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Work package between EP-DT and LHCb for the design, construction, installation and commissioning of the CO_2 cooling plants for the Upstream Tracker and the upgraded Velo detector

Abstract

This work package defines the terms of the collaboration between the LHCb experiment and the CERN EP-DT group with respect to the construction, installation and commissioning of the cooling system for the LHCb UT and the Velo upgrade detector. It also summarizes the required resources.

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History of Changes

Version	Date	Modification
1	October 2015	First version released
2	December 1, 2015	Comments from M. Capeans, P. Petagna and B. Schmidt included
2.3	January 20, 2016	Further Comments B. Schmidt
3	April 13, 2016	Released version with comments from approval process included

Contents

1 INTRODUCTION

This document describes the material and personnel resources needed for the manufacturing, installation and commissioning of the cooling systems for the LHCb Upstream Tracker (UT) and the upgraded VELO detector, as agreed between EP-DT (in the following "DT") and the LHCb experiment.
The project includes two identical systems for P8. The preliminary review, which will give the green light for the activity is foreseen in December 2015, and the commissioning of the plants together with the detector will be done during LS2.

2 DELIVERABLES

The requirement documents issued by LHCb for the design of the CO2 cooling systems are collected in the EDMS document 1556963.
Based on these requirements, the Process and Instrumentation Diagram document (P&ID document, EDMS 1556956) has been issued by DT after several iterative discussions with all stakeholders.

The CO_2 cooling system includes:

- Two cooling plant skids
- Two accumulators
- Two control racks (including both the electrical and electro/pneumatic components)
- One junction box with dummy loads per each plant, in close vicinity to each other
- The transfer lines from the plants to the junction boxes, and from the junction boxes to the detector

This work package (WP) comprises the following deliverables under the responsibility of DT:

- Design of the cooling system, selection and procurement of components (Technical specifications for all components will be made available in EDMS)
- Definition and implementation of a Quality Assurance plan
- Assembly and qualification of all the plants, accumulators and the junction boxes
- Preliminary sizing of the transfer lines
- Installation of all parts but the transfer lines in the LHCb underground area
- Connection of junction boxes to the transfer lines and to the detector and final leak tightness tests
- Control hardware and software (jointly with BE-ICS)
- System test and commissioning
- Engineering and management labor required to supervise and manage the construction, to procure components, and to conduct tests.

Not included in the WP, to be provided by LHCb:

- The production design of all the transfer lines (between plants and junction boxes, between junction boxes and detector manifolds)
- The procurement of all the transfer lines
- The installation of the transfer lines, along a path to be agreed with LHCb technical coordination and following the LHCb design
- The preparation of the electrical connection to the general network and/or any secured network requested by LHCb
- The preparation of the water network with the requested cooling power in the dedicated area
- The verification of the ventilation system if an air cooled primary chiller is used
- The preparation of the dry air/ dry gas supply for the electro-pneumatic modules and the flushing of the plants and junction boxes
- The detector cooling loops, manifolds and safety systems design, installation and testing
- Cabling between the different zones of the experimental site (from control cabinet to junction boxes and detector, where needed)

In addition to the above-mentioned deliverables, a joint effort between DT and LHCb will guide the

design, procurement and mounting of the pipework, including: transfer lines, manifolds and capillaries in the close vicinity of the detectors. As part of this effort, DT will contribute to the conceptual design and will be part of the approval process at different stages of the project: the completion of the design, the procurement of components, and the definition of the installation and validation procedures. However, LHCb will retain the final responsibility for the pipework, and will provide for the personnel and the cost for its design, construction and installation.

The assembly of the plant skids and the junction boxes will be done in the DT laboratory, according to its standard quality control procedures. Cables with connectors between control racks and plant/junction boxes will be ordered and installed by LHCb according to specifications prepared by DT.

Technical changes, alterations to the original layouts or modifications in the scope of the installation tasks, will imply modification of the cost, and, once the WP document is approved, will require formal engineering change requests. This will also apply if major modifications are made to the LHCb requirements, since this would imply modifications in the system built by DT.

3 COST ESTIMATES

Table 1: Cost estimate for the LHCb UT and Velo upgrade CO_2 cooling system

Main chapter	Detail	Unit price [kCHF]	Total QTY	Total price x 2 units [kCHF]
Hardware				
Primary				
	Main chiller	40.00	1	40.00
	Backup chiller	10.00	1	10.00
Hydraulics				
	Main components	100.00	2	200.00
	Pipework & structure	42.00	2	84.00
	Instrumentation	17.00	2	34.00
Controls				
	Control HW	40.00	1	40.00
	Cables & pneumatic pipes	10.00	1	10.00
Service work				
	PH-DT Assembly Services	20.00	2	40.00
	PH-DT Cabling & programming	15.00	2	30.00
	QualificationServices	10.00	2	20.00
	Design	3.30	6	20.00
	Total 2 CO2 plants & primary system			*528.00*
Infrastructure				
	Dry air system	16.00	1	16.00
	Vacuum-jacketed pipes plant to junction box	0.45	160	72.00
	Concentric lines junction box to detector	0.40	30	12.00
	Power distribution in alcove		not evaluated	
	Water distribution in alcove		not evaluated	
	Cabling & pneumatic pipe laying between caverns		not evaluated	
	Total Infrastructure & transfer lines			*100.00*

