welds (along the circumference of the collecting tube) should be like on drawing LHCF99900016-3.

When two pipes are joined by a weld, care should be taken that the longitudinal welds do not fall in line. They should be at least 13 mm apart. This distance is measured along the circumference.

When pipes are cut, care should be taken that they are correctly deburred and that the inside of the pipes stays perfectly clean and free from filings or other waste. The grinding discs and saw blades shall be chosen so as not to modify the quality of the stainless steel of the pieces being cut.

In no case, CERN will accept that short pieces of pipes are welded together in order to replace standard pipes of 6 m of length.

Due to lack of space inside the buildings manual welding in position is very difficult. Therefore CERN recommends the use of automatic orbital welding machines where ever possible. Each weld must be labelled with the identification number of the welder or welding operator.

5. SUPPORTS AND FIXINGS

The supports and fixed points shall be arranged so that the pipework imposes no stresses on the seals, fittings and accessories.

The supports shall be made from commercially available steel sections (LHCF99900013-2).

The pipes shall be secured to the fixed points by flat collars or another locking system. Fixings shall not be welded directly to the pipe. Sliding supports shall be positioned to allow the pipework to expand, absorb lateral forces to maintain the alignment of the pipework and allow the pipes to move longitudinally without noticeable wear and without damage to the lagging.

The supports shall be carefully protected and spaced so that the deformation of the pipework during operation or testing results in neither any impermissible stresses in the pipes nor reverse gradients which could hamper the flow of the fluids or of any condensates or the escape of air from liquids.

The steel components shall be generously designed to allow for accidental overloads. In all cases the pipes shall be assumed to be full of water.

The supports shall be thoroughly examined before fitting. Cut steel components shall be deburred and any sharp edges rounded off. Holes shall be drilled or punched (the cutting torch may in no circumstances be used for this operation).

The concealed parts of the supports shall be coated with rustproof paint before the various components are assembled together or secured to the building framework.

The supports and fixed points shall be arranged so that the pipework imposes no stress on the unions, fittings and accessories.

The collars shall:

- Be made of carbon or galvanised steel for steel pipes
- Consist of collars with rubberised strips (MUPRO[2TM]) for small diameters < 50 mm.

The spacing of the pipework supports shall not be greater than the values given in the next page:

Diameter of pipes DN	Largest distance between supports in m
6 to 10	1.5
15 to 32	2.5
40 to 65	3.5
80 to 150	5.0
200 to 300	6.0
350 to 400	7.0

It should be noted that the pipes may not themselves be regarded as supports and no pipe shall be attached to another by any system whatsoever.

The supports for pipework conveying hot or cold fluids shall be designed so that the pipes may expand freely without excessive stresses (sprung supports, supports on rollers, etc.).

6. ACCESSORIES

Where details of a type or make is given it is only to indicate the level of quality or performance required.

6.1 Stopcocks

All valves shall be quarter-turn butterfly or ball valve type. The actuation shall be manual or motorised.

6.2 Manually Operated Valves

- <u>for the pipe diameters >DN50</u>:
  Butterfly type TTV Lug or make of similar quality
  Leakproof to standard ISO 5208
  Overall dimensions to standard ISO 5752

[2TM] Mupro is a Trade Mark

Base plate to standard ISO 5211
Cast-iron body with threaded holes
Epoxy-coated ductile cast-steel butterfly with EPDM sleeve
Manual actuation using reduction gear with position indicator, no end of travel.
For the pipe diameters =DN100 with lever,
for the pipe diameters >DN100 with gear box.

- <u>for the pipe diameters =DN50</u>:
  Ball valve
  Leakproof to standard ISO 5208
  Overall dimensions to standard DIN 3202
  Base plate to standard ISO 5211
  Cast-iron body, stainless steel inner capsule, PTFE seal
  Flanged connections
  Manual actuation using reduction gear with position indicator, no end of travel.

6.3 Motorised Valves

- Butterfly valve type TTV Lug or make of equivalent quality
  -with pneumatic actuator,
  -compressed air controlled by a 24V electro valve fitted with an air exhaust reducer
- Open-closed contacts

6.4 Automatic By-pass Valves

- CLA-VAL type GE 250 01 or similar quality
  - for demineralised water stainless steel body, electro polish finishing, stainless steel pilot,
  - for other fluids carbon steel body

6.5 Regulation Valves.

CAMFLEX® II Masoneilan or similar.
-with eccentric plug,
-electro pneumatic positioner.

6.6 Check Valves

KSB type hydrostop or make of similar quality,
-cast iron body covered with 0.5mm of polyamide.

All the valves shall be supplied by the same trader.

6.7 Compensators

Quality KCC/green
Kleber™ Dilatoflex type or product of equivalent quality

Camflex® II is registered Trade Mark

6.8 Air Vents

Air vents shall be provided at all high points in the system. Each of these shall consist of a stop valve (fitted close to the pipe or apparatus) and an automatic air purge valve.

Amstrong type 11AV DN20 PN40 or similar.

Connections according to drawing 15 LHC F 99900017 3.

Rated pressure PN40 bar.

6.9 Drains

Drains of adequate size shall be provided at all low points in the piping and the connected components, so that the whole system or parts of it can be emptied completely when needed for servicing or repairs. Each drain shall consist of a shut-off valve fitted close to the pipe or apparatus which serves and of a galvanised piece of piping (having a continuous slope towards the final drain point) leading from the shut-off valve to the drains of the building.

Spherical bump tap or make of similar quality

Connections according to drawing 15 LHC F 99900017 3.

Cast iron or steel body. Fitted with the same type of spherical plug-cocks as the drains.

Drain connections shall also be provided for conveying the leakage water on each pump. These shall be made of galvanised steel and lead to the building drains (individually or connected to a common collector) from collecting pans which shall be provided for each pump.

For the compressed air circuits – compressed air automatic traps shall be provided.

7. LAGGING

The pipes marked "insulated" in the DQE shall to be surrounded completely by a layer of Foamglas® with a minimum thickness of 40 mm. This lagging shall to be protected on the outside by a layer of sheet aluminium. The Foamglas® shall to be replaced by 40 mm high density polyurethane (RG80 or similar) where the pipe supports are placed, in order to guarantee stability.

7.1 Application on Pipework

- Clean the pipes.
- Supply the lagging.
- Fit the lagging.
- Secure it and join it with intumescent Mastic®, or similar.
- Hold it in place with galvanised steel wire.
- Smooth with intumescent Mastic®, or similar.
- Apply folded riveted or screwed 0.6 mm thick sheet aluminium.
- Any other requirements for a perfect finish.

7.2 Application on Accessories

Full lagging of all the accessories in each circuit:

- Fabrication of removable and re-usable sealed casings of riveted or screwed sheet aluminium lined with 19 mm thick Armaflex® 2 NH, or similar.

® Intumescent Mastic is registered Trade Mark of Intumescent Fire Protection Supplies Ltd.
[2] Armaflex® is a registered Trade Mark of Armstrong World Industries, Inc.

- Wiping off the fittings.
- Coating with water-free cold bitumen.
- Fitting the casings.
- Finishing with Armaflex® NH, silicone seal and covers screwed on all the stubs, wells, bleeds, drains and end of lagging.

7.3 Marking

Each lagged pipeline shall be marked with a band of epoxy paint in CERN's colour code around the galvanised protective sheet metal. Refer to TIS paper A3 (Safety colours and safety signs).

Width of band 100 mm. An arrow in the same colour shall indicate the direction of flow of the fluid.

8. PAINTING AND LABELLING

8.1 Rustproofing

All pipework, control components, stopcocks and supports, except those made of galvanised steel, shall be given a coat of rustproofing paint. Before being painted the surfaces shall be carefully scraped and brushed. All parts of the pipework and supports in contact when assembled shall be protected by a coat of rustproof paint (lead-free zinc chromate).

The paint shall be applied after assembly and testing and not before, even if certain components have been given a first protective coating at the works.

Any coats of paint applied on prefabricated components by the contractor at his works shall be regarded as non-existent.

8.2 Final Coats

The contractor shall apply the final coats of paint on the pipework after assembly and testing. They shall comprise two coats of epoxy paint (in a colour approved by CERN).

8.3 Paintwork on Supports

The supports shall be given two coats of lead-free zinc-chromate-based primer and two coats of epoxy paint (in a colour approved by CERN).

8.4 Labelling

All cocks and valves of the installation as well as the extremities of the pipes (close to each flange) shall be fitted with label holders firmly secured to the pipework bearing CERN reference numbers. The labels shall be:

- black text on a white background,
- not handwritten,
- readable from a distance of a few metres,
- water and light resistant.

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

Group Code.: TS/CV
EDMS No.: 440027
LHC Project document No.: LHC-F-CI-0007

The Large Hadron Collider Project ***IT-3255/TS/LHC***

Technical Specification for the Supply and Installation of the Underground Cooling Plant for the CMS Detector in the Experimental Area at Point 5 of the LHC

ANNEX B TO THE TECHNICAL SPECIFICATION

Tests – Inspections

January 2004

TESTS AND INSPECTIONS

APPLICABLE PROCEDURES FOR INSPECTIONS AND TESTS

A detailed programme of inspections and tests will be drawn up by CERN in collaboration with the Contractor. The items covered under the programme are described in the chapters that follow. It should be noted that the cost of the various tests and instrumentation required, setting them up and fitting them out, the supervision and the skilled manpower required to run the tests shall be included in the bid.

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. 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.

CERN reserves the right to inspect, in the workshops of the Contractor or his subcontractors, equipment or fittings provided under the specification, and to attend all tests that may be run in these workshops. To that end, the Contractor shall keep CERN informed of the progress of manufacture and give it adequate notice of tests that are to be held. CERN will then inform the supplier whether or not it intends to be present at the tests.

Unless standard tests have been run previously, the following tests will be conducted:

1. COOLING PLANT

1.1 Pre-Delivery Inspections and Tests

Unless the relevant tests have been carried out previously, the following shall be conducted at the works:

- acceptance tests on the electrical equipment,
- tests on the control systems and safety devices of each plant,
- acceptance tests on the monitoring system,
- pressure tests on the hydraulic components of each cooling plant,
- measurement of the noise level of the different units,
- performance tests on each piece of equipment and on the whole cooling plant.

1.1.1 Acceptance Tests on the Electrical Equipment

These shall be conducted to check conformity with the Technical Specification and its Annex D.

1.1.2 Tests on the Control Systems and Safety Devices of the Cooling Plant

They shall comprise in particular:

- continuity of wiring and connections of the power supply and monitoring system,
- electrical input and output performance,

- operation of the monitoring units.

Provision shall be made for test points in reading and control mode, particularly at the level of the connection terminals.

Use of the monitoring unit (CU):

The monitoring unit of the cooling set shall be used to test all controls and read-out points (measurements and statuses).

Controls:

The various components shall be remotely controlled by the "CU" which shall be responsible for start-up and stop sequences, taking into account the various simulated conditions, i.e. threshold value exceeded, equipment out of service etc.

The Contractor shall describe the operating logic, including storage and delays, in the working documents.

The performance of the components under the various conditions shall be analysed and compared to the requirements set out in the Technical Specification.

Read-out:

The "CU" shall give a static read-out of the various parameters (analog or digital measurements, status of the contacts) for which a detector/transmitter would have been required. If necessary, calibration equipment may be used for verification purposes.

Adjustment:

The performance of the adjustment loops (adjustment values recorded, values to be adjusted, transfer function) shall be monitored for speed, accuracy and stability. Changes in the parameters and the sounding of alarms shall be recorded for a period of time, which will vary in accordance with the operation being monitored. The change from manual to automatic shall be tested in the first case by altering the adjustment value, and in the second by altering the setting.

Alarms:

All the alarms stipulated in the Technical Specification shall be simulated. The internal actions resulting from this and the transmission of defects to the acquisition system shall be checked.

1.1.3 Acceptance Tests on the Monitoring System

The Contractor shall be responsible for the supply of hardware and software for testing the operation procedure, via the connections and in accordance with the various connection diagrams.

The test reports shall be submitted to CERN for approval.

Application programmes and local dialogues:

Access to readings and controls:

The various actions relating to the acceptance procedures listed above shall be carried out by means of simple programs. These shall be written and structured so that the following basic operations can be performed either individually or combined:

- Reading of one or more parameters with conversion to the corresponding physical unit
- Issue of a command to the process
- Checking of adjustment and automatic systems
- Automatic action in the event of an alarm.

These various programs shall be carried out in sequence on all of the equipment supplied in a systematic manner, to ensure that all the instruments relating to the operation procedure meet the required specifications.

1.1.4 Pressure Tests on the Internal Hydraulic Components of the Cooling Plant

1.1.4.1 Pressure Vessels and pipelines

An official independent body, to be agreed upon jointly by the supplier and CERN, shall monitor manufacture at the works, in accordance with the code selected.

One or more CERN representatives may inspect the components of the plant during manufacture and will attend all tests that take place at the works of the manufacturer or of any subcontractor. The supplier shall therefore inform CERN at least three weeks in advance of the date of proposed checks and allow free access to the works during manufacture. The constructor shall provide all the documents specified in CERN Safety Code D2, Chapter 6.

X-ray inspections:

At CERN's request, any welded joints in any component of the plant shall be X-ray inspected in accordance with document TIS/TE/MI/CM/ 00-14.

Pressure tests:

All pressure vessels shall be subjected to a hydraulic test at 1.5 times the nominal pressure before being fitted on the cooling set. In the case the vessel contains more than one circuit (heat exchangers) the test shall be conducted on each circuit independently with the other circuit under atmospheric pressure.

1.1.4.2 Pipework

X-ray inspections:

10% of all the welds shall be inspected in accordance with document TIS/TE/MI/CM/ 00-14.

CERN may require other non-destructive tests in the event of negative results.

<u>Pressure tests:</u>

- Hydraulic circuits

Each circuit shall be subjected to an overall hydraulic test at 1.5 times the nominal pressure.

<u>Preparation of the tests</u>

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 flat plates, stops, electrical connections and all other additional equipment needed to carry out the test in accordance with the set conditions, as well as the hardware required for these tests.

Ensuring compliance and additional tests

- The Contractor shall rectify all sealing defects discovered during each test by making any necessary repairs at once and at his own expense
- Once these repairs have been completed, a further test shall be conducted under the same conditions as specified above.

