EP-DT Detector Technologies	**Work package between EP-DT and CMS for the design, construction, installation and commissioning of the Gas System upgrade for the RPC Detector**		
EDMS Id. **2068585**		Created: 23 Nov 2018	Nb of pages: 7
		Last Modified: July 19th, 2019	Version: 5

This document can be found at:

https://edms.cern.ch/document/2068585

Work package between EP-DT and CMS for the design, construction, installation and commissioning of the upgrade Gas System of the RPC Detector

Abstract

This work package defines the terms of the collaboration between the CMS experiment and the CERN EP-DT group with respect to the construction, installation and commissioning of the Gas System upgrade for the RPC Detector. It also summarizes the required resources.

The content of this note is intended for CERN internal use and distribution only

Prepared by:	*Checked by:*	*To be approved by:*
B. Mandelli EP-DT-FS **R. Guida** EP-DT-FS	**P. Tropea** EP-DT-FS (SL) **G. Pugliese** EP-UCM (CMS-RPC PM)	**B. Schmidt** EP-DT (GL) **A. Ball, W. Zeuner** EP-CMX (CMS Technical Coordination) **A. Charkiewicz** EP-CMO **(**CMS Resource Manager) **S. Carrillo** EP-UCM (CMS-RPC Resource Manager) **A. Colaleo** EP-UCM (CMS-Muon Project Manager) **G. Pugliese** EP-UCM (CMS-RPC Project Manager)

History of Changes

Version	Date	Modification
1	23 November 2018	First version
2	16 January 2019	Second version
3	07 May 2019	Third version (Comments from P. Tropea and G. Pugliese included)
5	19 July 2019	Third version (Comments from B. Schmidt included)

Contents

1 INTRODUCTION

This document describes the material and personnel resources needed for the manufacturing, installation and commissioning of the gas system upgrade for the CMS-RPC detector, as agreed between the EP-DT (in the following "DT") and the CMS experiment.
The present RPC gas system consists of about 46 functional units which are installed in 28 standard Eurorack 600 x 600 x 1800 mm3. This upgrade requires important modification/reconstruction of 18 functional modules and the addition of new components in other 16 functional modules. In conclusions, about 75% of the functional modules will be interested by at least one of the upgrade interventions described in this document.
The upgrade includes four activities, all to be executed on the existing distribution system:

1) Pre-distribution upgrade
It is a consolidation of the present system that will automate the chamber pressure regulation (today done with manual valves).
It will avoid pressure steps due to manual adjustment of currently used manual needle valve.
It will allow to follow any change in the gas mixture density (for example during transition between RPC standard mixture and N2 or other gas in view of shutdown and vice versa to prepare the gas system for data taking periods). It will help also in all situations where different modules need different regulation.
The final goal is to minimize as much as possible any pressure changes to decrease the risk of developing new leaks at the detector level.

2) Dummy chambers
The chamber pressure for the pressure regulation should be measured at the return of the highest chamber of each sector. Pressure sensors are installed but they cannot be used due to the presence of leaks at the detector level. This upgrade consists in the installation of volumes that simulate the chambers allowing to have a reliable measurement of the pressure in a safe place. The pressure regulation will be done with this new pressure sensor.
The final goal of this consolidation is to have a reliable measurement of the pressure in the highest point of each circuit. The advantage is that this measurement is not affected by the hydrostatic pressure of the mixture present in the detector and distribution module. It will therefore allow to minimize the overpressure at the detector level and, consequently, the risk of developing new leaks at the detector level.

3) RE1+ and RE1- gas mixture distribution top/bottom splitting
Consolidation/Modification of current system
The mixture distribution in RE1 is divided in outer and inner rings. The inner ring was originally foreseen for RE1/1 but now it will be equipped with GEM (GE 1/1). This upgrade will split the mixture distribution in top half disk and bottom half disk and, therefore, minimize the hydrostatic pressure at the detector level. It will help in reducing the risk of developing new leaks at the detector level.

4) RE3.1 and 4.1 upgrade
Two additional distribution modules are needed to supply the gas mixture to the new stations 3.1 and 4.1 which are part of the phase 2 upgrade of the RPC detector system.

The activities 1), 2) and 3) aiming in reducing the risk of developing new leaks at the detector level are part of the CERN common strategy for the optimization of the use of greenhouse gases for particle detection.

2 DELIVERABLES

In the following, for each activity the sub-tasks are divided in deliverables for DT and CMS-RPC team.

2.1 PRE-DISTRIBUTION UPGRADE

Includes

- Design of the modification for the pre-distribution modules of the RPC gas systems. Replacement of the existing HVxx37 valves. It impacts 6 functional modules and the gas system will not be operational during all the modification period, as specified in the schedule paragraph below.

Deliverables under DT responsibility

- Design of new pre-distribution modules
- Selection and procurement of components
- Delivery and installation of new modified pre-distribution modules
- Hardware and software integration of dummy chambers in GCS (jointly with BE-ICS)
- System test and commissioning (jointly with detector contact person)
- Technical, engineering and management labour required to supervise the project for all above deliverables.

