Future Circular Collider

Technical Infrastructure

Cooling and Ventilation systems in the RF points

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Outline

• RF Cooling Requirements for the FCC-ee
  • Raw water
  • Primary water
  • Demineralised water
  • Chilled water

• RF Ventilation
  • Heat loads on air
  • Access mode
  • Emergency mode

• Further steps
COOLING
Cooling Water Types.

- Raw water
- Chilled water
- Industrial water
- Demineralised water
- Primary water
- Industrial water
- Demineralised water
## Primary Water: Requirements.

### FCC-ee Cooling Power Needs for Primary Circuits (MW)

<table>
<thead>
<tr>
<th>Point</th>
<th>Cryogenics</th>
<th>Experiment</th>
<th>General Services</th>
<th>Power Converters (RF)</th>
<th>Chilled water</th>
<th>Underground</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>0.5</td>
<td>2</td>
<td></td>
<td>4.6</td>
<td>42.5</td>
<td>49.6</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>3.9</td>
<td>1.0</td>
<td>7.0</td>
</tr>
<tr>
<td>D</td>
<td>0.5</td>
<td>2</td>
<td></td>
<td></td>
<td>4.6</td>
<td>42.5</td>
<td>49.6</td>
</tr>
<tr>
<td>F</td>
<td>0.5</td>
<td>2</td>
<td></td>
<td></td>
<td>3.9</td>
<td>1.0</td>
<td>7.0</td>
</tr>
<tr>
<td>G</td>
<td>0.5</td>
<td>2</td>
<td></td>
<td></td>
<td>4.6</td>
<td>42.5</td>
<td>49.6</td>
</tr>
<tr>
<td>H</td>
<td>40</td>
<td>2</td>
<td></td>
<td>4.5</td>
<td>10.1</td>
<td>48.6</td>
<td>105.2</td>
</tr>
<tr>
<td>J</td>
<td>0.5</td>
<td>2</td>
<td></td>
<td></td>
<td>4.6</td>
<td>42.5</td>
<td>49.6</td>
</tr>
<tr>
<td>L</td>
<td>10</td>
<td>2</td>
<td></td>
<td>0.07</td>
<td>4.5</td>
<td>2.5</td>
<td>19.1</td>
</tr>
</tbody>
</table>

- Cooling requirements on surface.
- Cooling requirements in underground.
- ~ 50% reduction with respect to previous values.
Primary Water: Cooling Towers.

Largest cooling needs
~ x 2 Cooling tower power respect to Experimental Points

T water coming to cooling tower: 40 °C.

T water leaving cooling tower: 25 °C.

<table>
<thead>
<tr>
<th>MAKE-UP WATER NEEDS (m³/h)</th>
<th>A</th>
<th>B</th>
<th>D</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>J</th>
<th>L</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blowdown recycling</td>
<td>96</td>
<td>13</td>
<td>96</td>
<td>13</td>
<td>96</td>
<td>202</td>
<td>96</td>
<td>37</td>
</tr>
<tr>
<td>Reject water</td>
<td>13</td>
<td>2</td>
<td>13</td>
<td>2</td>
<td>13</td>
<td>27</td>
<td>13</td>
<td>5</td>
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</table>
### Demineralised Water: Needs.