Report

The Contractor shall compile and submit a minimum of two copies of a report covering the following information:

- Serial number of the test
- Duration of the test, pressure, results obtained
- Decisions relating to any repairs required and conclusions.

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

Leak tests on the cooling circuits:

Having undergone the tests under pressure described above, each cooling circuit shall be subjected to a leak test.

This test shall be carried out by the Contractor following assembly of all the cooling components, before beginning painting and lagging.

The cooling fluid itself shall be the test fluid, at a pressure at least as high as the operating pressure. The detector shall be electronic. The overall leakage rate shall be less than 6 g per year.

The report on these tests shall include the same information as the report on the pressure tests.

1.1.5 Measurement of the Noise Level of the Equipment:

This measurement shall be taken at full load at the Contractor's test rig.

The Contractor shall respect the various ISO noise measurement standards.

1.1.6 Performance Tests on the Equipment

The Contractor shall carry out a series of tests to confirm the performances indicated by him in his description, in accordance with CERN's specification.

1.1.6.1 Type of Tests:

Procedure

The test procedure shall meet the following standards:

- EN2858 and ISO 9906

Operating points

Each motor pump set shall be tested at the nominal operation point and at four other points (including cut-out and zero flow) to allow the determination of the slope of the characteristic curve.

1.1.6.2 Test Procedure:

The tests shall take place at the works on a test ring supplied by the Contractor

The Contractor shall have already submitted the protocol for the test reports to CERN for approval at least 2 weeks before the start of the tests:

The tests shall take place in the presence of a CERN representative who shall request a series of additional tests if the previous results are not satisfactory. The calibration certificates of the instrumentation used and that of the test rig as a whole shall be produced.

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, cooling units will be rejected by CERN. The Contractor shall replace any items which fail the performance test by a new one that meets the standards of performance requested. A new series of performance tests for these new items shall be organised by the Contractor.

CERN reserves the right to have a representative of a certified body present at these tests.

Tests report:

After each test the Contractor shall compile and submit in duplicate a report containing the following information:

- serial number and date of the test,
- values specified and results obtained, stating the difference between the two,
- decisions relating to any repairs or ensuring of compliance needed,
- list of instrumentation employed (serial No, make, type) and their certificates of calibration,
- conclusions.

This report shall be signed by the representatives of the Contractor and of CERN or CERN's representative.

1.1.7 Preparation of the Equipment for Dispatch:

All the hydraulic circuits shall be completely drained. The connecting flanges shall be plugged with plastic or metal stoppers, and the whole properly labelled and packed to avoid damage to the equipment.

2. POST-DELIVERY INSPECTIONS AND TESTS

The Contractor shall assume full responsibility for the tests described below.

2.1 Physical Checks

A certificate shall be issued confirming safe delivery of 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 note will be made of any defect discovered, which shall be rectified by the Contractor at his own expense.

2.2 Weldings

If welding has to be done on site, the welders shall be certified according to the procedures set out in the attached document. Welder's qualification:

2.2.1.1 Inspection of Welds

The extent of inspected (X-ray, gamma, etc.) welded joints shall be as laid down in the design code. Other non-destructive tests may be required by CERN in case of doubt. Each weld shall be labelled with the identification number of the welder.

As a minimum requirement “T” joints in pressure vessels shall be X-rayed 100%, circumferential welds and longitudinal welds in pipework shall be X-rayed at not less than 10%. If faults are discovered, CERN or the inspector may require additional X-rays, up to 100%, the cost of which is to be made by the Contractor.

These radiographs will be evaluated in accordance to ISO standard 5817, requirement B, and a report submitted to CERN for approval. CERN reserves the right, in the light of the results, to have defective welds ground, redone and X-rayed (by the Contractor himself or by a third party) at the expense of the Contractor.

2.3 Hydraulic Tests on Water Pipes

- This work will be carried out by the Contractor at his own expense and under the direction of the CERN official in charge of the work
- The length of the test segment may vary depending on the type of the assembly, the diameter and nature of the piping, while taking into account the opinion of the pipework manufacturer and possibly the position and shape of the segment in question
- In particular, piping with locked joints must be tested according to the manufacturer's instructions for this type of installation.

2.3.1 Preparation of the Tests

The test will be run in a way that will permit proper examination of the length of pipe in question and in particular all joints. In particular, the Contractor shall provide and fit all the solid elements, blanking plates, mains connections and other installations needed for running the test in the prescribed manner along with any equipment the tests may need.

2.3.2 Water Supply

The following two alternatives may occur :

- Fitting piping from an existing mains connection or installations already supplied: CERN will provide the Contractor free of charge with the water needed for running the tests, while the latter's responsibility is to make all the requisite connections
- Fitting piping from installations not yet supplied except in special circumstances provided for in the Technical Specification, the Contractor shall provide and transport the water he needs. The latter shall not contaminate the pipes in any way.

2.3.3 Priming with Water

The pipes will be primed gradually, avoiding water hammer from over-rapid filling and ensuring that the air is properly bled off.

2.3.4 Pressurization

CERN imposes a pressure test as defined hereunder for the period laid down, with all precautions being taken to avoid hammering in the pipes.

2.3.5 Test pressures on Fitted Pipes

As a general rule test pressures are set at 1.5 times the design pressure.

2.3.6 Test Procedures

- Test pressures will be applied for a duration of 60 minutes, without any pressure drop of more than 0.01 MPa (0.1 bar) at stabilised temperature
- Should the pipes and junctions need checking over their entire length, the test will be extended, but may not exceed two hours; in that case the pressure may not fall by more than 0.03 MPa (0.3 bar) at stabilised temperature
- At the request of the Contractor, tests on piping will only be carried out after a given time following filling. This time is the Contractor's responsibility to state.

2.3.7 Rectification and Follow-up Tests

- The Contractor must rectify all leaks noted during the test by immediately undertaking at his own expense whatever repairs the test has shown to be necessary
- When the repairs have been done, a new test will be conducted using the same criteria set out above.

2.3.8 Testing on Gate-Valves

When a segment of pipes tested includes a gate-valve, the latter will effectively be tested in "gate open" position, at the test pressure set out in paragraph 2.3.5. above.

When the gate-valves are tested with the gating system shut the test pressure will be the maximum service pressure.

2.3.9 Testing the General Behaviour of the Water Distribution System

Before acceptance, unless otherwise stated in the Technical Specification, the Contractor shall, in the presence of the CERN official in charge of works, undertake general pressurization of the system from the mains water supply in regular service conditions, with the taps and connecting valves and gates in the shut position. After 48 hours under service conditions, the leakage shall not exceed that measured during the tests referred to in paragraph 2.3.6.

2.3.10 Report

The report, to be prepared at least in duplicate by the Contractor in a notebook with numbered pages, will contain the following information:

- Reference no. of the test and date made
- Duration of the test, test pressure, results obtained
- Decisions on any repairs and conclusions.

2.4 Cleaning Pipework

- After testing and prior to commissioning, piping shall be cleaned out in order to eliminate foreign bodies (sand, scale, solder and welding residues, tags, etc.)
- The cleaning will be done using drinking water or filtered industrial water
- It will be performed by sluicing for at least 15 minutes at a time at a minimum pressure of 0.03 MPa (0.3 bar)
- All the necessary precautions will be taken for flushing fluids down the mains drains. To that end, temporary water removal pipes will be installed in case of need
- If flushing out is impossible, pipes may be cleaned with compressed air, the residues being pumped out into the open air
- The manpower and equipment needed for cleaning shall be provided at the Contractor's expense

- Water will be provided in accordance with paragraph 2.3.2.

2.5 Pump tests

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 classe 2),
- determination of the required NPSH at the operation point and its marking on the pump NPSH theoretical curve,
- determination of the motor power comsumption at the tests points,
- verification of required materials (foundry certificates),
- adjustment of components such as motors and coupler line alignments,
- pressure tests (1.5 x operating pressure).

3. PHYSICAL VERIFICATION OF DELIVERIES

3.1 Electrical tests

These shall be conducted to check conformity with the Technical Specification and its Annex D. A report shall be prepared by CERN.

All defects shall be repaired by the Contractor at his own expense before provisional acceptance.

3.2 Tests on the Automatic Systems

All components shall be tested after installation for correct functioning. The Contractor shall adjust all safety devices (pressostats, thermostats etc.), and the various adjustment or measurement values, such as pump flow rates, power consumed etc. shall be recorded. The Contractor shall draw up a technical document for each machine, giving a summary of this information.

3.3 Monitoring System

At each installation point, after the monitoring connections to the central management systems have been made, the Contractor and CERN shall jointly check access to the controls and readings, in accordance with the Technical Specification, its Annex E and the function analysis.

3.4 Testing programmable controllers

After installation, all programmable controllers, control loops and regulation stability performance will be subjected to functional analysis for test purposes. The Contractor shall adjust the various safety devices (pressure switches, thermostats, etc.). The various settings or measurement values such as flow-rates, pressures, absorbed currents, etc. shall be noted. For each of the circuits, the Contractor will provide a technical document where this information will be recorded.

The stability of the regulation shall be tested by the Contractor and validated by CERN. This shall be done with the help of the data recorded over the period of one year after the commissioning of the plant.

4. PERFORMANCE TESTS OF COOLING PLANT

The Contractor shall run a series of tests intended to check the performance he has given in his own specification document, in accordance with the CERN specification.

Guaranteed values of the different circuits:

Acceptable maximum deviations from the values (flow-rates, pressure levels, cooling powers) of this Technical Specification and its annexes are as follows:

Flow-rate	± 0.5 %
Pressure levels	± 2 %
Temperature	± 0.5 % (except ECAL cooling circuit)
Cooling power	± 2 %

Stability of control loops for water temperature level set at:

Chilled water	6 °C ± 0.5 K
Mixed water	13 °C ± 0.5 K

Depending on the heat to be dissipated, tests shall be made as close to the rated values as possible. If these values are not attained the tests shall be made on part-load. The Contractor must attach to his tender all the various documents (curves, design memoranda, etc.) that can be used to determine the values of the rated thermal power as a function of the part-loads.

Test procedure:

The tests shall be run on the CERN site.

The Contractor will have submitted for CERN's approval the test protocols beforehand (at least two weeks before the start of testing).

CERN's representative may request supplementary test series, for example after calibrating the sensors used or bringing the measurements into line with standards.

If the results of the tests show that the equipment does not meet specification or have defects, the Contractor shall take steps to improve the performance or correct defects or errors until, after repeated tests, they do meet specification and all detected defects and errors have been eliminated.

5. CONTROL AND MONITORING SYSTEM ON SITE INSTALLATION TESTS

The Contractor can only request CERN to proceed to the on site installation tests (§10 of the Specification) if the following points have been done:

- The compliance of the every element in the system with the specification.
- All labelling for electrical components, control, devices, sensors.
- The availability of the documents to be provided (§7 of the Specification).
- The cleaning of the installation.

The Contractor will carry out the tests, measurements, adjustments and calibration on the measurement and regulation loops.

The various operations needed for the tests shall be performed by the Contractor, who shall assume full responsibility for them. He shall be responsible for any incorrect work and for all his operation.

The on site installation test is composed of two different stages.

- Static tests stage
- Dynamic tests stage

5.1 Static Tests Stage

The static tests procedure shall be implemented without the power components (motor-pumping set) .

For the electrical part, an inspection, with a CERN responsible, shall be made to ensure that all the equipment operates properly and that the various adjustments have been correctly made.

Various inspections shall be made, e.g:

- Measurement of the insulation of the systems between phases, neutral and with respect to ground.
- Measurement of the insulation of the systems between phases and neutral
- Inspection of the various control and protection systems.
- The electrical compliance of the installations with the specification (§8 of the Specification).
- All components, which shall have power/supply provided by the Contractor.

All the cables without exception shall be inspected with special regard to the measurement of the insulation.

The control system tests procedure shall be :

- Check on the continuity of the programmable controller inputs and outputs
- Full testing of the process measurements
- Check on the automatic sequences
- Safety system tests
- Full testing of the supervisory application
- Test on the controls
- Check on the process alarms
- Equipment_Controller tests
- TDS alarm test
- Client-server application test

5.2 Dynamic Tests Stage

Once all the operating defects discovered during the static testing stage have been remedied, the Contractor shall submit to CERN approval, in accordance with the schedule for the other operations on the CERN work site, the date of the dynamic tests stage.

The dynamic tests stage consists of the installation tests with the motor pumping set powered. The principal criteria for the dynamic tests is whether the considered installation is ready for an operational run. A period of a dynamic operation for the installation is required to show that every software and hardware meets all the requirements of Function and Malfunction draft in accordance with the specifications.

6. LONG TERM ADJUSTMENT

After successful completion of all tests, the Contractor shall carry out the long term adjustment of the system at monthly intervals, for at least six months, with fine-tuning of the PID controller.

Report:

A report will be drawn up by the Contractor after every test, in duplicate, and will contain the following information:

- reference no. for test and date held,
- values specified and results obtained together with differences between the two;
- decisions on any repairs or adjustments required to meet standards, and
- Conclusions.

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

All defects shall be repaired by the Contractor before the provisional acceptance.

