REQUIREMENT DOCUMENT

CMS Endcap Cooling Upgrade requirements for Muon detectors

This document describes the changes in power dissipation towards the Endcap cooling circuit from the different Muon detectors of CMS foreseen for the period 2019-2026. It includes references to the present Endcap cooling circuit measured performances and an estimate of their changes due to the new heat load.

https://edms.cern.ch/document/1829163

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**History of Changes**

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**Outline**

1. Scope of the document 3

2. The Endcap Muon system upgrade 3

2.1. Endcap muon systems changes in LS2 and 2021-22 YETS 3

2.2. Endcap muon systems RUN3 3

2.3. Endcap muon systems LS3 3

# Scope of the document

This document describes the changes in power dissipation towards the Endcap cooling circuit from the different Muon detectors of CMS foreseen for the period 2019-2026. In includes references to the present Endcap cooling circuit measured performances and an estimate of their changes due to the new heat load.

With this document, the Muon detector experts validate their additional power dissipation requirements for the Endcap region with respect to the present situation and the changes in the detector thermal gradients that are expected with these new loads.

# The Endcap Cooling circuit

The Endcap cooling circuit is a demineralized water circuit serving all the Endcap Muon stations of CMS and several ancillary circuits (Disk, EE cable trays, HE RBX).

The design of the Endcap Cooling circuit was done based on the data of table 1 [[1]](#footnote-1):

|  |  |  |
| --- | --- | --- |
| Cooling  power | Flow  rate | Temperature  inlet/outlet |
| [kW] | [m3/h] | [°C] |
| 170 | 73 | 18/20 |

**Table 1** – ENDCAP cooling, design parameters

During Run 2, a detailed analysis of the circuit performances has been done by EN-CV, resulting in the performances listed in table 2[[2]](#footnote-2):

|  |  |  |  |
| --- | --- | --- | --- |
| Average  cooling power | Peak of  cooling power | Average  Flow rate | Average inlet/outlet temperatures |
| [kW] | [kW] | [m3/h] | [°C] |
| 107.3 | 137.1 | 75.7 | 16.9/18.1 |

**Table 2** – ENDCAP cooling, 2017 working parameters

For sake of clarity, we refer all additional power and flow request to the present performances: 76 m3/h of flow and 140 kW of cooling power.

# The Endcap Muon system upgrade

## Endcap muon systems changes in LS2 and 2021-22 YETS

The Endcap Muon system will undergo several changes in the period between LS2 and the YETS 2021-22:

* On YE+1 and YE-1: the GE1/1 system will be installed, requiring 2.9 kW per each endcap (80 W per Super Chamber for a total of 36 Super Chambers). On the Endcap circuit, this represents an increase of **5.8 kW**
* On YE+2 and YE-2: the CSC electronics of ME2/1, ME3/1 will be replaced and the power dissipation of the chambers will double with respect to the present 4.7 kW per endcap (260 W per chamber for a total of 36 chambers instead of 130 W per chamber). On the Endcap circuit, this represents an increase of **9.4 kW**
* On YE+3 and YE-3: the CSC electronics of ME4/1 will be replaced and the power dissipation of the chambers will almost double with respect to the present 2.2 kW per endcap (260 W per chamber for a total of 18 chambers instead of 123 W per chamber). On the Endcap circuit, this represents an increase of **4.7 kW**

The total increase in power dissipation for LS2 is 5.8+9.4+4.7 kW = **19.9** kW

For the request to the EN-CV team, a value of 20 kW is considered.

## Endcap muon systems RUN3

During EYTS 2021-22 and 2022-23, GEM based muon stations will be added on the YE1 Endcaps, and additional RPC stations will be added to the YE3 disk, all to be cooled by the Endcap cooling circuit:

* On YE+1 and YE-1: the GE2/1 require 5.8 kW per each endcap (160 W per chamber for a total of 36 chambers). On the Endcap circuit, this represents an increase of **11.6** kW
* RE3/1 chambers will be connected in series to the existing RE3 cooling circuits, adding 1 chamber per circuit (20 W each for a total of 18 chambers). On the Endcap circuit, this represents an increase **0.72** kW.
* RE4/1 chambers will be connected in parallel to the existing RE4 cooling circuits, adding 2 chamber in series on 9 of the 18 circuits (20 W per chamber for a total of 18 chambers). On the Endcap circuit, this represents an increase **0.72** kW.

The total increase in power dissipation for Run3 is 11.6+0.72+0.72 kW = **13.04** kW

For the request to the EN-CV team, a value of 14 kW is considered.

The total increase for the ENDCAP cooling circuit in LS2-LS3 will then be 34 kW

## Endcap muon systems LS3

During LS3, additional muon stations will be added on the Endcaps, to be cooled by the present cooling circuit:

* On YE+1 and YE-1: ME0 systems will be installed, 18 ME0 stacks per Endcap. ME0 require 6.5 kW (60 W per module, each ME0 stack will be realized by 6 module for a total of 108 module endcap). On the Endcap circuit, this represents an increase of about **13 kW**

For the request to the EN-CV team, a value of 13 kW is considered.

The total increase in power for the ENDCAP circuit after LS3 will be 34 kW + 13 kW = 47 kW.

The value including some margins for the EN-CV team to re-size the cooling circuit capacity is 50 kW

## Considerations on cooling circuit needed modifications

At the end of LS3, the Endcap circuit will be loaded with a maximum of 50 kW more than present measured load, which has been measured by EN-CV to be at maximum 137 kW during the Run2.

On the other hand, in LS3, some of the flow presently dedicated to cable cooling will be available to be re-distributed to the muon systems.

In between LS2 and LS3, maintaining the present flow rate available for the muon stations, the calculated temperature rise of the circuit would be about 2.3 degrees in Run3, against the 1.7 of design, and the 1.5 measured during Run 2 ([https://edms.cern.ch/file/2027036/1/Annex\_[3]\_Bilan\_puissance\_ED\_USC\_55\_2017.xlsx](https://edms.cern.ch/file/2027036/1/Annex_%5b3%5d_Bilan_puissance_ED_USC_55_2017.xlsx)).

In order to cope with this, CMS has requested to EN-CV to reduce the operation inlet temperature of the circuit, going from 17 C to 15.8 C.

This change will only impact the overall circuit performances, but will not guarantee the desired local temperature gradient on all parallel circuits.

Three options are now being evaluated in order to cope with the different sub-detector requests:

1. Re-balance the existing circuits and reduce the flow to the circuits with the lowest local temperature gradient
2. Increase the total system flow; the study has been asked to EN-CV, feedback on cost and impact on overall operating pressure will be shared (the additional flow needed for all new systems is a maximum of additional 9.5 m3/h during LS2-LS3, lowered to about 4 m3/h after LS3)
3. Test the performances of the so-called “disk circuit” and evaluate if some flow can be re-directed from there to the detectors.

1. Technical specification for the supply and installation of the underground cooling plants for the CMS detector in the Experimental area at P5 of the LHC <https://edms5.cern.ch/document/440027/1> [↑](#footnote-ref-1)
2. CMS experiment – EN/CV cooling systems - Analysis of operational data of years 2017/2018 (EDMS document #2021642) [↑](#footnote-ref-2)