#### FCC-ee COOLING POWER NEEDS FOR DEMINERALISED WATER CIRCUITS IN THE UNDERGROUND (MW)

<table>
<thead>
<tr>
<th>Point / Sectors</th>
<th>Magnets</th>
<th>Alcoves</th>
<th>Synchrotron Radiation Absorbers</th>
<th>Experimental Area</th>
<th>Power converters (for accelerator)</th>
<th>RF underground</th>
<th>Cryo RF</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PA / L-A, A-B</td>
<td>2 x 7.1</td>
<td>2 x 0.9</td>
<td>2 x 12.5</td>
<td>0.5</td>
<td>1.05</td>
<td></td>
<td></td>
<td>42.5</td>
</tr>
<tr>
<td>PB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.05</td>
<td></td>
<td></td>
<td>1.05</td>
</tr>
<tr>
<td>PD / B-D D-F</td>
<td>2 x 7.1</td>
<td>2 x 0.9</td>
<td>2 x 12.5</td>
<td>0.5</td>
<td>1.05</td>
<td></td>
<td></td>
<td>42.5</td>
</tr>
<tr>
<td>PF</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.05</td>
<td></td>
<td></td>
<td>1.05</td>
</tr>
<tr>
<td>PG / F-G G-H</td>
<td>2 x 7.1</td>
<td>2 x 0.9</td>
<td>2 x 12.5</td>
<td>0.5</td>
<td>1.05</td>
<td></td>
<td></td>
<td>42.5</td>
</tr>
<tr>
<td>PH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.05</td>
<td>45.7</td>
<td>1.8*</td>
<td>48.6</td>
</tr>
<tr>
<td>PJ / H-J J-L</td>
<td>2 x 7.1</td>
<td>2 x 0.9</td>
<td>2 x 12.5</td>
<td>0.5</td>
<td>1.05</td>
<td></td>
<td></td>
<td>42.5</td>
</tr>
<tr>
<td>PL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.05</td>
<td>0.69</td>
<td>0.8*</td>
<td>2.5</td>
</tr>
</tbody>
</table>

- T demi water coming to heat exchanger: 47 °C.
- T demi water leaving heat exchanger: 27 °C.
- Points H and L don’t provide demineralised water to equipment in Tunnel.
- Cryo RF is supplied with industrial water.
### Chilled Water: Needs.

<table>
<thead>
<tr>
<th>POINT</th>
<th>COOLING POWER (kW)</th>
<th>FLOW RATE (m³/h)</th>
<th>NUMBER OF CHILLERS</th>
<th>COOLING POWER/CHILLER (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>3,834</td>
<td>551</td>
<td>5</td>
<td>1,000</td>
</tr>
<tr>
<td>B</td>
<td>3,284</td>
<td>472</td>
<td>5</td>
<td>900</td>
</tr>
<tr>
<td>D</td>
<td>3,814</td>
<td>548</td>
<td>5</td>
<td>1,000</td>
</tr>
<tr>
<td>F</td>
<td>3,284</td>
<td>472</td>
<td>5</td>
<td>900</td>
</tr>
<tr>
<td>G</td>
<td>3,834</td>
<td>551</td>
<td>5</td>
<td>1,000</td>
</tr>
<tr>
<td>H</td>
<td>8,400</td>
<td>1,207</td>
<td>6</td>
<td>1,800</td>
</tr>
<tr>
<td>J</td>
<td>3,814</td>
<td>548</td>
<td>5</td>
<td>1,000</td>
</tr>
<tr>
<td>L</td>
<td>3,779</td>
<td>543</td>
<td>5</td>
<td>1,000</td>
</tr>
</tbody>
</table>

Chilled water for cold batteries in AHUs / Fancoils in:
- Surface Buildings
- Shaft pressurization
- Service Cavern & UAs
- Half Tunnel Sector 1
- Half Tunnel Sector 2
- Klystron Galleries

T water coming to chiller: 12 ºC.

T water leaving chiller: 6 ºC.
Cooling circuits at Points H & L
Cooling circuits at Points H & L

Primary water underground

Power Converters for accelerator

Cooling for Klystrons

Cooling for Cryogenics RF
Cooling circuits at Points H & L
Cooling circuits at Points H & L
Klystron Gallery, Point H

Demineralised water

Chilled water
Tunnel Sector, Point L

- Chilled water
- Raw water
- Demineralised water

Booster 400 MHz Cryomodules
Klystron Gallery, Point L

Demineralised water

Chilled water
VENTILATION
# Heat loads on Air (kW)