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

Group Code.: TS/CV
EDMS No.: 440027
LHC Project document No.: LHC-F-CI-0007

The Large Hadron Collider Project *IT-3255/TS/LHC*

Technical Specification for Supply and Installation of the Underground Cooling Plant for the CMS Detector in the Experimental Area at Point 5 of the LHC

ANNEX C TO THE TECHNICAL SPECIFICATION

Drawings and Schematics

January 2004

1. LIST OF DRAWINGS

	T I T L E
CDD:	
CMSDIEXL0028	SERVICE CAVERN USC55 (INFRASTRUCTURE, CV ZONE, SERVICE GALERIES)
CMSDSEXL0027	SERVICE CAVERN USC55 CROSS SECTIONS
CMSDIEXL0027	INFRASTRUCTURE OF UXC55
CMSDIEXC0009	COOLING DETECTOR, PIPING LAYOUT
CMSDIEXL0034	EXPERIMENTAL CAVERN UXC55 (LONG SECTIONS)
CMSDIEXL0035	EXPERIMENTAL CAVERN UXC55 (CROSS SECTIONS)
CMSDSEXL0017	LASER ROOM
CMSDSEXL0023	TUBES BETWEEN USC55 AND UXC55
CMSDSEXL0029	USC55 - BREACH AND SLAB
EDMS:	
CMS-DISIR-ED-0002	RACKS NUMBERING SCHEME USC55 UPPER LEVEL
CMS-DISIR-ED-0003	RACKS NUMBERING SCHEME USC55 LOWER LEVEL
CMS-DISIR-ED-0004	RACKS NUMBERING SCHEME UXC55 ZONE 4
CMS-DISIR-ED-0005	RACKS LAYOUT USC55 UPPER AND LOWER LEVEL
LHCF35240008	HYDRAULIC CIRCUIT - CHILLED AND MIXED WATER
LHCF35250001	UXC55 EXPERIMENT AREA PIPING
LHCF35240001	HYDRAULIC NETWORK BETWEEN PM54&CV ZONE
LHCF35240003	USC55 COOLING STATION TOP VIEWS
LHCF35240004	USC55 COOLING STATION ELEVATION VIEWS
LHCF35240005	USC55 COTROL AREA PIPING
LHCF35000001	USC55-UXC55 SERVICE AREA PIPING
LHCF35000011	COMPRESSED AIR NETWORK
LHCF35000012	FIRE NETWORK
LHCF35000010	FIRE NETWORK FOAM SYSTEM DIAGRAM
LHCF99900001	STANDARD DRAWING - DRAINS AND AIR VENT PRINCIPLE
LHCF99900003	STANDARD DRAWING - SUPPORT – PRINCIPLE OF ASSEMBLY
LHCF99900013	STANDARD PIPE SUPPORTS - PRINCIPLE OF ASSEMBLY 2
LHCF99900014	STANDARD DRAWING - STAINLESS STEEL FLANGE
LHCF99900015	STANDARD DRAWING - CARBON STEEL FLANGE
LHCF99900016	STANDARD DRAWING - STRAIGHT BRANCH FROM COLLECTOR
LHCF99900017	STANDARD DRAWING - 2 - DRAINS AND AIR VENT PRINCIPLE
LHCF99900018	DETAIL - 2 - HYDRAULIC CONNECTIONS
LHCF35240008	HYDRAULIC CIRCUIT - CHILLED AND MIXED WATER
LHCF35240022	HYDRAULIC SCHEMATIC - AL CIRCUIT
LHCF35240023	HYDRAULIC SCHEMATIC - ED/CU CIRCUIT
LHCF35240024	CMS - PROCESS INSTRUMENTATION - ED/CU
LHCF35240025	CMS - PROCESS INSTRUMENTATION - ED/AL
LHCF35240026	CMS - PROCESS INSTRUMENTATION - CHILLED AND MIXED CIRCUIT

2. ALPHANUMERICAL SYSTEM FOR THE IDENTIFICATION OF THE COMPONENTS

2.1 General

This system has been developed by CERN for the LEP project for the following reasons:

- For identification of the various systems and components
- For use in lists of quantities and prices
- For organising transportation, handling and installation of materials
- For the labelling of system components

The contractor shall use this system in all the documents and drawings he submits to CERN for approval.

2.2 Explanation of the System

The system comprises of four groups of characters as follows :

2.2.1 First Group

Four Alphabetical characters

- 1st (letter): U stands for ventilation and F for fluids.
- 2nd (letter): material category

A	**Air Handling Unit**
B	**Transducer**
C	**Compensators**
D	**Water Treatment**
E	**Heat Exchangers**
F	**Filters**
G	**Ducts**
H	**Chilled waterproduction plant**
I	**Electrical distribution equipment**
J	
K	**Controllers**
L	**Measuring Instruments**
M	**Motors**
N	
O	**Electronic operators**
P	**Pumps and compressors**
Q	**Miscellaneous Cooling and Ventilation Equipment**
R	**Vessels**
S	**Supports**
T	**Pipework**
U	**Fans**
V	**Valves and dampers**
W	
X	
Y	**Racks**
Z	**Surveillance**

- 3rd (letter): defines the type of material *
- 4th (letter): clarifies the type *

* see chose pages which group the identification , the symbol and the name.

2.2.2 Second Group

Three numerical Characters

These characters define the order of the components.

2.2.3 Third Group

Four or five Alphanumerical characters

These characters define "the zone where the component is situated".

- 1st (letter): type of zone

S	**-**	**Surface**
R	**-**	**Ring**
U	**-**	**Underground**
P	**-**	**Shafts (pits)**
T	**-**	**Tunnels**

- 2nd (letter): identifies "the function of the zone"

A	**-**	**High frequency, Acceleration**
B	**-**	**Low Beta**
D	**-**	**Unloading of material**
E	**-**	**Electricity**
G	**-**	**Gas**
H	**-**	**Compressor He**
I	**-**	**Injection**
J	**-**	**Junction**
L	**-**	**Link**
M	**-**	**Magnets**
P	**-**	**Protection**
R	**-**	**Rectifier**
S	**-**	**Service**
T	**-**	**Transfer of beams**
U	**-**	**Ventilation**
W	**-**	**demineralised water**
X	**-**	**Experiments**
Z	**-**	**Annexe**

- 3rd (figure or letter): identifies the "locality of the intersection point". In this case:

1	-	Commune of Meyrin- ATLAS	Switzerland

A supplementary letter is used when necessary to define the function of the area.

Examples:

SLU - Surface link for ventilation
SUH - Surface building for helium compressors, adjoined to SU
SUX - Surface buildings for ventilation adjoined to SX
UFX - Underground cooling room for the detector

- 4th or 5th (figure or letter): "places and underground zone in relation to an intersection point", like:

  5 - Intersection point
  4, 3, 2, 1 - Moving anticlockwise from the intersection point
  6, 7, 8, 9 - Moving clockwise from the point of intersection

2.2.4 Fourth Group

Four Alphanumerical Characters (information)

- 1st (number): defines the assignment of the circuit or the area in which the installation shall take place

1 - Machine tunnel
2 - Accessible zone
4 - Experimental zone (inside)
6 - Survival zone (inside concrete module and protected lobby)
7 - Survival and accessible zone
10 - SU building supply
11 - SUX building supply and extract
12 - SD building supply and extract
13 - SX building supply and extract
14 - SZU33 building supply

- 2nd (letter): defines the "direction of the network" in relation to: the centre of the LEP ring, when the site does not permit identification (SU, connection SU/PM, PM, etc.). D is for "Droite" (right, clockwise), G is for "Gauche" (left, anticlockwise) and C is for "Centre", and P is for "Provisional". GD is for left and right.
- 3rd and 4th characters:

  For point 2 (UX only),

  1 closest to the centre

  2 next closest,

  3 furthest from the centre.

3. LIST OF SYMBOLS

SYMBOL	DESCRIPTION
PEE	Mixed water pump
PEF	Heat recovery water pump
	Expansion vessel
EWF	Heat plate exchanger
	Air separator

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

Group Code.: TS/CV
EDMS No.: 440027
LHC Project document No.: LHC-F-CI-0007

The Large Hadron Collider Project ***IT-3255/TS/LHC***

Technical Specification for the Supply and Installation of the Underground Cooling Plant for the CMS Detector in the Experimental Area at Point 5 of the LHC

ANNEX D TO THE TECHNICAL SPECIFICATION

Electricity

January 2004

1. BASIS FOR CALCULATIONS

1.1. Circuit-Breaking Capacity

The equipment used to protect and cut off the various circuits shall be compatible with the possible short-circuit current at the head of the main rack power supply.

The Contractor shall obtain information on the short-circuit power of the power supplies provided by CERN in order to take all the necessary steps to comply with the NF C 15-100 regulations (circuit-breaker selection, etc.).

1.2. Mechanical Strength

This part of the calculations relates especially to the resistance of the materials to the static, dynamic and electro-dynamic forces. The control cubicle shall be highly rigid. Cable carriers, busbars, minor metalwork, supports, etc., shall be designed and adapted for their purposes in order not to distort the cubicle in any way and to withstand the ordinary overloads. They shall be installed with special care and the equipment used shall be of the highest quality.

1.3. Equipment Selection

In all cases the equipment used (circuit breakers, switches, differentials, etc.) shall withstand the short-circuit currents at their point of installation. The Contractor shall provide calculation notes to justify the sizing of the cables and the protecting devices.

The calculation notes shall comply with the following criteria:

- Protection of the cables
- Protection of the terminal equipment
- Protection against indirect contacts
- Permissible voltage drops
- Selectivity

1.4. Environment

The cubicle shall be designed taking into account the environmental conditions which may range from +10 °C to +40°C.

2. UIAC - POWER CUBICLES WITH PLUG-IN CRATES (CERN'S SUPPLY)

The make of this type of cubicle will be Hazemeyer or similar, with plug-in crates, in the blue colour. Each feeder is fitted with a communication module. The values of the measured and calc ulated data(current, power,…) are available in real time.

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 protecting devices,
- Laying and connecting the control and monitoring cables needed to each of the components of the cells
- Providing a bus connection to access the communication modules of each cell from the PLC

3. SOFT STARTER CUBICLE

The Contractor shall provide a Soft Starter cubicle for the pump motor with a power above 160kW. Thee cubicle will house the Soft Starter and must have the following features:

- Vertical type
- Electro-plated zinc sheet, highly rigid, coated with an epoxy-polyester paint
- Maximum height 2 m
- Grip handle with lock type 2132A
- IP 54
- Temperature inside the cubicle below 35°C.
- protection of the soft starter against short-circuit

The Soft Starter must be type Schneider for compatibility reasons

4. UIAN : CONTROL CUBICLE (SUPPLIED WITH SECURED POWER)

The Contractor shall provide the UIAN cubicle, including the control components.

The cubicle shall be of vertical type, of electrically galvanised sheet steel 15/10ths thick with epoxy + polyester paint coating with aerating apertures. All the sides shall be closed. They shall be fitted on bases or metal frames and designed for wall-fixing. Their upper edge shall be at a maximum of 2 m from the finished floor level.

For the sake of uniformity in spare parts, CERN requires the use of equipment from the Télémécanique's or Merlin Gérin's range. The racks shall be prefabricated and pre-wired on the terminals.

The cubicle shall comply with the criteria below:

- Colour RAL 2003,
- vertical painted sheet-steel with all sides sealed,
- doors fitted with handles and 2132 A-type locks,

- IP 54,
- cubicle earthed,
- 30 % spare space available for the future extensions (also 30% of available power capacity regarding the sizing of bus bars and the main switch),
- internal lighting switches on when the doors are opened,
- relay circuit in accordance with PLC input/output (maximum voltage 24 V),
- marking of the relays and the circuit-breakers by engraved plates (incl. the equipment on the doors),
- have en engraved plate with the name of the cubicle, the origin of the power supply, the name of the plant, …
- have engraved plates above each circuit breaker (or fuses) with a short description of the protected circuit,
- have a relay tuned to the safety components with gold contacts.
- the terminal blocks for control and signals shall be fitted with spring loaded terminals. The terminal blocks shall be located in the lower part of the cubicle,
- equipped with a rigid pocket for the documentation and a foldaway table for the use of a laptop computer,
- the wiring shall be fitted in accordance with the relevant technological standards and requirements and with the following provisions:
  - Separation of the power and the control circuits,
  - marking of the switch gear and the cubicles with engraved panels,
  - input cables through the cable glands,
  - all wires shall be connected to the terminal blocks,
  - the wires inside the cubicle shall be marked at both ends by coloured rings according to the international resistance identification code.

Front panel

- All the applicable "voltage on" indicator lights according to the IEC standards,
- one "general fault" flashing indicator light,
- one hand-operated emergency stop button fitted with a mechanical protection against accidental stops,
- the front rotating command of the general switch gear,
- one inspection port to view front panel of the PLC.

Composition

- One 3P+N+E 400V input according to the needs determined by the Contractor,
- one set of distribution busbars with a protection from accidental contacts,
- one four-pole cut-off device (circuit-breaker) with outside padlockable handle,
- a 3-phase voltage controller,
- one inverter (un-interruptible power supply. The type has to be approved by CERN),

- PLCs with a suitable configuration (crate, boards, memory) for the proper technical management of the process, taking into account all the data to be processed and the system's response times,
- the power supplies for the PLCs, sensors, actuators, etc. protected by circuit-breakers (DPN, C32H-DC or the like) ,
- a stand-by power supplies protected by a circuit-breaker (number to be determined),
- one circuit breaker with 30mA differential protection for the supply of two 230 V 2x 10/16 A + E sockets, one Swiss type (Feller type 13) and one French type (CEE17).

5. CABLES

All cables shall meet the requirements of Safety Instruction IS 23 Rev. 2 and colour code A3. They shall be marked in black indelible print on white labels.

The cables shall be carefully laid out and also be marked every 20 metres (in straight sections), at each extremity and at each change of direction. They shall be laid in two layers at the most. They shall be subject to no mechanical stress when being laid.

Every precaution shall be taken with regard to the environment in the transmission of the analog and digital measurements, and the peripherals, especially:

- A suitable connecting cable,
- a lightning protection,
- a galvanic insulation.

CERN gives in the list of unit prices the type and cross-section of different cables by way on indication only. Should the Contractor believe that a different type/cross-section is needed he shall indicate it in the price list.

All the electrical components over 50 V shall be connected to an earth circuit. The earth cables shall be yellow/green. Its cross-section shall be suitable for that of the active conductors in accordance with the prevailing standards and PG requirements. The Contractor shall be responsible for the equipotential links of the metal components of the installations. It shall be made using a flexible copper braid or cable.

6. CABLE CARRIERS

The cables shall be laid on cable carriers. The cables shall be secured to the cable carriers every 3 m at the most. The cable carriers and the connections between the main cable carriers and the electrical components of the installations shall be supplied and fitted by the Contractor.

The "power" and "control" cable carriers must be physically separated. The heavy-current cable carriers shall run beneath those for low currents, with a minimum distance between them and shall not be perpendicularly crossed. All the cable carriers shall have an excess supporting capacity of at least 25%.

The Contractor shall use electro-zinc plated cable trays from CABLOFIL or a product of equivalent quality. The whole structure shall be rigid. The Contractor shall ensure that the bearing structure is suitable for attachment and shall fit all the securing accessories for both suspended and cantilever-fitted components.

