PH-DT Detector Technologies	Work Package M&O ATLAS & CMS CO_2 cooling 2018 to 2021		
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Work Package
M&O ATLAS & CMS CO_2 cooling
2018 to 2020

Abstract

This document is an M&O agreement between EP-DT and the ATLAS and CMS experiments. It describes the service provided by EP-DT to maintain and operate the CO_2 cooling system for ATLAS and CMS during the **period 2018-2021** (end of LS2**)**, as well as the financial implications.
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Prepared by:	***Checked by:***	***Approved by:***
Paola Tropea [EP-DT-FS]	J. Daguin P. Petagna L. Zwalinski B. Verlaat [EP-DT-FS]	A. Ball [EP-CMX] A. Charkiewicz [EP-CMO] C. Decosse [EP DPO] F. Dittus ATLAS [EP-ADO] D. Ferrere [ATLAS PIX PM] M. Krammer [EP DH] F. Hahn [EP DDH] L. Pontecorvo [EP-ADO] B. Schmidt [EP-DT] Andrea Venturi [CMS TK PM]

Distribution List

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1 Introduction

This document establishes an M&O agreement between EP-DT and the ATLAS and CMS experiments. It describes the service provided by EP-DT to maintain and operate the CO_2 cooling systems defined in the next section.
The service described in this document will be operational from March 2018.
This agreement is valid for a period of three years. It comes into effect on March 1st 2018 and will be valid until February 28th 2021 (current end of LHC Long Shutdown 2). In case the conditions laid down in this document change during the period of validity, each party can request a revision at the end of each calendar year for changes to be applied in the following year. At the end of the 3 years all parties shall revise the agreement. It is indeed foreseen to enlarge the scope of the M&O agreement also to the LHCb experiment once the LHCb Velo and UT cooling plants will be in operation with the detectors, i.e. during LS2.

2 Scope of M&O Work and cooling systems concerned

2.1 ATLAS system

In the framework of the consolidation of the CO_2 cooling activities within one CERN team, ATLAS mandated the EP-DT group to take over the M&O responsibility for the IBL CO_2 cooling system excluding the maintenance of the primary chillers and the full M&O of the dry air system, for which EN-CV will keep the responsibility, as stated in the EDMS document 1892352.
Such system consists of:

- Cooling unit A in USA15, level 3:
  - Plant core A
  - Chiller A
  - Control cabinet for cooling unit A
- Cooling unit B in USA15, level 3:
  - Plant core B
  - Chiller B
  - Control cabinet for cooling unit B
- Accumulator unit shared by unit A&B in USA15, level 3:
  - Accumulator
  - Local control box
- Junction Box in sec 5 inside Toroid area of UX15
- Manifold Box in sec 5 inside Toroid area of UX15
- Vacuum system
  - instrumentation and pumps in level 6 of UX15, HS structure, USA side
  - electrical interconnection boxes in level 6 of UX15, HS structure, USA side
  - control cabinet in USA15, level 3
- Dry air system in USA15, level 3
- Compressed air manifolds for cooling units in USA15, level 3
- Permanent vacuum insulated transfer line from USA15 to UX15

2.2 CMS systems

In the framework of the CMS Pixel Phase I Upgrade, CMS has mandated the EP-DT group the construction, installation and commissioning of the CO_2 cooling systems (EDMS 1231269). After acceptance, the systems are now under M&O responsibility of EP-DT.

Such system consists of:

- 1 full-scale prototype plant installed in the Tracker Integration Facility (TIF, building 186) to prove the design functionalities and serve as test bench for detector sub-assemblies (EDMS 1712343)
- 2 identical units installed in P5 underground premises in 2015 and connected to the new detector in February 2017 (EDMS 1390533)
  - Cooling unit BPix in USC55, level 2:
    - Plant core BPix
    - Accumulator BPix
  - Cooling unit FPix in USC55, level 2:
    - Plant core FPix
    - Accumulator FPix
  - Cabinets common to BPix and FPix in USC55, level 2
    - 1 Control cabinet
    - 1 Power cabinet
    - 1 auxiliary cabinet
  - Manifolds in UXC55, X5
    - 1 for Fpix
    - 1 for Bpix
  - Vacuum insulated transfer lines from manifold to detector in UXC55
  - Vacuum control cabinet in USC55 for backup getter pumps of UXC55 transfer lines
  - Permanent vacuum insulated transfer line from USC55 to UXC55

Additional cooling systems have been installed in the Pixel clean room at P5.