<table>
<thead>
<tr>
<th>POINT</th>
<th>Cryogenics</th>
<th>Power Converters</th>
<th>General Services</th>
<th>Experimental Areas</th>
<th>Shaft pressurisation</th>
<th>Fresh air for underground areas</th>
<th>TOTAL TO CHILLED WATER</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td>500</td>
<td>50</td>
<td>300</td>
<td>150</td>
<td>1000</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td>500</td>
<td>150</td>
<td>50</td>
<td>700</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td></td>
<td>500</td>
<td>40</td>
<td>300</td>
<td>150</td>
<td>990</td>
</tr>
<tr>
<td>F</td>
<td></td>
<td></td>
<td>500</td>
<td>150</td>
<td>50</td>
<td>700</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td></td>
<td></td>
<td>500</td>
<td>50</td>
<td>300</td>
<td>150</td>
<td>1000</td>
</tr>
<tr>
<td>H</td>
<td>2,000*</td>
<td>2,250*</td>
<td>500</td>
<td></td>
<td>150</td>
<td>150</td>
<td>800</td>
</tr>
<tr>
<td>J</td>
<td></td>
<td></td>
<td>500</td>
<td>40</td>
<td>300</td>
<td>150</td>
<td>990</td>
</tr>
<tr>
<td>L</td>
<td>500*</td>
<td>35*</td>
<td>500</td>
<td></td>
<td>150</td>
<td>150</td>
<td>800</td>
</tr>
</tbody>
</table>

*Extracted without chilled water

**Surface**

**Underground**
Underground Ventilation Point H, Klystron Gallery

High local heat loads → Fancoils

4600 kW over 2030 m → 2 kW / m

230 AHUs of 20 kW each, every 8.8 m
Underground Ventilation Point H, Tunnel
Underground Ventilation Point L, Klystron Gallery

High local heat loads → Fancoils

75 kW over 1400 m → 0.05 kW / m

15 AHUs of 5 kW each, every 93 m
Underground Ventilation Point L, Tunnel
Ventilation modes, Klystron Gallery

Access mode

- Emergency extraction duct closed
- Compartment doors opened
- Temperature: Between 18 °C and 26 °C
- 2080 m³/h per compartment

Emergency mode

- Emergency extraction duct opened
- Compartment doors closed
- 10000 m³/h per affected compartment
- 3500 m³/h per adjacent compartment

4 air inlets @ 520 m³/h

8 air inlets @ 1250 m³/h
Point H

Main entrance
Klystron Gallery

Point L

Point H → 6 fire compartments
Point L → 5 fire compartments
Point H

Connection tunnels to Klystron Gallery

Point L

Point H $\rightarrow$ 6 fire compartments

Point L $\rightarrow$ 5 fire compartments
Point H

Evacuation staircase

Point L

Point H → 6 fire compartments

Point L → 5 fire compartments
Fire emergency in Klystron Gallery, Point H & L

Case 1: Fire in an extremal compartment.

- Not that problematic, as the entrance to Klystron Gallery and connection tunnels are not blocked.
**Fire emergency in Klystron Gallery, Point H & L**

Case 2: Fire in an intermediate compartment.

- Problematic: evacuation is done through the Klystron Gallery entrance or connection tunnels. If unreachable, evacuation is done through the passages to the Tunnel.

<table>
<thead>
<tr>
<th>Affected compartment</th>
<th>Adjacent compartment</th>
<th>Adjacent compartment</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 air inlets @ 1250 m³/h</td>
<td>8 air inlets @ 438 m³/h</td>
<td>8 air inlets @ 438 m³/h</td>
</tr>
</tbody>
</table>
Fire emergency in Klystron Gallery, Point H & L

Case 3: Fire in the Klystron Gallery entrance or connection tunnels.

- Problematic: entrance of Klystron Gallery and/or connection tunnels is blocked, so evacuation is done forcefully through the passages to the Tunnel.

Adjacent compartment
8 air inlets @ 438 m³/h

Affected compartment
8 air inlets @ 1250 m³/h

Adjacent compartment
8 air inlets @ 438 m³/h
**Tunnel Sector, Point H**

- **Emergency extraction duct**
  - **Fancoils**
  - **Terminal units**
  - **Inlet slab duct**

**Collider 400 MHz Cryomodules**

**Collider 800 MHz Cryomodules**
Klystron Gallery, Point H

- Emergency extraction duct
- Fancoils
- Terminal units
- Inlet slab duct
Klystron Gallery, Point L

Emergency extraction duct
Fancoils
Terminal units
Inlet slab duct
Further Steps

• RF Cooling Requirements for the FCC-ee
  • Reduce environmental impact: waste heat recovery, water reject treatment & optimization of blowdown water.
  • Regular update of the heat load requirements from our clients.

• RF Ventilation
  • Heat recovery through air recycling.
  • Iteration of the fire emergency scenarios.
  • Regular update of the heat load requirements from our clients.
Thank you for your attention.