The cable carriers fitted by the Contractor shall be laid out in such a way as to allow a clear passage and not hinder the dismantling of equipment (valves, pipes, etc.) which may lay in the vicinity.

CERN gives in the list of unit prices the type and width of different cable trays and carriers by way on indication only. Should the Contractor believe that a different type/width is needed he shall indicate it in the price list.

The Contractor shall supply copies of the descriptions and other technical information (technical data sheet) for all the proposed equipment, clearly showing the results of the selection in accordance with CERN specifications and requirements.

The Contractor shall not install any cable carriers before having obtained CERN's agreement.

No cable shall be unsupported.

7. ELECTRICAL CONNECTIONS

The Contractor shall be responsible of all the connections.

All the connections shall be made in accordance with normal trade practice and shall comply with the prevailing standards and the attached CERN technological requirements.

No junction boxes may be fitted on runs between the points normally fitted for their connection (physical continuity).

The connections required for circuit branches shall be made in boxes provided for the purpose and using terminals only.

These boxes shall be marked on the diagrams and working drawings and fitted at points where they are separate and permanently accessible. The location shall be shown on the drawings.

The insulated cables may be secured by collars, supports or bushes.

The wiring shall be taken through the walls, partitions, flooring and roofing in bushes.

The cables shall be marked before being powered. All cables without exception shall be inspected with special emphasis on the measurement of the insulation and the markings.

The cables shall be taken into the electric racks via packing glands.

The connections shall be made on terminal blocks supplied and fitted by the Contractor. The terminal blocks shall be fitted with quick-release spring-loaded multi-input terminals (without screws) fitted with a test point. Only one conductor shall be connected to each terminal input.

The internal wiring in the racks shall run in perforated plastic trunks with covers.

All the cable ends shall be fitted with clamped end-caps.

Each yellow-green protective conductor shall terminate individually on a bar to ensure continuity.

No more than two inputs or outputs on the same connection block shall be permitted for active conductors. If more than two conductors are to terminate on the same connection block, a busbar tail shall be used.

The use of terminal-relays with several conductors clamped at the same point is forbidden.

Each rack shall have a power, a control and a signalling terminal block.

8. ELECTRICAL DRAWINGS

1.5. Specification

The technical documentation to be placed in the cubicles shall be composed of :

- Cover: standard CERN title block
- index
- front panel of the cubicle
- layout of the components in the cubicle
- folios of the power/control circuits (folio 100->199)
- folios of the analog inputs (folios 200->299)
- folios of the analog outputs (folios 300->399)
- folios of the digital inputs (folios 400->499)
- folios of the digital outputs (folios 500->599)
- terminal diagrams with both starts and ends (folios 900->980)
- list of equipment (complete nomenclature)
- cable book
- loop diagram of each component(sensor, actuator, motor, …) : drawing showing all the electrical connection (power/control) related to the component

1.6. Electrical components

Symbols used shall be according to the IEC 617 standard.

Numbering of the equipment

The name of each equipment shall be determined with the folio number, the type of the equipment and a chronological number.

Protecting devices

Regarding the characteristics of the protection device, the following information shall be reported:

- (voltage) nominal current
- range setting
- time-delaying
- type

coils/relays

The marking of the relays shall be labelled as following:

xKmy : power contactor
xKay : auxiliary relay
with x: folio number

y: chronological number

Under each coil/relay, there shall figure :

- function
- list of auxiliary contacts (according to VDE standard)

Motors

For each motor, a table comprising the function of the item and the technical data below shall be included:

- name/Item
- In (A)
- P (kW)
- rpm

shall be written underneath each motor.

Terminals

XP; power terminals
XC: control terminals

Transformers and other feeders

Their function and characteristics shall be defined

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

Group Code.: TS/CV
EDMS No.: 440027
LHC Project document No.: LHC-F-CI-0007

The Large Hadron Collider Project *IT-3255/TS/LHC*

Technical Specification for the Supply and Installation of the Underground Cooling Plant for the CMS Detector in the Experimental Area at Point 5 of the LHC

ANNEX E TO THE TECHNICAL SPECIFICATION

Regulation, control and monitoring

January 2004

1. GENERAL REQUIREMENTS

The Contractor shall be responsible for supplying and installing all the equipment necessary for the regulation, control and monitoring of the installations.

The regulation loops shall be designed to ensure the requested functionality and dynamic performances of the process.

The control system and its associated components shall be designed to report status and alarm information to the Technical Control Room (TCR). The communication between the local supervision and the TCR is done by means of the CERN TCP/IP network.

The control system and its associated components shall be designed to provide the possibility of changing set point, commanding and supervising the states of the process remotely from the Experiment Control Room (ECR). The communication between the local supervision and the ECR is done by means of the CERN TCP/IP network.

The automatic control installation shall be configured so that remote commands and set points from the ECR have the priority to those commands or set points requested from the local supervision. The latter shall only be considered whether the appropriate operation authorisations have been granted by the ECR, which transmits this information to the process control PLC.

Means shall be provided so that all the operations that can be operated automatically can also be performed manually.

The information on the operational mode that is active shall be read by the local supervision from the process control PLC. When the local operation is active, this information shall be displayed in the local supervision SCADA application and also transmitted to the TCR:

- *Local operation*
    - *Manual:* use of the manual local commands (for maintenance interventions or tests).
    - *Automatic:* automatic control and operation of the facilities by the local supervision, or by means of a laptop computer supporting the PLC dialogue software (refer to 1.1.2), locally connected to the PLC or remotely through the network.
- *Remote operation:* autonomous and automatic control from the remote ECR monitoring system.

The functional safety of the system shall not be affected by the type of operational mode that is selected.

Figure 1 shows a principle schema of all the control system architecture and its interfacing with the external systems: mainly ECR, TCR. Data exchange with the primary water process control PLC (Schneider® Premium TSX make) shall also be possible through the CERN TCP/IP network.

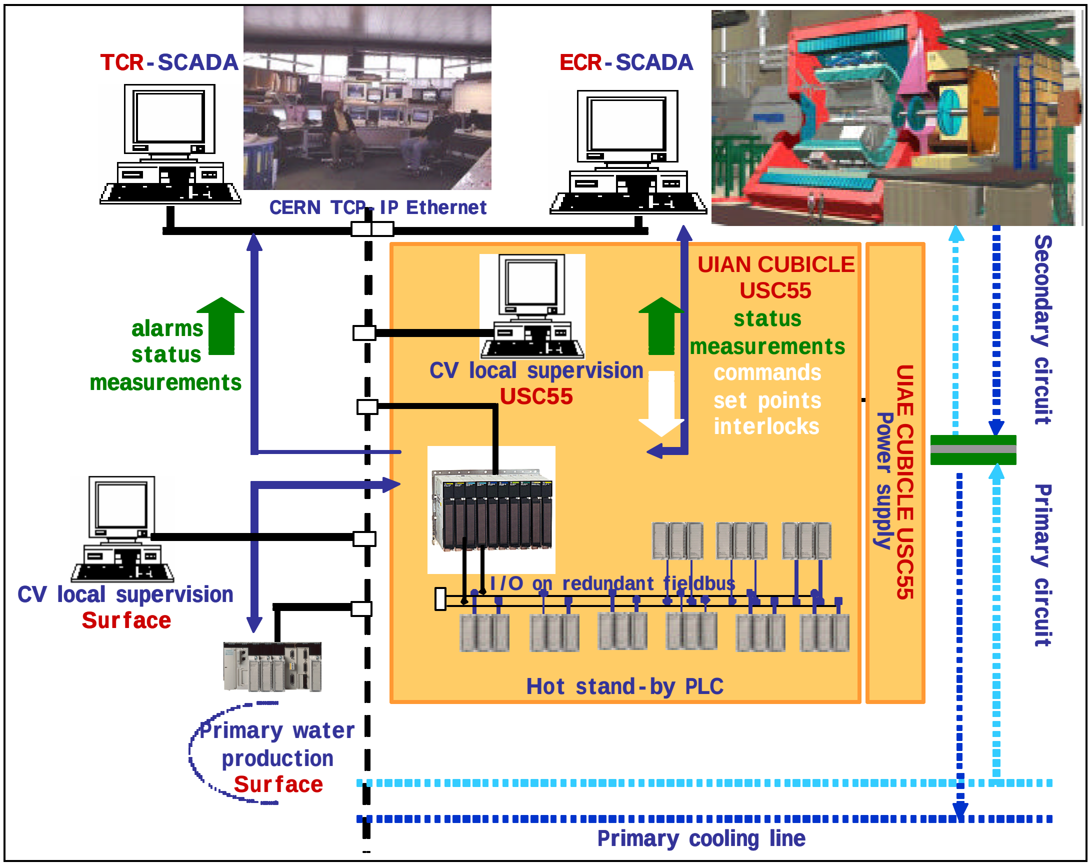


Figure 1. Control system architecture and interfaces with external systems: mainly ECR, TCR, but also the primary water production process

1.1 Control and local supervision

1.1.1 Hardware

The control system shall be built on a hot stand-by architecture (normal/stand-by CPU redundancy), of the make Schneider® Quantum, complemented with a Wizcon® SCADA supervision[1] platform.

The main PLC control rack shall include at least:

- 2 power redundant supply module 230V-AC / 24V-DC / 15A equipped with Modbus and Modbus Plus interfaces (TSX Quantum),
- 2 CPU module (TSX Quantum),
- 1 kit hot stand-by (normal/standy-by CPU redundancy) for TSX Quantum 140CPU53414A (TSX Quantum),
- 1 Ethernet communication module (TSX Quantum).

A distributed I/O architecture can be helpful in order to optimize the cabling and it is proposed to install I/O stations in proximity of the equipment. 30% spare I/O capacity shall be foreseen at each distributed peripheral station. Each station requires an I/O distributed peripheral

[1] A product of Axeda Supervisor (www.axeda.com)

adapter module (TSX Quantum). Distributed peripheral stations shall be housed in cubicles conform to the prescriptions given in 2.5 of Annex D.

The Contractor can also opt for a centralized I/O architecture (all the I/O modules inside the main control cubicle), if this solution is considered more advantageous. A spare I/O capacity of 30% shall be foreseen.

The local supervision platform shall consist of a Windows XP PC platform, with a standard Ethernet communication card, supporting the Wizcon® SCADA and its associated communication drivers.

The local supervision PC shall be integrated in the control cubicle, which shall allow the use of the local supervision station from the front panel. Access for displaying the monitor screen shall be provided on the door of the control cubicle. The keyboard and mouse shall be secured to a hinged panel below the monitor screen.

The features of the office automation PC shall be at least:

- Case type — Midi Tower,
- CPU — Intel Pentium IV 2.4 GHz, sys. bus at 533Mhz,
- Memory — 256 MB,
- Floppy Disk — 3,5” 1,44 MB,
- Hard Disk — 40 GB,
- CD ROM — x 40 minimum,
- Display — 48 cm (19 inch) TFT Color LCD Panel
- Mouse — Logitech 2-buttons+wheel from & mouse pad,
- Keyboard — waterproof keyboard,
- Parallel port — Required for the Wizcon® security plug
- Warranty — 3 years
- Ethernet card — Integrated Ethernet 10/100 Mbits RJ45 or 3COM with equivalent characteristics,
- Warranty — 3 years
- Operating system — Windows XP Professional Service Pack 1 and mandatory Microsoft® security patches,
- Web server — A web server is required for publishing the Wizcon® application. For example, the Microsoft Internet Information Server that can be downloaded from the Microsoft web site.
- Web browser — Internet Explorer 6.0

The floppy disk and the CD ROM drives shall be available simultaneously.

1.1.2 Development software

The Concept® software package is required to program the Schneider® Quantum PLCs regulation and control application. In general, all the required PLC development software (packages, libraries, and licenses) shall be included in the Tender.

The Wizcon® SCADA software package is not included in the Tender. CERN will provide a set of this development software package, including the product references:

- Wizcon® development 65000 tags (WIZ-DEV-65 000)
- Wizcon® for Internet Clients (W4I-5r),
- Schneider driver for TCP/IP devices.

This set of software for developing the local supervision application will be made available to the Contractor on acceptance of the Order.

1.1.3 Application software

1.1.3.1 PLC regulation and control application

The Contractor will be in charge of the programming of the PLC application and the following services:

- Design and implementation of the control application programs, including the calculation, simulation, tuning and validation of the parameters for each regulation loop,
- the handling of the hot stand-by configuration for the redundant CPU set of the PLC, and the communication between the PLC and the local monitoring SCADA platform; the PLC will be able to inform the local monitoring SCADA about the availability/unavailability status of any of its CPUs, which has to be periodically self-tested and reported by event,
- the communication between local monitoring SCADA platform and the TCR remote monitoring system for the purpose of serving process status and alarms,
- the handling by the PLC application of remote commands and set points from the ECR remote monitoring system, as well as the reporting from the PLC to the ECR of the process status,
- the communication with the PLC which is dedicated to the chilled water production and primary cooling circuits monitoring, with the purpose of only recovering status data – no remote commands are foreseen at this level.

In particular, data structures allocation, definition of tables allowing the setting of the command and set points variables shall be carefully designed and documented in the Detailed Design Document (DDD) (refer to 2.2.4). Complete and clear information must be available in the DDD so that a laptop computer equipped with the Concept® software package can offer an operational backup to the local supervision application, should the latter be unavailable.

Logging functions (data, events, alarms, commands, graphs) and user access rights definition shall also be given particular importance and must be minutely detailed in the Software Requirements Document (SRD) (refer to 2.2.2).

The Contractor shall be solely responsible for all the installation, configuration and development of the PLC regulation and control application and its correct performance as it shall be defined in the Function and Malfunction analysis in the SRD document (refer to 2.2.2). For this purpose, expertise from Schneider® technical support organisation can be required by CERN during the software project lifecycle. This support shall be included in the Tender.

1.1.3.2 WizconÒ SCADA local supervision application

The definition of variables in the local Wizcon® SCADA database shall be foreseen for all the available process information –alarm, status, parameter, remote command,…– attached to the sensors, regulators, actuators and equipment.

The definition of status, alarms and variables that shall be archived for process analysis and troubleshooting is included in the scope of the supply, as well as all the appropriated parameterization in order to generate the archiving files in the local monitoring Wizcon® SCADA platform. The archiving files shall include: alarm history files, event history files and graphs.