- 1 "Lucasz" CO_2 portable plant (EDMS 1889051), delivered to CMS in November 2016, for installation in the CMS Pixel clean room (Lower floor) in the surface premises of P5
- 1 "Lucasz" CO_2 portable plant (EDMS 1889051), delivered to CMS in December 2017, for installation in the CMS Pixel clean room (upper floor) in the surface premises of P5

2.3 Validity of the agreement

This M&O agreement covers the operation and maintenance of the above-mentioned cooling systems of ATLAS and CMS, from their acceptance up to the end of the validity of the agreement. The acceptance of each system is formalized by the approval on EDMS of a "Hand-over document", describing the status of the systems and operation modes, which can be found in EDMS (1729774 for the P5 underground units, 1729778, 1743546 for the LUCASZ plants, 1412040 for ATLAS IBL CO_2).

2.4 Limit of Responsibility

The CO_2 cooling systems consists of equipment racks built by EP-DT and collaborating institutes and peripheral infrastructure built and maintained by other CERN groups or services. For completeness, the different service parts of the cooling units are listed in Tables 1 to 4.

Table 1 *Groups involved in CO_2 cooling M&O work at P1.*

ATLAS IBL units	Constructed or Installed by	M&O Responsibility
Primary cooling circuit	ECR Nederland BV	EP-DT (operation), EN-CV (preventive and corrective maintenance)
Cables	ATLAS	ATLAS (No major maintenance foreseen)
CO_2 cooling plants (including back pressure regulator & expansion valves) & manifolds	Nikhef/MPI	EP-DT cooling team M&O work is described in this document.
CO_2 cooling control hardware	EP-DT EN-CV	
CO_2 cooling PLC control software	EP-DT	
CO_2 cooling WinCC OA	EP-DT BE-ICS BE-CO	EP-DT: • Develops, maintains and updates application layer including database files, user and communication interfaces BE-ICS: • Maintains and updates WinCC OA versions including frameworks components • Provides standard support via JIRA Issue Tracking Service for framework or hardware related issues not requiring urgent interventions • Provides support for operational issues with the DIP communication to the experiments as far as it concerns any software and hardware within the technical network BE-CO: • Maintains and updates hardware in CCC. As stated in EDMS 1391249
Piping between plant and manifold	DEMACO	Sub-detector group and/or ATLAS TC
Connection and piping inside the experiment (from manifold to the detector)	MPI ATLAS TC	Sub-detector group and/or ATLAS TC
Vacuum system for flexible vacuum insulated lines	Demaco + TE-CRG	EP-DT for operation; for maintenance: TE-CRG contract with SERCO for diffusion pumps, contract with 30/40 for primary pumps

Table 2 *Groups involved in CO_2 cooling M&O work at TIF (bldg. 186).*

CMS TIF unit	Constructed or Installed by	M&O Responsibility
Primary cooling circuit	EN-CV	EN-CV
Fixed Piping System from Primary to CO_2 plant	Arctica	CMS (No maintenance foreseen)
Cables	CMS	CMS (No maintenance foreseen)
CO_2 cooling plant (including back pressure regulator & expansion valves), manifold, transfer line and accumulator	EP-DT	EP-DT M&O work is described in this document
CO_2 cooling control hardware	EP-DT	
CO_2 cooling PLC control software	EP-DT	
CO_2 cooling WinCC OA	EP-DT BE-ICS BE-CO	EP-DT: • Develops, maintains and updates application layer including database files, user and communication interfaces BE-ICS: • Maintains and updates WinCC OA versions including frameworks components • Provides standard support via JIRA Issue Tracking Service for framework or hardware related issues not requiring urgent interventions • Provides support for operational issues with the DIP communication to the experiments as far as it concerns any software and hardware within the technical network BE-CO: • Maintains and updates hardware in CCC. As stated in EDMS 1391249
Piping between manifold and detector set-up	EP-DT	EP-DT
Connection and piping inside the test bench (or part of experiment)	Sub-detector groups	Sub-detector group