Table 1 gives a cost estimate for the hardware components and the personnel required for the assembly and installation of the LHCb UT and VELO upgrade CO2 cooling system. It should be noted that:

1. the material estimates are based on components used on previous DT installations, thus leading to a confidence bar of about 10% on the hardware for the CO2 system
2. Service costs have been calculated on the basis of the current Field Support Unit (FSU PH-02) cost per hour or the cost of CERN Technical Student. Existing DT staff is not accounted and will not be charged.
3. Infrastructure estimated costs are purely given as indication (confidence bar 20%): the activities related to the preparation of the infrastructure are not under EP-DT responsibility (power distribution, water distribution, dry air system).

4. All costs will be covered by LHCb projects. Common LHCb funds are already available for common infrastructure. For the transfer lines, about 30% of the cost can be estimated to be for installation activities.

4 COMMISSIONING OF THE CO_2 COOLING SYSTEM

Several steps are involved in the commissioning of the CO_2 cooling system of the LHCb Velo upgrade and UT.

4.1 PRE-COMMISSIONING OF THE SYSTEMS (ACCUMULATOR, PLANTS JUNCTION BOXES)

The pre-commissioning process includes, for each system (plants, accumulators, junction boxes and electric racks): pressure and leak testing, and functional checks of all components (hydraulic, electric and pneumatic). Pressure and leak tests will be conducted following the design pressure and leak requirements described in EDMS 1563347.
Verification of the system behavior, based on the functional analysis document (EDMS 1562732) will be performed on the assembled cooling plants. This will include verification of the PLC code, the SCADA software and the communication to/from the Detector Control System.
DT will provide the personnel required in the pre-commissioning phase.

4.2 SYSTEM COMMISSIONING

The system commissioning includes the setting up of the entire cooling system, the connection to the final cabling and pipework in the LHCb premises and the progressive process of bringing the system to full operation. This phase entails active participation from the detector sub-systems beside the DT personnel. Each sub-system is requested to name a detector expert to actively participate in this phase. The person shall be aware of the basic cooling concepts and the detector operation modes/constrains. During the commissioning phase, he/she will give feedback to the cooling engineers about the detector performances and needs. The contact persons known at the moment of the signature of this work package are listed in Chapter 6.

Before detector installation, preliminary tests will be done circulating the CO_2 in by-pass mode at the junction boxes level and simulating the detector load by means of dummy loads. Commissioning reports (electrical, controls, performance) will be stored on EDMS.
The cost of any possible additional commissioning activity will be included in the LHCb M&O agreement to be released 6 months before the system acceptance.
Expenses for consumables like gas and other store materials are expected to come from the M&O budgets of the experiment and are not included in the present estimate

After commissioning, a handover document will release the cooling system for operation by detector teams. Following the handover, the maintenance of the LHCb Velo and UT CO_2 cooling systems will be covered by the EP-DT group. A dedicated maintenance agreement will be concluded at least 6 months before the acceptance date of each system.

5 SCHEDULE

CO_2 cooling plants for LHCb Velo upgrade and UT

- LHCb cooling EDR in December 2015: P&ID document, schedule & cost update
- PRR in October 2016: Detailed design & part selection, updated cost
- Transfer line design ready by July 2016
- Transfer lines installed February 2017 (LHCb responsibility). The feasibility of this shall be evaluated in YETS 2015/16. In case the transfer lines cannot be installed in advance, the commissioning activity will have to be organized accordingly (surface space & services, resource availability to be verified for later stage commissioning, etc.)
- Plants ready for installation July 2018
- By-pass commissioning completed September 2019

- Plants ready for detector connection October 2019
- System commissioned with detector: at least 6 months after detector connection.

The Gantt chart for the project is annexed to this document. Major modifications shall be discussed between the two parties.

6 CONTACTS

At the time this document has been released, the contact persons for each part of the LHCb Velo Upgrade and Upstream Tracker cooling system are the following:

Overall coordination of the system – LHCb	B. Schmidt
DT Project Leader	P.Tropea
Safety and infrastructure at Point 8 (piping, cables, supply)	E. Thomas
LHCb Technical Coordination	R. Lindner
VELO	P. Collins, K. Rinnert
Upstream Tracker	S. Coelli, R. Mountain

ANNEX 1 – SCHEDULE