Means shall be provided for the automatic deletion of old history data so that free space for the normal operation of the PC platform is always available in the hard disk.

The local monitoring Wizcon® SCADA application shall keep homogeneity with other local monitoring systems existing at CERN. In particular, it shall be compliant to the ST User Interface Conventions. CERN will provide with a Wizcon® SCADA application framework.

The development of the mimic diagrams required for the operation has to be included for the totality of the database and independently of the required number of views, which will be of approximately 20.

The local monitoring Wizcon® SCADA application shall be served to web clients for the remote use of the plant operation and TCR.

The Contractor shall be solely responsible for all the installation, configuration and development of the local supervision application and their correct performance as it shall be defined in the Function and Malfunction Analysis in the SRD document (refer to 2.2.2). For this purpose, the expertise from Wizcon® technical support can be required by CERN during the software project lifecycle.

The non-operational status of the local supervision shall not disturb the operation of the PLC, nor the communication on the fieldbuses.

1.1.4 Installation security stops

All electrical equipment shall be equipped with an installation security stop pushbutton. It shall be hardwired up to the control cubicle and from the control cubicle to the power cubicle so that the power supply to the concerned equipment is cut-off in the event of a security stop being requested.

1.2 Integration in the TCR remote monitoring system

1.2.1.1 Concept and Functions

The TCR is responsible for the overall supervision of the CERN technical infrastructure. For this a central monitoring system integrates all the data coming from the different systems such as cooling, air conditioning, electric power distribution, control and safety systems, etc.

The system coherence is assured by a unique reference database (TDRefDB), which contents all the relevant information about the monitored data.

1.2.1.2 Integration

CERN will provide the Contractor with the appropriated interface between the local monitoring Wizcon® platform and the TCR central monitoring system. This interface will be hereby called Equipment Controller (EC). This software communicates with the TCR via a message oriented Data Acquisition Library (Ddal). The installation, testing and validation for the SCADA EC configuration parameters shall be at the charge of the Contractor.

1.2.1.3 Data Definition

To ensure system integrity, the equipment data has to be defined in an equipment reference database, which is called Technical Data Reference Database (TDRefDB), along with the control system topology. Each piece of monitored data is defined as a tag, following a generic tag naming convention that covers the needs of all the systems to be supervised.

The reference database allows the configuration of the system at any time and ensures the coherence of the run-time data in the overall system. For every supervised tag, the required information includes the alarm or technical parameter description, origin, consequences, physical address, etc.

The Contractor shall provide 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 functionality. These data tag names shall be delivered using the predefined TCR data integration form, an Excel file table (refer to “TCR Control Desk Procedure” document).

1.3 Integration in the ECR remote control system

The control system and in particular the PLC software shall be designed to provide the possibility of performing some predefined operations (remote commands and change of set point) remotely from the Experiment Control Room (ECR). Additionally the control system reports back to the ECR the process status information.

The automatic control installation shall be configured so that remote commands and set points from the ECR have priority over those commands or set points requested from the local supervision (auto or manual). The latter shall only be considered whether the appropriate operation authorisation have been granted by the ECR, which transmits this information to the PLC.

The communication between the local supervision and the ECR is done by means of the CERN TCP/IP network. Additionally, the circuit interlock signals must be hardwired from the PLC digital outputs to the ECR control system racks. These racks are placed in the UXC and in the USC, at the proximity of the counting room.

The Contractor shall provide the PLC addresses corresponding to the data to be exchanged with the ECR at least eight weeks in advance to the date foreseen for the acceptance test of the complete monitoring functionality. The Contractor shall provide the means in the PLC so that these bits and words can be read / written from the ECR by OPC protocol.

Description	**Type/ Origen to Destination / Quantity**	**Transmission**
Start command	Binary / ECR to PLC / 1 per cooling circuit	TCP/IP
Stop command	Binary / ECR to PLC / 1 per cooling circuit	TCP/IP
Temperature set point	Analog / ECR to PLC / 1 per cooling circuit	TCP/IP
Remote supervision mode on (Local supervision mode off)	Binary / ECR to PLC / 1 for the installation	TCP/IP
Local supervision mode on (Remote supervision mode off)	Binary / ECR to PLC / 1 for the installation	TCP/IP
Interlock	Binary / ECR to PLC / 1 per circuit	TCP/IP + hardwired (PLC binary input)
Remote supervision mode on (Local supervision mode off)	Binary / PLC to ECR / 1 for the installation	TCP/IP
Local supervision mode on (Remote supervision mode off)	Binary / PLC to ECR / 1 for the installation	TCP/IP
Circuit in service Circuit stopped	Binary / PLC to ECR / 1 per circuit Binary / PLC to ECR / 1 per circuit	TCP/IP TCP/IP
Circuit not available (fault)	Binary /PLC to ECR / 1 per circuit	TCP/IP
Measured temperature	Analog / PLC to ECR / 1 per circuit	TCP/IP

1.4 Communications

1.4.1 Communication between the PLC and the electrical cubicles supplied by CERN

The electrical power cubicles, which are supplied by CERN, shall communicate with the PLC, by a fieldbus type Modbus or similar. The protocol and parameters shall be in conformity with the industrial standard. They shall be documented and made available to CERN. The installation of the physical link and the communication through this bus shall be under the Contractor's responsibility.

The non-operational status of an electrical cubicle shall not disturb the operation of the PLC, nor the communication on the fieldbus. This non-operational status shall be reported to the local supervision, which shall handle it as an alarm and shall signal the anomaly in a mimic diagram specifically dedicated to troubleshooting and maintenance diagnosis.

The features required to control the electrical cubicles from the PLC and from the local monitoring SCADA platform shall be included.

1.4.2 Communication between the PLC and the distributed periphery I/O

The distributed periphery I/O shall communicate with the PLC by a fieldbus type Modbus Plus. The protocol and parameters shall be in conformity with the industrial standard. They shall be documented and made available to CERN. The installation of the physical link and the communication through this bus shall be under the Contractor's responsibility.

The non-operational status of an I/O distributed peripheral station, or of one of its modules, shall not disturb the operation of the PLC, nor the communication on the fieldbus. This non-operational status of one station or one module shall be reported to the local supervision, which shall handle it as an alarm and shall signal the anomaly in a mimic diagram specifically dedicated to troubleshooting and maintenance diagnosis.

1.4.3 CERN TCP/IP network

The CERN TCP/IP network, at 10/100 Mbit/s, will allow the following communication:

- The dialogue between the PLCs and the local monitoring SCADA platform,
- the communication between the PLC and the ECR; at this level, it is requested handling remote binary and analog commands as well as serving process status data,
- the communication between the local monitoring SCADA platform and the TCR, with the purpose of providing process status information,
- the communication with the PLC which is dedicated to the chilled water production and primary cooling circuits local monitoring, with the aim of exchanging process status information.

The physical network link, as well as the network parameters (IP address, gateway, subnet mask, DNS), will be provided by CERN. The dialogue between the different equipment using this network is under the Contractor's responsibility.

All the interventions on the CERN network have to be authorised by CERN. The IP configuration parameters to connect portable computers on this network can be obtained from CERN upon request.

The Contractor shall respect the rules for a turnkey integration of industrial systems at CERN on the TCP/IP network, as defined in the "Guidelines for Integration of PLCs in CERN Services Network".

CERN requires that all networked computers use protocols based on the TCP/IP network protocol suite. All computing systems provided shall follow the CERN Computer Security recommendations; an upgrade of the underlying operating system shall not have any impact whatsoever on the application programs.

In particular, the Contractor shall be responsible for the installation in the PC platform of all the Security Patches to the Operating System, as soon as they might be issued by Microsoft. This rule applies from the moment of the computer's connection to the CERN Ethernet TCP/IP network and until the Acceptance is granted. The installation of the Security Patches shall not have any impact whatsoever on the application programs.

The non-operational status of any of the previous communication links shall not disturb the operation of the PLC, nor the communication on the CERN Ethernet TCP/IP network. This non-operational status of one communication link shall be reported to the local supervision, which shall handle it as an alarm and shall signal the anomaly in a mimic diagram specifically dedicated to troubleshooting and maintenance diagnosis.

2. SOFTWARE PROJECT MANAGEMENT

The process of planning, organising, staffing, monitoring, controlling and leading the software project will be covered in the Software Project Management Plan by the Contractor. Any deviations between estimates and actual data shall have to be reported and documented.

2.1 Software Configuration Policy

Software Configuration Management (SCM) is recognised as an essential part of the development process.

The Contractor shall, in addition to the compiled version of all the application software, supply the source software, the basic libraries and all the programs and licenses needed for compilation and regeneration. The correct regeneration of the application software from the sources, libraries and compilers provided by the Contractor and introduced into the CERN Software Configuration Tool (Razor®), may be requested during the different tests for the Provisional Acceptance.

The PLC application software shall be developed in accordance with the standard IEC 1131.3. All the variables, the sequential lines, the function blocks, the sub-programs, the operating Grafcet and the system functions calls shall be clearly commented.

2.2 Phases, activities and milestones

The control software development project, including the hardware and communication aspects which are involved, will be managed and carried out in conformity with the ESA Software Engineering Standards. Consequently, all the products resulting from the development shall be delivered in a timely manner, suitable to their purpose. There will be six major milestones that will mark the progress and each has to be agreed upon individually before proceeding to the next one:

- Approval of the User Requirements Document (URD);
- Approval of the Software Requirements Document (SRD);
- Approval of the Architectural Design Document (ADD);
- Approval of the Detailed Design Document (DDD), the Software User Manual (SUM), the code, and the statement of the readiness for provisional acceptance testing;
- Statement of provisional acceptance;
- Statement of final acceptance. This milestone falls at the end of the warranty period.

These milestones have been selected as the minimum for a workable contractual relationship.

2.2.1 User Requirements Definition Phase: Problem Definition

The Contractor shall create a document called "User Requirements Document", defining the basis upon which the control system will be accepted. The URD shall compile a general description of what the CERN expects from the system, as clearly and consistently as possible. The URD shall define all the operations that the system will perform. The URD shall define all the constraints CERN imposes on the solution. The URD shall identify also any external interfaces to the software system.

The URD has to be agreed and accepted by CERN. It will be the basic document to organise and generate the Test Acceptance Documents, for the Provisional Acceptance of the system.

2.2.2 Software Requirements Definition Phase: Analysis

The Contractor shall transform the user requirements stated in the URD into the software requirements stated in the SRD, by building a coherent and comprehensive description of what the software is to do. The Contractor shall build an implementation-independent model of what is needed according to the URD. The software requirements will, at least, include:

- *Function requirements* that are derived from the logical model adapted to the URD.
- *Performance requirements,* as a quantitative specification of the regulation functions.
- *Interface requirements* that specify all the elements with which the system must interact.
- *Operational requirements* that specify how the system will run and how it will communicate with the human operators.
- *Resource requirements* that specify the upper limits on physical resources as PLCs processing and communicating module power, main memory CPU module, PC supervisory station disk space, etc.
- *Verification requirements* that specify how the software is to be verified to be compliant with the SRD. They might include requirements for simulation, emulation, live tests with simulated inputs, real tests with real inputs, and interfacing with the testing environment.
- *Security requirements* that specify the requirements for securing the system against threats to integrity and availability. Examples of security requirements are interlocking operator commands, inhibiting of commands, read-only access, password system and computer virus protection.

Depending on the case, the Contractor may draw up, during this phase, certain detailed parts of logic sequences in an oriented Grafcet form or in others like phase diagram, operating organisational chart or description by functional blocks.

In the same way as for the function requirements, a malfunction analysis must precise and fully identify the behaviour of the processes after a restart caused by power failures or breakdowns in the various components. CERN facilities can be affected by power failures that are related to safety aspects. For this reason the local monitoring system shall be capable of an automatic restart after a power failure and return the process to a nominal state.

The malfunction analysis shall contain, at least:

- Initialisation and general control phase,
- transient task identification,
- transient task sequencing.

TS department and the CV group attach particular importance to the care taken in drawing up the function and malfunction analyses in the SRD. The Contractor shall identify in detail the resources needed to perform the work and complete the on-site tests.

2.2.3 Architectural Design Phase

The Contractor shall define the structure of the software. The logic model constructed during the previous phase is the starting point. This model is transformed into the architectural design by allocating functions to software components and defining the control and data flows between them.

The deliverable item at the end of this phase is the Architectural Design Document.

2.2.4 Detailed Design and Production Phase

The Contractor shall design, code, document and test the software. The Detailed Design Document and the Software User Manual are produced concurrently with coding and testing. The three deliverable items (code, DDD, SUM) can be subject to intermediate reviews by CERN. At the end of these reviews, the software will be declared ready for provisional acceptance testing.

2.2.5 Tests

All software verification and validation activities shall be documented in the Software Verification and Validation Plan (SVVP). The SVVP evolves throughout the software project lifecycle. Therefore, verification and validation requirements are produced and documented during the User Requirements Definition, Software Requirements Definition, Architectural Design and Detailed Design Phases (top-down approach), concurrently to the software design and development

2.2.5.1 Static Tests Stage

The static tests procedure shall be executed with the electrical power of the cooling plants' equipment turned-off. This procedure shall include:

- Check on the continuity of the PLC inputs and outputs,
- full testing of the process measurements (sensor, transmitter and signal transmission),
- check on the automatic sequences,
- safety system and process alarm tests (faults, alarms, interlocks, safety actions),
- test on the controls (manual, local supervision, remote monitoring),
- test on the TCP/IP communication with upper levels (ECR, TCR).

2.2.5.2 Dynamic Tests Stage

Once all the operating defects discovered during the static tests stage have been corrected, the Contractor shall submit for CERN's approval, in accordance with the project global schedule, the date expected of the dynamic tests.

The dynamic tests stage consists of the installation tests with the electrical power switched on for all the cooling plants' equipment. Dynamic tests validate the system, i.e. they demonstrate the capabilities of the software in its operational environment. Acceptance tests plans, test designs, test cases and test procedures are defined in the SVVP. A period of operations (3 weeks) is required to show that all software and hardware meets all the requirements in the URD.

2.3 Training

As soon as CERN takes over the installations and at a date mutually agreed, the Contractor shall delegate a qualified representative for a duration matching the size and complexity of the installation to instruct the operating staff in every detail of its operation and maintenance. Training shall be required for about 8 people.