Experiment responsibility

- System test and commissioning (jointly with EP-DT expert)

Remarks-Schedule

- Dismounting of the existing pre-distribution modules for modification: Feb 2020
- Replacement of manual regulation valves with software-controlled valves. Installation and connection: Feb 2020 to Mar 2020
- Leak test of modified modules: Mar 2020
- Commissioning: May 2020 (i.e. after PLC replacement that will take place between Apr-May 2020)
- Gas system off from Feb 2019 to May 2020
- This schedule is subject to the outcome of R&D studies for the selection of the new regulation valve model that is still ongoing.

2.2 DUMMY CHAMBERS

Includes

- Upgrade of the chamber pressure regulation system with one dummy chamber per distribution unit (a detailed list of components will be released after the approval of the present Workpackage).

Deliverables under DT responsibility

- Procurement of dummy chamber components (volumes, gas connectors, pressure sensors, gas and electrical connectors)
- Dummy chambers assembly
- Provide number and type of cables needed to detector contact person
- Provide number and type of pipes needed to detector contact person
- Final connection of dummy chambers (pipes and electrical)
- Leak test of dummy chambers and pipes up to the distribution module
- Software integration of dummy chambers in GCS* (jointly with BE-ICS)
- System test and commissioning (jointly with detector contact person)
- Technical, engineering and management labour required to supervise the project for all above deliverables.

Experiment responsibility

* Gas Controls Software interface (winCCOA based interface)

- Define exact location for installation of each dummy chamber (according with the design requirement to have the dummy chamber located at the same height of the highest RPC chamber of the distribution module)
- Define the size of the volumes to be used as dummy chamber considering real detector volume and available space
- Design and construction of any mechanical support might be needed for the installation of the dummy chambers in the experiment
- Define length of cables and pipes
- Procurement of pipes and cables
- Installation of pipes and cables from distribution module to dummy chamber
- Installation of dummy chambers in the experiment
- System test and commissioning (jointly with EP-DT expert)

Remarks-Schedule
- Construction of dummy chambers: July 2019-March 2020
- Installation and connection: March 2020
- Leak test: Oct 2019-March 2020
- Commissioning: March 2020
- Gas system off: May 2020

2.3 RE1 MIXTURE DISTRIBUTION SPLITTING

Includes
- Modification for the RE1 distribution modules to align RE1 to the same top and bottom separation as the rest of the RPC system.

Deliverables under DT responsibility
- Design of new distribution modules (including implication at pre-distribution level)
- Disconnect main supplies and returns (mixture, backup and purge)
- Disconnect electrical cables from distribution modules
- Remove bubbler before module removal
- Provide specification for protection of copper pipes connected to chambers
- Procurement of material in the gas distribution modules and related part in pre-distribution
- Delivery of new modified distribution modules and related part in pre-distribution
- Provide number and type of cables to detector contact person
- Provide number and type of pipes to detector contact person
- Connection of gas supply, return, backup and purge pipes on the new modules
- Electrical connection of new modules (18 V, 24 V, CANbus, flow-cells read-out)
- Leak test of new modules in the EP-DT workshop and after re-installation on the experiment
- Hardware and software integration of dummy chambers in GCS[†] (jointly with BE-ICS)
- System test and commissioning (jointly with detector contact person)
- Technical, engineering and management labour required to supervise the project for all above deliverables.

Experiment responsibility
- Extraction of existing RE1 modules
- Disconnection and protection of copper pipes (running from distribution module to detector) at distribution modules location
- Define length of cables and pipes
- Procurement of pipes and cables
- Installation of pipes and cables
- Installation of modified distribution modules

[†] Gas Controls Software interface (winCCOA based interface)

- Reconnection of copper pipes (from/to detector) to distribution modules
- System test and commissioning (jointly with EP-DT expert)

Remarks-Schedule

- Extraction of RE1distribution modules for modification: beginning Jan 2019
- Installation and connection: - side May-June2019 (following CMS schedule), + side Nov 2019 (following CMS schedule)
- Leak test of modified modules: April-May 2019
- Commissioning: March 2020 (i.e. after PLC replacement that will take place between Feb-March 2020; date still to be confirmed since the PLC replacement planning is still under discussion)
- No mixture distribution to RE1 chambers from
  . - side Dec 2018 – May-June 2019
  . + side Dec 2018 – Nov 2019
- Gas system off from Dec 2019 to March 2020

2.4 RE3.1 AND 4.1 UPGRADE

Includes

- Modification for the RE3 distribution modules to include mixture distribution to the new stations RPC RE3.1 and 4.1.

