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Strategy and Status of Reference Cavities for European XFEL
Introduction: Cavity Surface Preparation

- **Two schemes** for the final surface treatment:
  - E. Zanon: BCP Flash
  - Research Instr.: Final EP

- at each company:
  - 4 Cav’s for set-up of infrastructure
  - 4 Cav’s for qualification of infrastructure

- **Close supervision of infrastructure, processes, procedures and handling** by DESY + INFN Milano required

- **No performance guarantee results in:**
  - the risk of unexpected low gradient or field emission is with DESY
  - responsibility for re-treatment at DESY
Strategy of Reference Cavities (RCV)

- Four reference cavities fabricated at each company
- First surface treatment and vertical acceptance test w/o He-tank at DESY (following the company preparation scheme: Final BCP for EZ; Final EP for RI)
- Stepwise qualification of surface treatment infrastructure at companies (after successful set-up of infrastructure with further dedicated cavities)

<table>
<thead>
<tr>
<th></th>
<th>RCV#0</th>
<th>RCV#1</th>
<th>RCV#2</th>
<th>RCV#3</th>
<th>RCV#4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation to + from company</td>
<td>OK</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>+ slow venting / slow pumping (incl. leak check + RGA)</td>
<td></td>
<td>ok(EZ)/ok(RI)</td>
<td></td>
<td></td>
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<tr>
<td>+ disassembly of beam tube flange (short side), full HPR-cycle, drying, assembly of beam tube flange</td>
<td></td>
<td></td>
<td>ok(EZ) /x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ disassembly of all flanges, assembly of flanges, leak check</td>
<td></td>
<td></td>
<td></td>
<td>ok(EZ) /x</td>
<td></td>
</tr>
<tr>
<td>+ Final 40µm EP (RI)/Final 10µm BCP (EZ), first HPR, ethanol rinse, FMS, 120° C bake</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Remark: Full preparation cycle will be done with CAV for set-up of infrastructure, only
Acceptance test of four RI reference cavities successful: All cavities with $E_{\text{acc}} > 28$ MV/m!
Starting Performance of Reference Cavities: EZ (after surface preparation at DESY)

- Three cavities vertical acceptance test successful (no FE)
- CAV00502 accepted though strong radiation (field emission)
8 RCVs: acceptance test successful

XFEL reference cavities $Q_0(E_{\text{acc}})$

XFEL reference cavities X-ray($E_{\text{acc}}$)

Gamma Radiation [mGy/min]

E_{\text{acc}} [MV/m]
Status of RCV’s

**RI:**
- RCV#0: CAV00002, t1 => t2: ok
- RCV#1: CAV00001, t2 => t3: not ok
- RCV#1.1: CAV00004, t1 => t2: not ok
- RCV#1.2: CAV00001, t4 => t5: ok (Q-degradation + leak => re-test ongoing)
- RCV#2: CAV00002, t2 => t3: in preparation
- RCV#3:
- RCV#4:

**EZ:**
- RCV#0: CAV00500, t1 => t2: ok
- RCV#1: CAV00506, t2 => t3: ok
- RCV#2: CAV00503, t2 => t3: not ok
- RCV#2.1: CAV00500, t2 => t3: ok
- RCV#3: CAV00502, t2 => t3: ok
- RCV#4: CAV00506, t4 => t5: vertical test in preparation
Transport tests: RCV#0
(0. step of RCV qualification)

- Transport test to and from RI done with CAV00002 => successful
- Transport test to and from EZ done with CAV00500 => successful

\begin{itemize}
  \item Transport test to and from RI done with CAV00002 => successful
  \item Transport test to and from EZ done with CAV00500 => successful
\end{itemize}
Test of Slow Pumping / Slow venting @ RI: RCV#1 + RCV#1.1

- Test of Slow Pumping / Slow venting at RI done with CAV00001 (left) => failed
- 2. attempt of SPSV at RI done with CAV00004 (right) => failed

![Graphs showing test results](image_url)
3. attempt of SPSV at RI done with CAV00001 (left) => preliminary ok

Remark 1:
Small leak at 2K appeared during test => Re-tightening of screws for re-test

Remark 2:
Re-test of CAV00001 ongoing in order to find reason for Q-degradation (RF-procedure checked and ok).

Remark 3:
Decision taken to go on with RCV#2

no radiation
Test of Slow Pumping / Slow venting @ EZ:

**RCV#1**

- Test of SPSV at EZ done with CAV00506 => successful

remark: test 2 with too high Q due to problems with beta determination in "new software"

no radiation
1. attempt of HPR qualification done at EZ with CAV00503 (left) => failed

HPR qualification at EZ with CAV00500 (right) => successful
Qualification of full assembly at EZ with CAV00502 => successful
(lower Q-value w/o obvious explanation; higher $Q_{\text{trans}}$ than usual)
Re-Qualification @ DESY: 
RCV’s of RI

- CAV00001 by HPR @ DESY after RCV#1 failed at RI => successful
Re-Qualification @ DESY: RCV’s of EZ

- CAV00503 by HPR @ DESY after RCV#2 failed at EZ => successful
Usable Gradient of RI Cavities (after 1. DESY preparation)

- Usable gradient for RI cavities:
  - CAV00001, test 2: 26.4 MV/m (radiation > 10^{-2} mGy/min)
  - CAV00002, test 1: 27.1 MV/m (radiation > 10^{-2} mGy/min)
  - CAV00003, test 1: >34.2 MV/m (limited by power cable defect)
  - CAV00004, test 1: 31.7 MV/m (radiation > 10^{-2} mGy/min)

- **Remark 1**: CAV00001 needed additional test due to wrong assembly of valve in test 1 (cavity did not fit in transport box) => HPR + correct valve assembly before test 2

- **Remark 2**: Though qualified the radiation in CAV00001 + CAV00002 are close to acceptable limit!
Usable Gradient of EZ Cavities (after 1. DESY preparation)

- Usable gradient for EZ cavities:
  - CAV00500, test 1: 34.2 MV/m (Quench, no FE)
  - CAV00502, test 2: 17.9 MV/m (radiation > 10^{-2} mGy/min)
  - CAV00503, test 1: 34.6 MV/m (Quench, no FE)
  - CAV00506, test 2: 34.7 MV/m (Quench, no FE)

- **Remark 1**: CAV00502 + CAV00506 showed activation of strong FE in first Q(E) of test 1
- **Remark 2**: CAV00502 after test 1 => OBACHT inspection and HPR
  => OBACHT shows scratches at Iris 9
  => in test 2 again degradation in first Q(E) due to FE and more x-rays than test 1
- **Remark 3**: CAV00506 after test 1 => OBACHT inspection and HPR
  => in test 2 significant improvement with no FE