The training shall enable the maintenance and operation technicians to take effective action on the installations in the event of a breakdown or any other occurrence resulting in an unscheduled stoppage of the installation.

Following this training, the CERN staff shall:

- be capable of very quickly diagnosing a fault on the control system,

- have a good knowledge of the PLC and local supervision SCADA application software,
- be thoroughly familiar with the control system structure,
- be able of perform all the operations concerning the use of the local supervision SCADA,
- be capable of loading a program in the PLC and installing the SCADA PC platform.

The training shall at least consist of:

2.3.1.1 General

- Details of the components of the hardware architecture,
- details and mechanisms of the software architecture,
- communication relationships involved.

2.3.1.2 PLC

- Configuration of the rack(s),
- details of the application program,
- communication capabilities,
- loading a program in the CPU,
- access to the program and application data.

2.3.1.3 Supervision

- Operation functions: process data display and organisation (including data trends, alarm and events archives, etc.), default and alarms messages management (display, acknowledgement, priority levels), function keys, alphanumeric input of set points, users' access control (passwords),
- a user manual shall be prepared by the Contractor and used as training material.

3. MEASUREMENTS AND REGULATION

3.1.1 General

All the regulation algorithms shall be drawn up by the means of the integrated PLC regulation software tools, with the support of the Wizcon® software for the human-computer interface functionality.

Following the commissioning stage and during the operating period of the installations the Contractor shall demonstrate the behaviour of the regulators in closed circuit to optimise the adjustments and behaviour around the operating point.

3.1.2 Validation of measurements

The measurement precision, if required, will be assessed only if it is possible to make a sequence of measurements without any variation in the value measured during the sampling period. The number of samples shall be large enough for the mean to be as close as possible to the value measured. The uncertainty in the measurement shall be expressed by the degree of dispersion.

The measurements shall be characterised by the degree of dispersion in the measured values (dispersion, variance). This factor is important for the assessment of a corresponding mean.

As the coefficient of variation (relative variance), representing a ratio between the variance and the mean is much more significant, it may also be used to express the measurement uncertainty.

3.1.3 Regulating circuit

The Contractor shall have characterised each one of the regulating circuits according to the items below:

- *Stability* , assurance that the process will be controlled in any condition,
- *Precision* with which the set value is reached and maintained, it shall be higher than ± 0.5 K,
- *Regulation rate* , the time needed for the system to react to variations. A distinction is made between the establishment of characteristics start-up and the continuous characteristics due to variations from an established set value ,
- *Delay time* , the time elapsing between the variation in stage and the measurement of 50% of the final set value ,
- *Rise time*, the time needed for measurement on a stage rises from 10 to 90% of the final value,
- *Response time*, elapsed time from start to the time when the difference is a maximum of +5%,
- *Peak time*, elapsed time from start of the variation of the measurement to the time when the first overshoot reaches its maximum,
- *Overshoot*, the maximum difference occurring after the set value has been reached on the application of a step, it shall not exceed ± 3 K,
- *Damping*, the ratio between the amplitude of successive oscillations resulting in a change of stage.

3.2 ECAL cooling circuit specific requirement

ECAL cooling circuit presents specific requirements in terms of temperature measurement and regulation at its secondary.

- A relative precision in the measurement is required of ±0.01 K over the operating range (15 to 25ºC),
- the operating point must be reached and maintained with a precision of ±0.25 K,

The Contractor shall consider these restrictions when selecting the sensor and transmitter. The Contractor shall consider these restrictions in the design and implementation of the regulation loop, including the calculation, simulation, tuning and validation of the regulation parameters.

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Laboratoire Européen pour la Physique des Particules
European Laboratory for Particle Physics

Group Code.:	TS/CV
EDMS No.:	440027
LHC Project document No.:	LHC-F-CI-0007

The Large Hadron Collider Project ***IT-3255/TS/LHC***

Technical Specification for the Supply and Installation of the Underground Cooling Plant for the CMS Detector in the Experimental Area at Point 5 of the LHC

ANNEX F TO THE TECHNICAL SPECIFICATION

CERN Drawings storage CDD

January 2004

1. SCOPE

This procedure is an integral part of the deliverable to the Contractors contracts, in complement to the paper and file exchange of drawings. The aim is to harmonise the electronic drawing interchange through the Internet.

The drawing number identification and additional codification makes the electronic transfer traceable. The latest approved drawing is easily identified. All transmitted drawings can be retrieved in any revision status and consultation is possible from everywhere in the world.

There are several concepts around the management of drawings and it is important to identify them clearly. Throughout this manual and in the application itself, there are several commonly used terms which are explained below in detail.

2. GENERAL

2.1 Type of Exchange

The electronic exchange comprises three types of drawing information packages :

- all graphic files on paper print
- all graphic files handed over on CD-ROM
- the approved graphic files stored in CERN Drawing Directory (CDD).

2.2 What you Need

Internet connection

- IPS Internet Provider Service (e.g. CompuServe, World - Net..). It is recommended to ask for a personal open line for your company.

Transmission of drawing

- Netscape or other browser for CDD

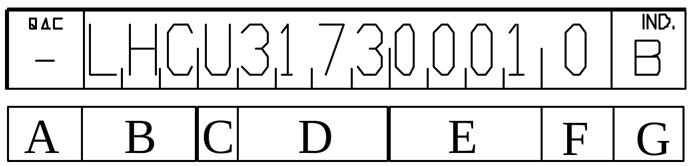
2.3 Drawing System

A drawing system can de defined as a common set of rules which define the way that any drawing created inside that system must be identified, numbered, and managed. In this way, we can deal with drawings belonging to different drawing systems. Some data and functionality will be common to all drawing systems, and some will be specific to each one.

One of the most important points which differentiates one system from another is obviously the way drawings are numbered. The following drawing system has been identified for cooling and ventilation projects at CERN:

2.4 Drawing Number

The drawing number system is given in the different documents of the LHC QAP. An abstract is given with the different blocks of the identification (A to G) :



<u>E.G.</u>: Drawing **35.LHCU3173.0001.0.B** where:

35 (not visible) = code of the Design Office which made the drawing

A : QA = the code of the quality assurance category

B : LHC = Project (LHC Project)

C : U = Activity (U=Ventilation, W =Demineralized water) ,

D : 3173 = Ouvrage code (Building 3173 at point 1.8)

E : 0001 = Sequence number

F : 0 = the drawing size A0

G : B = the reference of the revision index

<u>Management rules</u>: Drawings must be controlled twice before they can be archived.

<u>Other specific information</u>: Activity, Function and Design Office must also be defined for every drawing.

3. CERN'S DRAWING DIRECTORY (CDD)

3.1 What is CDD?

CDD is a multi-platform utility which manages engineering drawings made in any division at CERN or in external institutes and companies. Access to the data is provided via WWW (CDD Web) and a graphical user interface which is based upon ORACLE Forms (CDD Forms). Drawings which follow different numbering systems and different management rules can be handled by CDD. Several drawing systems have been identified in CERN and were therefore considered when designing the application. CDD supports the following naming systems: ALICE, ATLAS, CMS, EST/LHC, LHC-B, SL-PO, ST-CE and ST-CV; LEP and SPS naming systems are still supported though they are no longer in use. Other systems can be easily integrated on demand.

C.D.D. is the acronym for CERN Drawings Directory.

It is a multi-platform utility which manages engineering drawings made in any division at CERN. The aim of C.D.D. is not to store the graphical drawing itself, but to store a reference with every information related to the drawing. Access into this data is provided via a graphical interface based upon Oracle Forms (CDD) or the World Wide Web (CDD Web).

Drawings following different numbering systems and different management rules can be handled by C.D.D.The only condition is that those particular functionalities are well defined.

3.1.1 Parts of CDD

Different parts can be distinguished in the CDD application:

The CDD database

The CDD database is an ORACLE database where the information used in the application is stored, as well as some general procedures that deal with it. These procedures are stored in the database and can be executed from the external world.

The CDD user interfaces

The CDD user interfaces are sets of programs, which allow the CDD user to interact with the information stored in the database. There are two kinds of interface:

CDD Web which is a Web interface and offers all CDD functionalities including folder managem ent and approval process.

CDD Forms is a user interface written in ORACLE Forms 4.5 which offers some CDD functionalities: creation, quality control and retrieval of information.

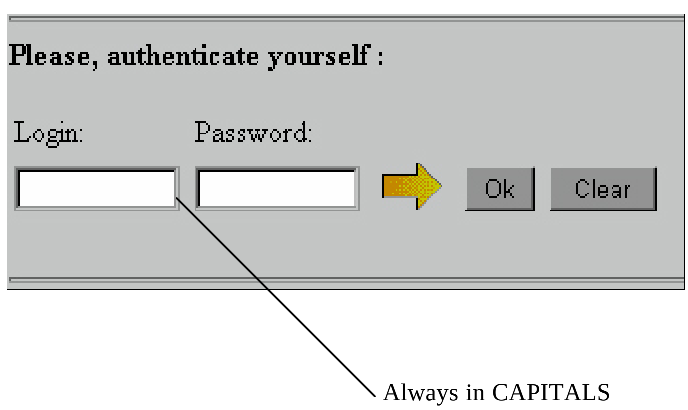
All general concepts and procedures described in this manual are valid for both interfaces. As it is the same database in both cases, the user can use the interface he prefers.

3.2 Internet Address

http://wwwlhc01.cern.ch:8005/cdd/owa/c4w.get_in

3.3 Connection

The Contractor should ask CERN for a password to access to CDD



3.4 CDD Home Page

The contractors have only access to the :

- New drawing insertion
- New version insertion
- Drawing retrieval

3.5 New Drawing Insertion

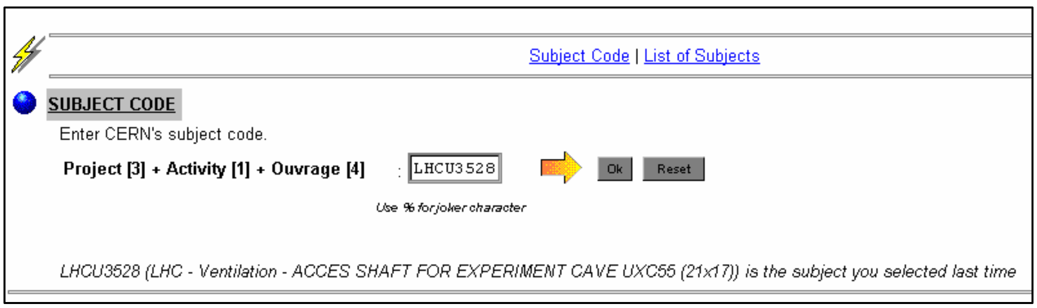
Important note:

As a general working principle, applicable to each single drawing or to a batch of forecasted drawings, it is recommended to reserve from the beginning a series of drawing numbers in CDD (even if the drawing isn't executed later).

First screen : Drawing Subject:

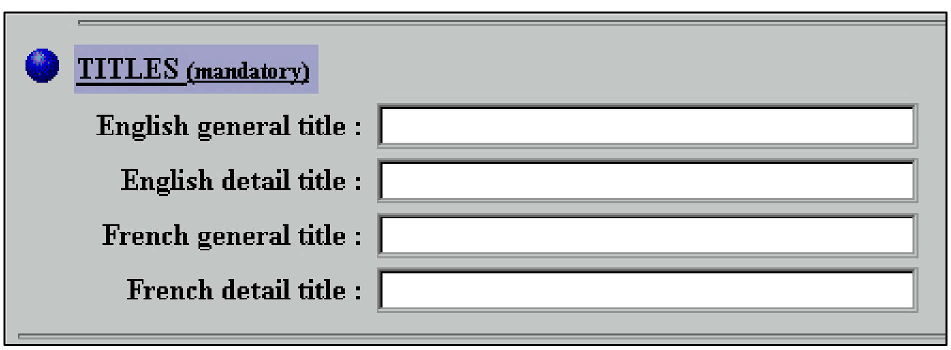
SUBJECT CODE : starts with the drawing number block identifier "B" followed by the block identifier of the design office respectively :

3 digits project code : LHC
1 digit for activity code : U for Ventilation
4 digits for the ouvrage number : 3528 for the UXC55 cavern



Second screen : Register New Drawing

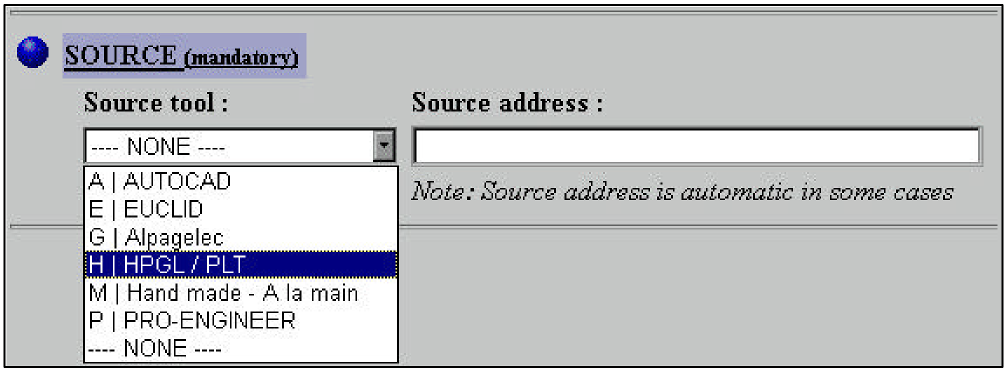
TITLES : the English title shall be mandatory completed (Appears in the drawing title block designation). The French titles are useful for text search in the drawing retrieval. If no French titles are filled in, complete each line with one space character.