Table 3 *Groups involved in CO_2 cooling M&O work at P5.*

CMS P5 Pixel units	Constructed or Installed by	M&O Responsibility
Primary cooling circuit	EN-CV	EN-CV
Fixed Piping System from primary to CO2 plant	Froid Seicar	CMS (No major maintenance foreseen)
Cables	CMS	CMS (No major maintenance foreseen)
CO_2 cooling plants (including back pressure regulator & expansion valves) & manifolds	EP-DT	EP-DT cooling team M&O work is described in this document.
CO_2 cooling control hardware	EP-DT	
CO_2 cooling PLC control software	EP-DT	
CO_2 cooling WinCC OA	EP-DT BE-ICS BE-CO	EP-DT: • Develops, maintains and updates application layer including database files, user and communication interfaces BE-ICS: • Maintains and updates WinCC OA versions including frameworks components • Provides standard support via JIRA Issue Tracking Service for framework or hardware related issues not requiring urgent interventions • Provides support for operational issues with the DIP communication to the experiments as far as it concerns any software and hardware within the technical network BE-CO: • Maintains and updates hardware in CCC. As stated in EDMS 1391249
Piping between plant and manifold	Criotec	Sub-detector group and/or CMS TC
Connection and piping inside the experiment (from manifold to the detector)	Demaco + sub-detectors	Sub-detector group and/or CMS TC
Backup getter vacuum system for Manifold to PP1 vacuum insulated lines	Demaco + EP-DT-DI	EP-DT

Table 4: *Groups involved in CO_2 cooling M&O work for the two units of the "LUCASZ" class.*

LUCASZ units	Constructed or Installed by	M&O Responsibility
Primary cooling circuit	Wagenaar + EP-DT	EP-DT
CO_2 cooling plants & manifolds	EP-DT	EP-DT cooling team M&O work is described in this document.
CO_2 cooling control hardware	EP-DT	
CO_2 cooling PLC control software	EP-DT	
CO_2 cooling WinCC OA	EP-DT BE-ICS BE-CO	EP-DT: • Develops, maintains and updates application layer including database files, user and communication interfaces BE-ICS: • Maintains and updates WinCC OA versions including frameworks components • Provides standard support via JIRA Issue Tracking Service for framework or hardware related issues not requiring urgent interventions • Provides support for operational issues with the DIP communication to the experiments as far as it concerns any software and hardware within the technical network BE-CO: • Maintains and updates hardware in CCC. As stated in EDMS 1391249
Piping between plant and manifold	Zec	CMS TK

EP-DT retains full M&O responsibility for the equipment listed in the above tables (1 to 3), where explicitly mentioned.
EP-DT provides an Expert On-Call service for the operation of the CO_2 cooling systems (ref. section 4.3). This On-Call service is a first level contact for the experiment for any problem related to the CO_2 systems. If parts that are not under the responsibility of EP-DT cause the problem, the EP-DT expert on-call will contact the relevant service.

