Efficiency of TCL-6 for debris cleaning with different materials

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WP10  Energy deposition & R2E

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Overview

- The aim of the study is to check the implications of replacing the TCL6 material jaws: from inermet as baseline to copper.
  - Local effect: impact in cell 6 MCBC lifetime.
  - R2E considerations in the RR.
  - Proton losses in the DS (half-cells 8 and 9).
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- Considering the worse case scenario:
  - Horizontal Crossing (IR1 – right side): 250 μrad half crossing angle.
  - HL-LHC optics v1.5 (May 2019).
  - p-p collisions at 7 TeV per beam.
  - Nominal conditions:
    - 3000 fb⁻¹ integrated luminosity
    - 5·10³⁴ cm⁻²s⁻¹ instantaneous luminosity
Peak dose distribution along Q6-assembly

Peak dose profile in the inner coils

TCL6: inermet jaws (ref)  
TCL6: Cu jaws

Q6 - assembly

MCBC

4.8 – 5.6 MGy
2.0 – 4.2 MGy

Peak dose [MGy / 3000 fb⁻¹]

Distance from IP [m]
The increase of the peak dose in the front face of the MCBC as part of the Q6-assembly has an important impact on the lifetime of this corrector for HC on the right side of IR1: the peak dose increases by 70 % while the lifetime decreases by 40 %.

The operation limit of the MCBCs is around 4 MGy. For the baseline configuration, it might not be needed to replace the corrector since it will reach the dose limit at the end of Run 6. Nevertheless, the replacement of inermet by copper will advance the intervention to LS5.

<table>
<thead>
<tr>
<th>Cumulative DOSE (MGy)</th>
<th>Inermet jaws (baseline)</th>
<th>Copper jaws</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to LS3 (360 fb⁻¹)</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Up to LS4 (920 fb⁻¹)</td>
<td>0.8</td>
<td>1.2</td>
</tr>
<tr>
<td>Up to LS5 (1844 / 2385 fb⁻¹)</td>
<td>1.8 / 2.4</td>
<td>2.9 / 3.8</td>
</tr>
<tr>
<td>Up to LS6 (3284 / 4165 fb⁻¹)</td>
<td>3.3 / 4.3</td>
<td>5.5 / 7.0</td>
</tr>
</tbody>
</table>
Local heat loads

- The power loaded in the TCL6 decreases by 5 W while an increase of ~1.2 W on the TCLM6 and > 2 W on the Q6-assembly is observed.

<table>
<thead>
<tr>
<th>Total power (W)</th>
<th>Inermet jaws</th>
<th>Copper jaws</th>
</tr>
</thead>
<tbody>
<tr>
<td>TCL6 inner/outer jaws</td>
<td>12 / 31</td>
<td>12 / 26</td>
</tr>
<tr>
<td>TCLM6 on B2 / B1</td>
<td>0.04 / 1.3</td>
<td>0.1 / 2.5</td>
</tr>
<tr>
<td>Q6-assembly</td>
<td>1.9</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Note: the remaining 1.6 W goes to the tunnel walls and surrounded material such as the vacuum pipes.
Peak dose distribution along Q7-assembly

No effect at the level of Q7-assembly

No impact at the level of cell 7
R2E considerations in the RR17: TID

Distance from IP: 240 m

Distance from IP: 250 m

Distance from IP: 245 m

Distance from IP: 255 m

Average over 140 cm in horizontal position starting at 115 cm from the iron wall
R2E considerations in the RR17: TID

In the *Radiation Level Specifications for HL-LHC* document (EDMS 2302154) it is quoted 25 Gy as the highest TID level in the RR17 for 360 fb\(^{-1}\). An increase of 50 % or more has an important impact in the lifetime of some equipment such as power converter racks.
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Attenuation of radiation levels thanks to the presence of the concrete tunnel roof.
Losses in the DS: half-cells 8 and 9

Proton losses up to half-cell 9 highly depend on the TCL6 settings: aperture and material. The replacement of inermet by copper in the TCL6 jaws has no effect on the DS-losses.
Summary and conclusions

- The replacement of the TCL6 jaws material has different implications:
  
  - Local effect: in case of IR1-HC right side of the IP, the first element in the assembly is the MCBC. The peak dose at the IP side of the corrector increases by 70%. In consequence, its lifetime decreases by 40%. For the baseline configuration, the MCBC in cell 6 may survive the whole HL-LHC era in ultimate conditions. Nevertheless, the change of inermet by copper in the TCL6 impacts the lifetime of the corrector thus it will need to be replaced earlier.

  - R2E considerations in RR17: Important increment, more than 50%, of the TID thus the lifetime of some equipment will be considerably reduced. Potential stochastic failures increases the SEE rate. Follow up in this regard shall be planned with the involvement of the equipment group to further study the impact of the replacement in terms of R2E.

  - **No impact** in Q7-assembly is observed.

  - **Proton losses in the DS**: No impact in half-cell 8 neither in half-cell 9.