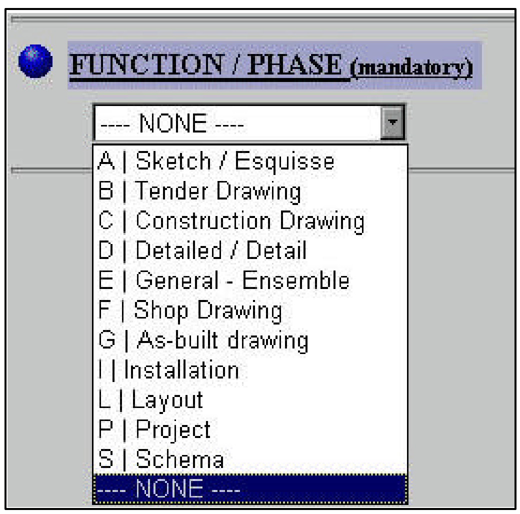
SOURCE :

Source tool : select H/HPGL/PLT

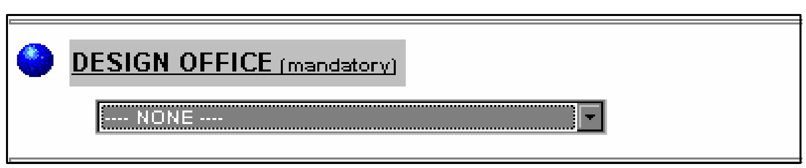
Source address : don't fill in.



FUNCTION / PHASE : select appropriate drawing type, admitted only A, B, C, F, G.

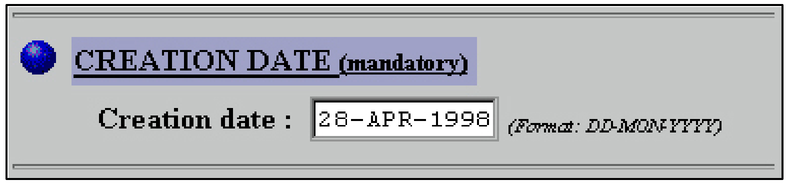


DESIGN OFFICE: enter the number code of your registered design office code

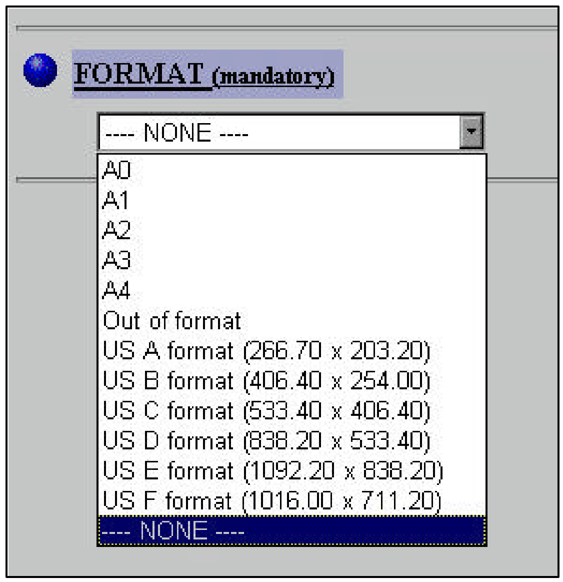


DESIGNER: filled in automatically by the login identification

CREATION DATE : Complete dd-mmm-yyyy, initial creation date of the drawing.



FORMAT : select one out of the normalised sizes A0, A1, A2, A3, A4 (corresponds to drawing block identifier “F”)



EXTERNAL REFERENCE :
The CDD system offers various options. Here’s the most used:

Option 1 : no external reference is typed in.

The CDD system will automatically increment by one the latest drawing serial number (corresponds to drawing number block identifier “E”). The contractors have no control on the drawing number.

e.g existing drawings in CDD	e.g. next insertion with option 1 will be
LHCU31830001	
LHCU31830002	**LHCU31830003**

3.6 New Version Insertion

First screen : New Version Insertion

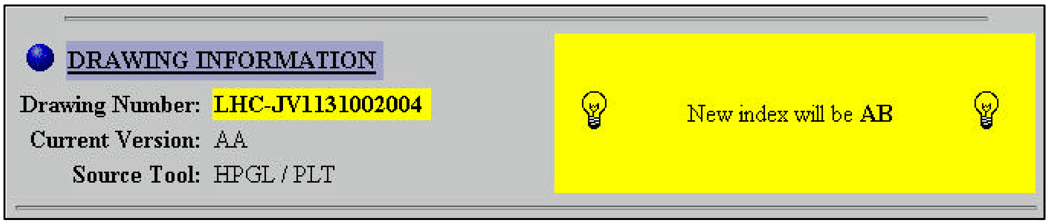
Drawing number : enter appropriate drawing number without drawing index

e.g. LHCU31830001

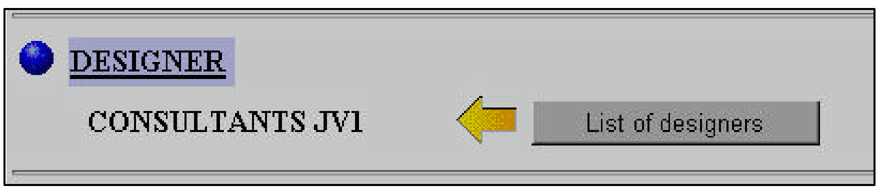
Second screen : New Version Information

Automatic display of :

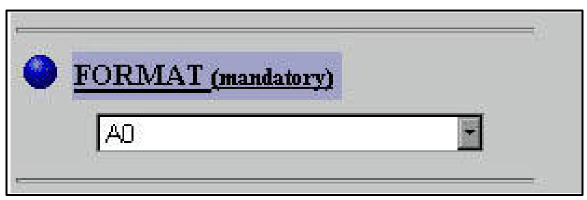
Drawing information / current version / new index suggestion



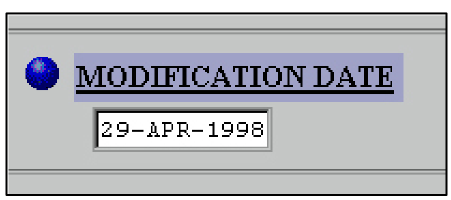
Designer



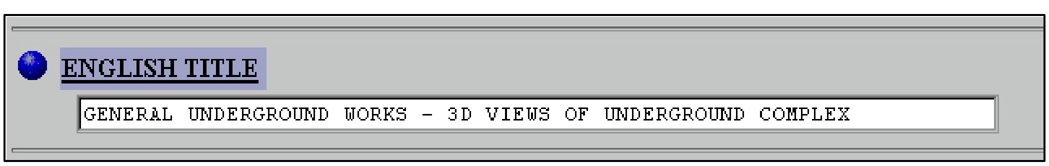
Format



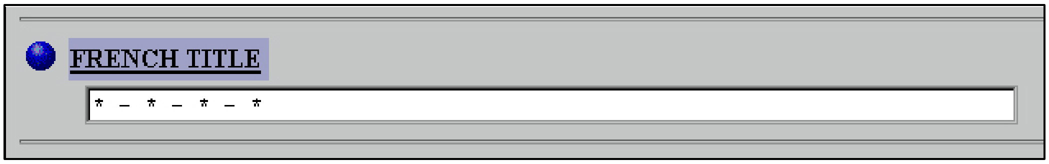
Modification Date



English title

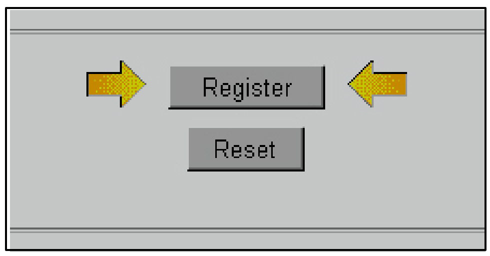


French title



To be completed :
Reason for new version

Insert (validates the new index suggestion)

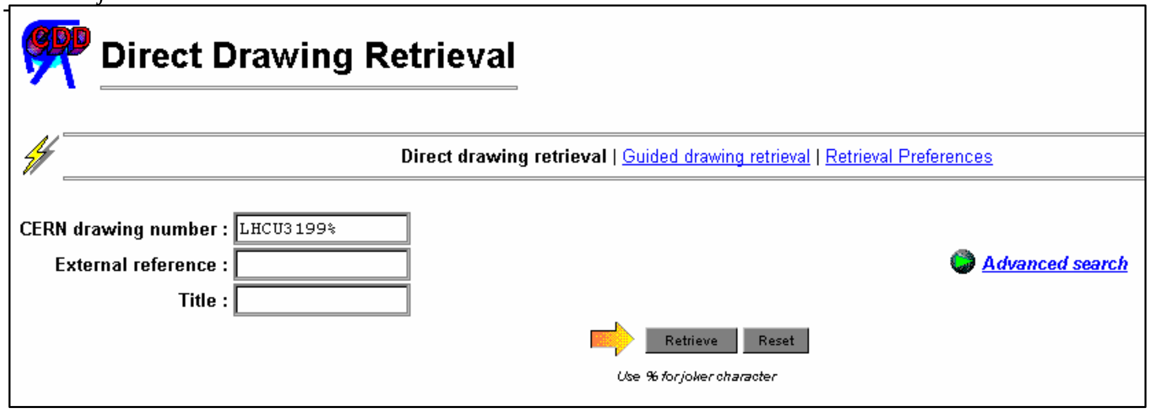


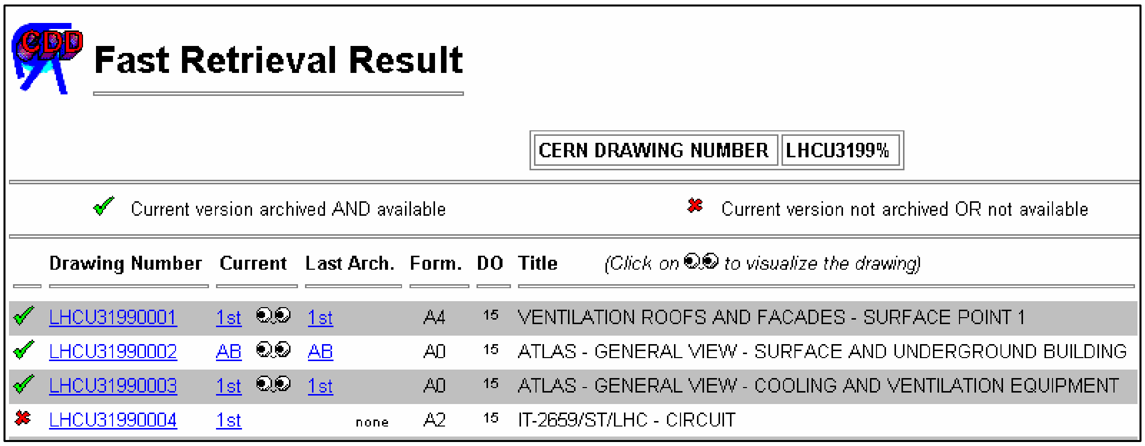
Mail controllers (send mail to the creator of the drawing)

3.6 Drawing Retrieval

Click on direct drawing retrieval or guided drawing retrieval

- DIRECT DRAWING RETRIEVAL : there exists 3 possibilities to retrieve a drawing:
  - CERN drawing number : enter the drawing number without drawing index.
  - The CDD system displays the latest available drawing version.
  - Title : not recommended (too long search)

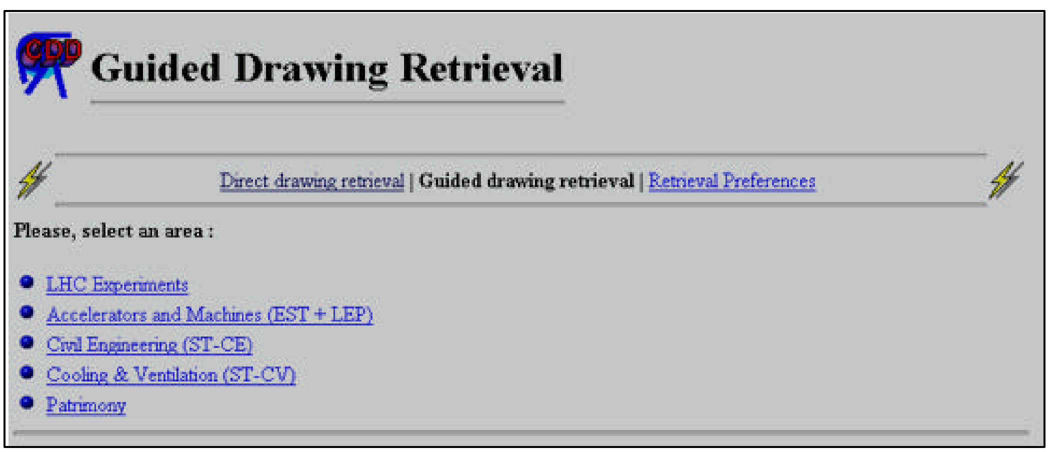




Important note :

Once a drawing has been approved by CERN, it is possible by the CDD system to display the graphics file (see second screen : Visualise drawing). For that you need to have an HPGL 1 viewer installed on your machine (see: Transmission format).

3.7 Guided Drawing Retrieval



4. APPROVAL PROCESS

The approval process is based on distribution lists. A distribution list contains the name of standard approvers and is managed by a single person, the "appro-leader".

Here is a typical approval process workflow:

1) The "appro-leader" selects some drawings that he wishes to have approved.
2) He starts the approval process, indicating a deadline and giving an explanation if necessary.
3) Everybody on the distribution list receives an automatic e-mail requesting them to send comments on the "started" drawings.
4) These standard approvers connect to CDD, check the drawings and enter their comments for each one. They can accept, refuse or mark a drawing as seen.

Note: a personal list is displayed for each approver, indicating the drawings that should be commented.

Note: if the user does not reply, this does not block the process. In most cases, no reply will be taken to mean acceptation.

5) According to the received comments, the "appro-leader" terminates the process by accepting or rejecting the drawings.

Note: nothing is automatic: the "appro-leader" is responsible for a correct analysis of the comments.

The "appro-leader" can even terminate the process before or after the deadline he set. He can decide to accept or reject a drawing whatever the received comments. He can base his decision on reports derived from the received comments.

There are several notifications which are sent to users by e-mail. For example, the "appro-leader" receives a message when the deadline is reached.

The active distribution lists are visible at any time via CDD Web as well as the relevant drawings.

5. GLOSSARY

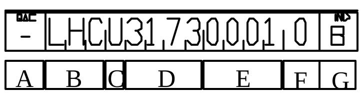
It is important to note that because CDD has been developed in the bilingual environment of CERN, where the official languages are French and English, some words are given slightly special meanings according to the habits which have developed over many years at CERN. In some cases this is because the French word does not have a well known or convenient English equivalent; for example, ouvrage. In others it is because the French meaning of a word is so well known and the word so frequently used by English speaking CERN staff in that sense, that it was judged better to use the normal CERN word rather than introduce a new term according to conventional English usage: for example the word control is used with an extended meaning, borrowed from the French.