3 Work provided during shut-down periods

3.1 Preventive Maintenance and Repairs

EP-DT will carry out during each shut-down or agreed period of maintenance all required preventive maintenance on the CO_2 cooling, including:

- Preventive maintenance on active parts (pumps, actuated valves);

- Checking of calibration of measurement devices, e.g. flow meters. Re-calibration or replacement of sensors if required;
- Repair or replacement of broken components (redundant ones not in the control loop);
- Small modifications;
- Improvements, which reflect the enhanced experience in the system operation

The CERN MTF (Infor EAM) database is used to track technical information for the most relevant parts of the cooling system installed in the underground experimental areas allowing to follow-up repairs. EP-DT has started building a stock of important components (connectors, valves, flow meters, etc.) to minimize system downtime during the shutdown and in particular during operation. The detailed list of spare parts can be retrieved on the Infor EAM dedicated pages (https://cmmsx.cern.ch/).
Components taken out from the experimental caverns must be traceable following the CERN TREC tripartite agreement. EP-DT is in charge of filling any necessary information into the Radiation Waste Management Database of the experiments for any equipment that is dismounted by EP-DT staff. The management and administration (including tools, interfaces, etc.) of the relevant databases will be handled by ATLAS, CMS and RP.

4 CO_2 cooling system: operation from 2018 to 2019

4.1 Responsibility of ATLAS and CMS

ATLAS and CMS, together with their sub-detector teams (Tracker, Pixel) are responsible for the "standard" CO_2 cooling system operation as far as laid down in the hand-over documents. This concerns in particular run control and monitoring on the experimental sites, e.g. daily checks, shifts and routine operations.
Each sub-detector team shall nominate at least one person as CO_2 cooling expert who shall act as contact person in matters of cooling for the shift crew on duty and for EP-DT.

4.2 Operational support provided by EP-DT

EP-DT takes care of the initial leak testing and filling of the CO_2 systems.
When a new test set-up is connected to the laboratory units or when a detector is connected to the cooling systems (in surface or underground), EP-DT will guide the users in the performance of the preliminary leak test after connection.
In addition to what is stated in the hand-over document for the standard operation, EP-DT will be also in charge of training the sub-detector team personnel for the use of the cooling plants in simple operation mode during testing phases. In this basic configuration, the user can only change the temperature set point of the cooling system and stop the plant. Any operation of opening/closing cooling loops or starting the system will be taken care by EP-DT personnel, in agreement with the detector team. After the first period of testing and debugging, the detector team can ask for further rights on the cooling plant operation (like opening/closing of detector loops): an addendum to this agreement shall be created and the proper training must be followed by all people involved.
During testing phases, EP-DT provides assistance and support to the experiments for any non-standard operation. Complementary to the experimental teams, EP-DT carries out checks to monitor critical parameters. If needed, EP-DT will optimize and tune the running parameters to reduce the risk of failures and therefore system downtime.
EP-DT will nominate a first contact person responsible for routine checks and operation during working hours. Urgent repairs or critical system improvements are done when deemed necessary and compatible with the testing schedule of the ATLAS/CMS users. In case of a CO_2 cooling system failure

preventing operation of a test set-up, EP-DT will make every endeavour to reduce the downtime to the strict minimum.

4.3 Stand-by Duty Service provided by EP-DT

EP-DT assures a Stand-by Duty Service with an Expert On-Call for all the systems included under the scope of this agreement, as soon as the respective handover document is signed. However, the procedures and reaction times may change based on the system and on the operation status (data taking, shut-down, commissioning, etc.)

4.3.1 Expert On-Call service for underground systems

EP-DT assures a 24h/7 days On-Call service for the underground systems during the operation periods of the LHC experiments. In case of CO_2 cooling system problems, this On-Call Service can be called directly by ATLAS/CMS for a first level intervention.

