Development of MO Seal

KEK

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<table>
<thead>
<tr>
<th></th>
<th>Seal Type</th>
<th>Handling</th>
<th>Tightening Torque [Nm]</th>
<th>Gasket material</th>
<th>Cost US$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Indium wire</td>
<td>△</td>
<td>15</td>
<td>Indium</td>
<td>24</td>
</tr>
<tr>
<td>B</td>
<td>DESY Diamond</td>
<td>⊙</td>
<td>30</td>
<td>Aluminum alloy</td>
<td>20</td>
</tr>
<tr>
<td>C</td>
<td>Indium plated U-tight Seal</td>
<td>○</td>
<td>13</td>
<td>Indium plated stainless steel</td>
<td>150</td>
</tr>
<tr>
<td>D</td>
<td>MO Seal</td>
<td>⊙</td>
<td>15</td>
<td>Copper</td>
<td>10</td>
</tr>
</tbody>
</table>
Developed two kind of MO seal

Type A (one edged)
- Ti
- SUS316L
- Gasket
- Nock-pin
- Nb pipe
- Vacuum side
- Pinhole

Type B (double edged)
- SUS316L
- Gasket
- Nock-pin
- Nb pipe

MO sealing
Developed MO seals and MO flanges
Cavity VT Test Results with MO seals

Type A

Both Cavities were treated by BCP.

Results are fine but Q is low a little.

Type B
He-Leak Rate Limit for High Gradient

He-II leak rate measurement: integrated method

Cavity was VT tested with metal closed valve, and held T < 2K for 3hr (10000s).

After warmed-up the cavity, He partial gas pressure was integrated and calculated the leak rate.

He-II leak rate should be better than \(~4E-11\) Pam$^3$/s for the high gradient $E_{acc} > 30$MV/m.
Leak Rate Measurement and Comparison between MO(Cu) and Indium Seal

ISE#3’ Double edged MO seal (copper gasket)
Leak rate 1.51E-11 [Pam³/s]

ISE#7 Indium seal
Leak rate 1.27E-11[Pam³/s]

Both has a very similar He-II leak rate.
Why Q is low a little bit?

Our reference BP length is 115mm. $R_{res} \sim 3\Omega$ is expected for SUS top flange.

ISE#3' and ISE4' were cut the flange, then re-welded MO flange. The BP length became shorter and 105mm.

Additional $R_{res}$ of $7\Omega$ is expected by the closer top flange location.
## Rres test results using copper alloy MO top flange

<table>
<thead>
<tr>
<th>Tight loop (HPR+VT)</th>
<th>ISE#4’ (Type A, single edge)</th>
<th>ISE#3’ (Type B, double edge)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rres [nΩ]</td>
<td>Leak rate [Pam³/s]</td>
</tr>
<tr>
<td>1</td>
<td>8.5</td>
<td>6.5E-11</td>
</tr>
<tr>
<td>2</td>
<td>12.9</td>
<td>3.6E-5</td>
</tr>
<tr>
<td>3</td>
<td>14.8</td>
<td>9.8E-5</td>
</tr>
<tr>
<td>4</td>
<td>10.1</td>
<td>9.3E-12</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>11.6</strong></td>
<td><strong>3.4E-5</strong></td>
</tr>
<tr>
<td><strong>Scatter</strong></td>
<td><strong>2.8</strong></td>
<td><strong>4.6E-5</strong></td>
</tr>
<tr>
<td><strong>Original test typical value</strong></td>
<td>19.0</td>
<td>17.9</td>
</tr>
</tbody>
</table>

*Rres is reasonably reduced by the copper alloy MO top flange.*

*The double edged MO flange is more reliable for He-II leak tightness.*
Leak tightness of MO seal (indium plated Al gasket)

Indium plated Al gasket on the one edge MO seal has been verified totally 7 times by the Ichiro#7 full 9-cell cavity at Jlab. It had never leaked.
Summary

- **MO seal has been successfully developed.**
- **Simple copper gasket can be use like ICF seal.**
- **One edged MO seal has been verified to be leak tight on In/Al gasket at Jlab by Ichiro#7 full 9-cell cavity.**
- **The double edged MO flange is more reliable and will keep the He-II leak rate less than \( \sim 1 \times 10^{-11} \text{Pam}^3/\text{s}. \)**