Appro-leader	the person responsible for a list of "approvers".
Approval process	the process of collecting comments from a list of "approvers".
Approvers	the members of an approval list.

Archived	used in a general sense to mean entered into CDD. It does not have any connotations of “no longer active” or “of no current interest” as might be expected from a normal English usage.
Control	used with an extended meaning borrowed from the French meaning of the word, where often check would be the more normal English word.
Euclid	The CAD system adopted by CERN and developed by Matra
In work	being worked on
Ouvrage	works, building, structure or construction.

6. ANNEXE

General - Title block right down corner



LHCU.3173.0001.0.B

Identifier "35" : Not visible - Design office source identification = 2 digits (to be agreed ST-CV).
In house drawings 35 for "ST-CV-".

Identifier "A" : QA category = 1 digit.

Identifier "B" : Project initials = 3 digits.
Large Hadron Collider: LHC

Identifier "C" : Trade identification, e.g. Cooling Ventilation = U.

Identifier "D"* : Structure code = 4 digits.
(details see structure code list Annex, French heading "Code Ouvrage").

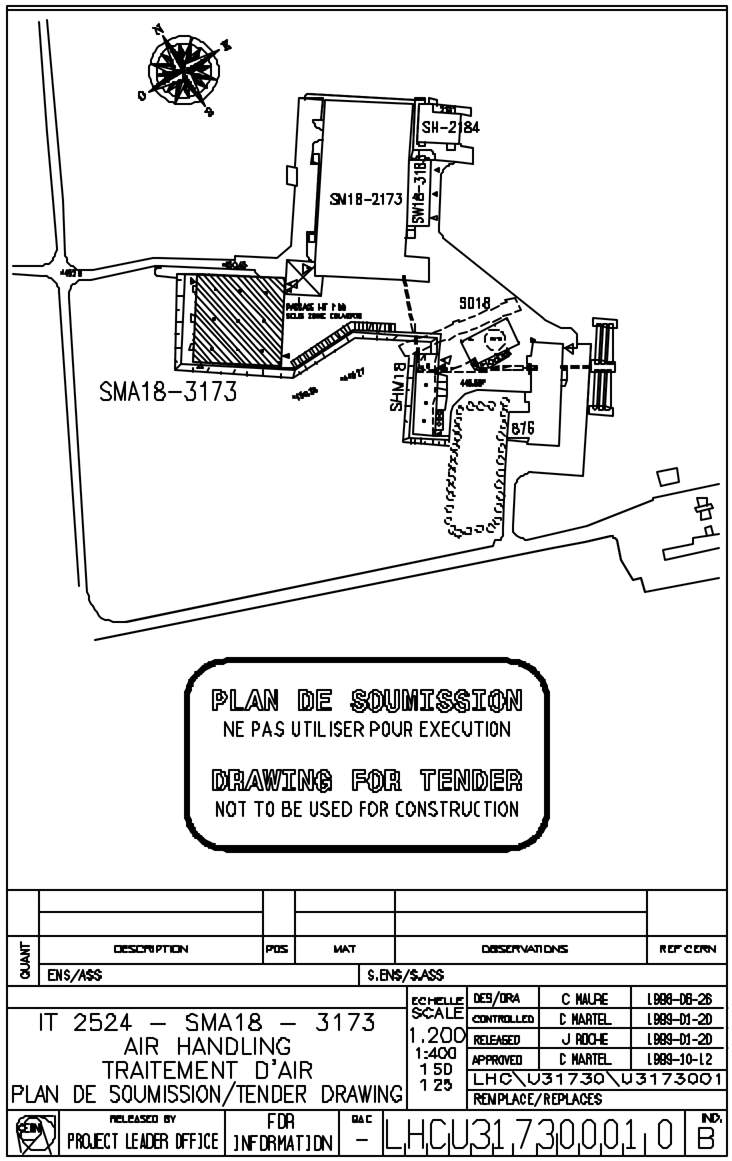
First digit = 3 for LHC
Second digit = geographical location number : 1,2,3,4,5,6,7,8
(details see Annex).
Last 2 digits : 00-49 for underground structures, 50-99 for surface.

Identifier "E" : Drawings serial number = 4 digits (fill with zeros to be left).
Read carefully 3.3.1 - External reference. See Annex.
In house drawings first digit = 0.

Identifier "F"** : Normalised drawing size = 1 digit (without preceding letter).

Identifier "G"*** : Revision index. A dash revision index shall be assigned at each new drawing. First index = "-", second index = "A", third = "B".

General - Title block



General – "Ouvrage" building code

Identifier "D" of drawing number = Code Plan / Ouvrage

Sigle Ouvrage	Code Plan Ouvrage	Description
SCX1	3162	BATIMENT CONTROLE ET BUREAUX
SD15	2155	BATIMENT (EXISTANT) TETE DE PUITS PM 15
SL14/15	3161	GALERIES DE SERVICES
	3199	ROUTE D'ACCES ET RESEAUX NEUFS
	3199	RESEAUX EXISTANTS - DEVIATION
SX1	3185	BATIMENT TETE DE PUITS PX14 ET PX16
SE1	3160	BATIMENT S/STATION ELECTRIQUE
SGX1	3170	BATIMENT MELANGE GAZ EXPERIENCE
SUX1	3182	BATIMENT VENTILATION ANNEXE
SH1	3184	BATIMENT COMPRESSEUR HELIUM
SDX1	3178	BATIMENT TETE DE PUITS PX 15
SY1	3190	BATIMENT CONTROLE ACCES AU SITE
SEH1	3160	PLATEFORME ELECTRICITE 66kV
RR13	3110	CAVERNE REDRESSEUR VERS PT 8
PX16	3132	PUITS D'ACCES CAVERNE EXPERIENCE UX15
PX14	3123	PUITS D'ACCES CAVERNE EXPERIENCE UX15
PM15	2126	PUITS D'ACCES EXISTANT US15
PX15	2122	PUITS D'ACCES EXISTANT CAV.USA15
UX15	3126	CAVERNE EXPERIENCE ATLAS
USA15	3125	CAVERNE TECHNIQUE ATLAS
ULX15	3122	GALERIE LIAISON UX15 / PX15
UPX14	3118	GALERIE LIAISON UX15 / USA15
UPX16	3130	GALERIE LIAISON UX15 / USA15
ULX14	3120	GALERIE LIAISON UX15 / USA15
ULX16	3128	GALERIE LIAISON UX15 / USA15
UJ13	3114	CHAMBRE DE JONCTION - EXTENSION UJ14
UJ17	3136	CHAMBRE DE JONCTION - EXTENSION UJ16
UPS14	3116	GALERIE VISEE GEOMETRE VERS UJ13
UPS16	3138	GALERIE VISEE GEOMETRE VERS UJ17
RR17	3141	CAVERNE REDRESSEUR VERS PT 2
	3187	PLATEFORME RESERVOIR HELIUM HORIZONTAL
SMA18	3173	HALL D'ASSEMBLAGE
SW18	3183	BATIMENT MONTAGE, EAU DEMINERALISEE, CRYO
SD18	2156	DEMOLITION DU SD18 EXISTANT + MOD. BA7-PP7
SD18	3156	BATIMENT DE DECHARGEMENT SUR PM18
SHM18	3177	BATIMENT COMPRESSEUR HELIUM
	3172	GALERIES TECHNIQUES
	3199	ROUTES D'ACCES
	3199	AMENAGEMENT DECHARGE BOIS DE SERVES
PM18	2145	BLINDAGE UJ18/PM18
UJ28	3240	CHAMBRE DE JONCTION
UP26	3229	GALERIE DE LIAISON UL26/UX25
RH23	3218	CAVERNE AIMANT DE REFERENCE VERS PT1
		BLINDAGE ET DIVERS

Sigle Ouvrage	Code Plan Ouvrage	Description
	3364	PLATEFORME RESERVOIR HELIUM HORIZONTAL
SDH4	3457	BATIMENT UCB 2
SHM4	3477	BATIMENT COMPRESSEUR HELIUM
	3461	GALERIES TECHNIQUES
	3499	ROUTES D'ACCES
	3599	RESEAUX EXISTANTS DEVIATION
	3561	GALERIES TECHNIQUES
	3599	RESEAUX EAUX USEES / CLAIRES
	3599	ROUTES D'ACCES
	3564	PLATEFORME RESERVOIR HELIUM HORIZONTAL
SDX5	3578	BATIMENT TETE DE PUITS PM 54
SF5	3565	TOURS DE REFROIDISSEMENT
SD5	2555	BATIMENT SD EXISTANT
SUX5	3582	BATIMENT VENTILATION EXPERIENCE
SU51	3580	BATIMENT VENTILATION MACHINE
SH5	3584	BATIMENT COMPRESSEUR HELIUM
SGX5	3570	BATIMENT MELANGE GAZ EXPERIENCE
SY5	3590	BATIMENT CONTROLE ACCES AU SITE
SCX5	3562	BATIMENT BUREAUX ET LABO CONTROLE
SX5 (5-13)	3585	BATIMENT TETE DE PUITS PX 56
SX5(0-5)	3585	BATIMENT TETE DE PUITS PX 56
	3599	AMENAGEMENT DECHARGE "LES MOUILLETS"
PX56	3528	PUITS D'ACCES CAVERNE EXPERIENCE UXC55
PM54	3521	PUITS D'ACCES CAVERNE TECHNIQUE USC55
US54	3520	FOND DE PUITS PM54
UXC55	3525	CAVERNE EXPERIENCE CMS
UL551	3527	GALERIE TECHNIQUE 1 ENTRE UXC55/USC55
UL552	3527	GALERIE TECHNIQUE 2 ENTRE UXC55/USC55
UL553	3527	GALERIE TECHNIQUE 3 ENTRE UXC55/USC55
USC55	3524	CAVERNE CONTROLE CMS
UJ53	3514	CHAMBRE DE JONCTION - R54 / UL54
UJ57	3537	CHAMBRE DE JONCTION - R56 / UL56
UL54	3515	GALERIE LIAISON CAV.USC55 / MACH. UJ53
UL56	3535	GALERIE LIAISON CAV.USC55 / MACH. UJ57
UL55	3522	GALERIE LIAISON TRAVERSANTE USC 55
UP53	3517	GALERIE LIAISON USC55 / RZ54
UPX56	3530	GALERIE LIAISON CAVERNES UXC55 / USC55
UP56	3533	GALERIE LIAISON UL56 / UJ56
UP55	3519	GALERIE LIAISON US54 / UXC55
UP541	3519	GALERIE LIAISON US54 / UXC55
UJ561	3530	CHAMBRE DE JONCTION GALERIES UP56 / UP57
TU561	3531	TUNNEL VENTILATION NOUVEAU
RZ54	3517	CHAMBRE DE JONCTION R54 / UP53
	3526	PILIER CONTINU ENTRE CAVERNES UXC55 / USC55
PM56	2526	PUITS D'ACCES EXISTANT SD5 / US56
UJ56	2537	CAV. DE JONCTION - FOND DE PUITS EXIS. PM56
RR53	3508	CAVERNE REDRESSEUR VERS PT 4
RR57	3541	CAVERNE REDRESSEUR VERS PT 6
UPS54	3516	GALERIE VISEE GEOMETRE VERS UJ53
UPS56	3536	GALERIE VISEE GEOMETRE VERS UJ57
UP542	3529	GALERIE DE DRAINAGE PM54/PX56

Sigle Ouvrage	Code Plan Ouvrage	Description
SHM6	3677	BATIMENT COMPRESSEUR HELIUM
	3661	GALERIES TECHNIQUES
SA6	2650	BATIMENT EXISTANT SA - MODIFICATIONS
SUH6	2681	BATIMENT PURIFICATEUR HELIUM - SURELEVATION
	3699	ROUTES D'ACCES
UJ62	3616	CHAMBRE DE JONCTION VERS PT 5
TD62	3614	TUNNEL BEAM DUMP VERS PT 5
UD62	3612	CAVERNE BEAM DUMP VERS PT 5
UP62	3610	GALERIE LIAISON TUNNEL R62 / CAV.UD62
UJ68	3634	CHAMBRE DE JONCTION VERS PT 7
TD68	3636	TUNNEL BEAM DUMP VERS PT 7
UD68	3638	CAVERNE BEAM DUMP VERS PT 7
UP68	3640	GALERIE LIAISON TUNNEL R68 / CAV.UD68
RR73	3718	CAVERNE ELECTRICAL FEEDBOX VERS PT 6
RR77	3732	CAVERNE ELECTRICAL FEEDBOX VERS PT 8
	3764	PLATEFORME RESERVOIR HELIUM HORIZONTAL
	3799	RESEAUX EXISTANTS - DEVIATION
SDH8	3857	BATIMENT UCB 2
SHM8	3877	BATIMENT COMPRESSEUR HELIUM
	3861	GALERIES TECHNIQUES
	3899	ROUTES D'ACCES
UJ82	3814	CHAMBRE DE JONCTION
RH87	3837	CAVERNE AIMANT DE REFERENCE VERS PT1
SDI2	3191	BATIMENT TETE DE PUITS PMI2
SMI2	3191	HALL DE MONTAGE ACIER
	3199	ROUTE D'ACCES PMI2
	3145	JONCTION TI2 ET TT60
PMI2	3149	PUITS D'ACCES INSERTION AIMANTS PMI2
TI2	3209	TUNNEL INJECTION
UJ22	3214	CHAMBRE DE JONCTION TI2 / UJ23
		PUITS DE POMPAGE TI2
		PILIER TI8/NT8
UJ88	3840	CHAMBRE DE JONCTION TI8 / UJ87
TI8/S4	3104	TUNNEL D'INJECTION COTE LSS4
TI81	3102	CAVERNE LSS4 ELARGISSEMENT TI8 BLINDAGE
TJ8	3101	CAVERNE DE JONCTION TI8 / PGC8
PGC8	3107	PUITS TI8 AU POINT LSS4
TI8	3809	TUNNEL D'INJECTION TI8 APRES TJ8
		TUNNEL NEUTRINO