- The On-Call person will check from remote the situation and, when needed, will normally be "on-site" in less than 1 hour after a call. In case of simultaneous alarms on several systems, these calls will receive highest priority with respect to those coming from non-data taking installations.
- The On-Call person will analyze the problem, try to repair the fault or to get help from other EP-DT experts. If the problem is caused by non- EP-DT equipment, e.g. the primary cooling circuit, dry air supply, the On-Call person will contact the service concerned as soon as possible.
- The On-Call person will inform the experiment contact persons listed in the annexed table to this document of any intervention or repair.
- The On-Call person will write a short report of intervention in the e-logbook of the experiment.
- Since the On-Call person will come alone, the shift personnel in the experiment may be needed to assist the On-Call person in order to obey to the rule "minimum two persons at work" [2].
- The On-Call person is on duty to verify that the CO_2 cooling systems are working properly at least once per day during week-end and other holidays. During shutdown periods, the need of a daily check has to be discussed and agreed with the detector responsible person. The on-call service is provided by EP-DT staff personnel and FSU. In agreement with ATLAS and CMS, a person from EP-CMX and initially two persons from EP-ADO also join the team. It is the responsibility of EP-DT to train the piquet personnel and to set-up adequate intervention procedures and e-log records. This On-Call service is a service for troubleshooting in case of failures or alarms. It should not be used for routine operation commands, e.g. Start or Stop of a system.

The On-Call Expert Service is normally active also during LHC shut down periods. However, procedures and reaction time need to be agreed upon case by case with the detector group. For instance, outside LHC data taking periods and in agreement with the experiment contact persons, it might be decided that not urgent On-Call interventions are postponed to the next working day or morning (if a problem occurred during the night)

4.3.2 Expert On-Call Service for surface installation (CMS TIF and CMS Lucasz)

EP-DT assures a specific On-Call service in case of CO_2 cooling system problems also for the surface installations. However, except special cases previously agreed upon between the detector team and EP-DT, an intervention of the On-Call person within 2 hours from the call is guaranteed if the call happens during working hours. Outside working hours, On-Call interventions are generally postponed to the next working day.

5 Cost Estimates and Resources

To cover the M&O needs of the CO_2 cooling systems for ATLAS and CMS, EP-DT provides staff personnel to run the basic support. In order to support the technical activities related to the M&O of the CO_2 plant, EP-DT will use the support of the FSU PH-02 unit.
The real cost of the required FSU and hardware expenses will be covered by the experimental M&O budgets.

5.1 Cost Estimates

EP-DT has made a preliminary estimate of the standard M&O expenses needed for the CO_2 cooling systems concerned by the agreement (ATLAS IBL, CMS TIF, CMS P5, CMS LUCASZ A & B), which amounts to 170 kCHF/year.
The details of this cost estimate are explained here below:

- material and exploitation [70 kCHF/y]
- field support personnel (FSU PH-02) [100 kCHF/y ~ full year]

A more detailed breakdown of the expected annual material expenses is shown in the following table.

Table 5 Yearly cost breakdown per activity items per experiment

		Budget 2018-21	
		CMS	ATLAS
Codes	Item	kCHF/year	kCHF/year
AU	Car	2	2
CT	Controls	2	2
FL	Fluids (CO2, oils, freon)	1	1
FP	Fittings, pipes, spares	2	2
FSU	FSU unit EP-DT	50	50
PM	Pump maintenance	20	20
RE	Repairs	4	4
SC	Calibration & replacement of sensors	4	4
	Total	85	85

The average technical support required from FSU personnel for the CO_2 cooling service is estimated to ~1 FTE/year (100 kCHF). The FSU personnel needed for the CO_2 cooling is taken from an existing pool of 4 persons employed for support to gas and cooling detector infrastructures in the EP Department and with the following expertise: 1 for electrical work, 1 for mechanical work and 2 for piping and welding work.
The cost for exceptional substitution of hardware components is not included in this agreement (for unexpected failures or requests on change of performances): such costs will be covered by ATLAS or CMS M&O budgets. At the end of every year, EP-DT will report to ATLAS and CMS on the costs occurred during the last 12 months and a common agreement shall be found between the parties if any money is left over. Based on the experience of the operational years covered by this work-package, the total cost for the experiment can be further modified at the renewal of this agreement.

6 Annex 1: EXPERIMENT CONTACT LISTS

CMS
DCS shifter: 75140
TK on-call: 165503
PIXEL on-call: 165502
TC on-call: 165000

ATLAS
1st call ATLAS Pixel Run manger 160032
2nd call ATLAS Slimos 78804
3rd call ATLAS OPM 165422