Deliverables under DT responsibility

- Design of new distribution modules (including implication at pre-distribution level)
- Disconnect main supplies and returns (mixture, backup and purge)
- Disconnect electrical cables from distribution modules
- Remove bubbler before module removal
- Provide specification for protection of copper pipes connected to chambers
- Procurement of material in the gas distribution modules and related part in pre-distribution
- Delivery of new modified distribution modules and related part in pre-distribution
- Provide number and type of cables to detector contact person
- Provide number and type of pipes to detector contact person
- Connection of gas supply, return, backup and purge pipes on the new modules
- Electrical connection of new modules (18 V, 24 V, CANbus, flow-cells read-out)
- Leak test of new modules in the EP-DT workshop and after re-installation on the experiment
- Hardware and software integration of dummy chambers in GCS (jointly with BE-ICS)
- System test and commissioning (jointly with detector contact person)
- Technical, engineering and management labour required to supervise the project for all above deliverables.

Experiment responsibility

- Extraction of existing RE3 and RE4 modules
- Disconnection and protection of copper pipes (running from distribution module to detector) at distribution modules location
- Define length of cables and pipes
- Procurement of pipes and cables
- Installation of pipes and cables
- Installation of RE3 modified distribution modules and RE4 modules
- Reconnection of copper pipes (from/to detector) to distribution modules
- System test and commissioning (jointly with EP-DT expert)

Remarks-Schedule

- Extraction of RE3 (and RE4) distribution modules for modification: beginning Jan 2019
- Installation and connection: - side May-June2019, + side Nov 2019
- Leak test of modified modules: April-May 2019

- Commissioning: March 2020 (i.e. after PLC replacement that will take place between Feb-March 2020)
- No mixture distribution to RE1 chambers from
  . - side Dec 2018 – May-June 2019
  . + side Dec 2018 – Nov 2019
- Gas system off from Dec 2019 to March 2020

3 COST AND RESOURCES ESTIMATES

Table 1 Cost estimate for the upgrades of the CMS-RPC gas system

	Hardware (kCHF)	FSU (weeks - kCHF)	CERN-FTE (weeks)
2.1 Pre-distribution upgrade	20	15 – 30	4
2.2 Dummy chambers	20	15 - 30	15
2.3 RE1 top/bottom distribution	22	7 – 15	3
2.4 RE3.1 and 4.1 upgrade	22	7 - 15	4

Table 1 gives a cost estimate for hardware components and personnel required for assembly, installation and commissioning of the upgrades of the CMS-RPC gas system. CMS/CMS-RPC teams are expected to cover entirely the cost of these projects. It should be noted that:

1. Material cost estimates are based on components used on previous DT installations. However, since an important R&D is ongoing and some components are not yet defined, the confidence level on the cost estimate for the hardware is about 70%
2. The cost of a designer is included in the FSU cost estimate and it is in total about 5 kCHF.
3. Service costs have been calculated on the basis of the current Field Support Unit (FSU PH-02) cost per hour. Existing DT staff (CERN-FTE) involvement is not accounted and will not be charged. Human resources cost estimates are based on previous DT installations. However, since an important R&D is ongoing and some components are not yet defined, the confidence level on the cost estimate for the human resources is about 70%
4. Costs for the items under CMS-RPC responsibility are not include in Table 1.
5. Cost of material have to be paid at the validation of the project (i.e. components cannot be bought before, and the project cannot start before its validation by experiment and detector representative). Request for payment of manpower cost will be issued at the end of commissioning.

Technical changes, alterations to the agreed layouts or modifications in the scope of the construction and installation tasks, could have implications on production cost, delivery dates and commissioning.

4 COMMISSIONING OF THE GAS SYSTEM

Several steps are involved in the construction and commissioning of the Gas System.

The pre-commissioning process includes, for each system (gas and electric racks): pressure and leak testing in DT workshop, and functional checks of all components (hydraulic, electric and pneumatic). Pressure and leak tests will be performed following the design pressure and leak standard of DT gas team.

The system commissioning includes setting up of the entire gas system, connection to final cabling and pipework in the CMS followed by the progressive process of bringing the system to full operation. Verification of the system behavior based on the functional analysis document will be performed on the assembled gas system. This will include verification of PLC code, SCADA software and communication to/from the Detector Control System.

The commissioning phase entails active participation from the detector sub-systems beside the DT personnel. The CMS-RPC system is requested to name a detector expert to actively participate in this phase. The person shall be aware of the basic gas concepts and the detector operation modes/constrains and he/she has to be present during the whole commissioning of the system. During the commissioning

phase, he/she will give feedback to the DT team about the detector performances and needs. The contact persons known at the moment of the signature of this work package are listed in paragraph 5. DT will provide the personnel required in the commissioning phase.

After the commissioning, the maintenance and operation of the CMS-RPC gas system will be covered by the EP-DT group under the conditions laid down in the Workpackage agreement for the maintenance and operation of the gas systems for the LHC experiments (EDMS 1721624).

5 CONTACTS

At the time this document has been released, the contact persons for DT and the CMS-RPC system are the following:

EP-DT-FS Gas System Project leader	R. Guida
Safety	N. Dupont
Integration	I. Mihaylov
CMS Technical Coordination	A. Ball, W. Zeuner
CMS-RPC contact person	A. Dimitrov, A. Aleksandrov
CMS-RPC Project Manager	G. Pugliese