R&D Status of Support Tube for Final Quadrupole Doublets

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Contents

1. Introduction

2. Dynamic Analyses
   Modal analysis
   Spectrum analysis

3. Calculation summary

4. Test
   Test-1
   Test-2
   Test-3

5. Conclusion
1. Introduction

Support configuration for IR region
- Self-weight
- Vibration (Ground motion)

→
- Deformation
- Stress
- Relative position between QC1 (|P1-P2|) < 1nm

- Static analysis
- Dynamic analysis
  Modal Analysis
  Spectrum Analysis
- Test
Configuration

- Total weight: 81 tons

Fixed

- Tungsten (t=100mm)

6.45m

3.35m

1m

7.0m
2. Dynamic analysis
(1) Modal Analysis (Resonant frequency)

(Model-A)
- Support Base is fixed by:
  - Rigid
  - 15Hz of resonant frequency
- Fixed

(Model-B)
- Not fixed this point
- 15Hz

(Model-C)

(Model-D)
- 15Hz
Resonant Frequency

(Model-A)
1st: 17Hz
2nd: 81Hz
3rd: 173Hz

(Model-B)
1st: 15Hz
2nd: 38Hz
3rd: 105Hz

(Model-C)
1st: 71Hz
2nd: 179Hz
3rd: 202Hz

(Model-D)
1st: 15Hz
2nd: 54Hz
3rd: 93Hz
2-(2) Spectrum analysis

(Model- A)  (Model- B)

(Model- C)  (Model- D)

<table>
<thead>
<tr>
<th>Frequency: ( f )</th>
<th>P.S.D: ( X )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1Hz</td>
<td>3.0 ( \mu ) m(^2)/Hz</td>
</tr>
<tr>
<td>1Hz</td>
<td>3.0 \times 10^{-4} ( \mu ) m(^2)/Hz</td>
</tr>
<tr>
<td>10Hz</td>
<td>3.5 \times 10^{-8} ( \mu ) m(^2)/Hz</td>
</tr>
<tr>
<td>100Hz</td>
<td>4.0 \times 10^{-12} ( \mu ) m(^2)/Hz</td>
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</tbody>
</table>

Responded deformation
Measurement of Grand Motion

Takeda, Tauchi, Yamaoka, Nakata, Uchida
Raw Data (14m-4:00PM-No.1-UD)

Power Spectrum Density

(Preliminary)
Calculation

(Model-A)  1st: 17Hz  
(Model-B)  1st: 15Hz

(Model-C)  1st: 71Hz  
(Model-D)  1st: 15Hz

![Graph showing the frequency response of different models with amplitude on the Y-axis and frequency on the X-axis. The graph compares the response of models A, B, C, and D with different frequencies and amplitudes.]
### 3. Summary of calculations

<table>
<thead>
<tr>
<th></th>
<th>Model-A</th>
<th>Model-B</th>
<th>Model-C</th>
<th>Model-D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deformation(mm)</td>
<td>1.6</td>
<td>-</td>
<td>0.09</td>
<td>-</td>
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<tr>
<td>Stress(MPa)</td>
<td>23</td>
<td>-</td>
<td>5</td>
<td>-</td>
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<tr>
<td>Resonant frequency(Hz) (Vertical)</td>
<td></td>
<td></td>
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<tr>
<td>1st mode</td>
<td>17</td>
<td>15</td>
<td>71</td>
<td>15</td>
</tr>
<tr>
<td>2nd Mode</td>
<td>81</td>
<td>38</td>
<td>179</td>
<td>54</td>
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<tr>
<td>3rd mode</td>
<td>173</td>
<td>105</td>
<td>202</td>
<td>93</td>
</tr>
<tr>
<td>Spectrum analysis(nm) @QC1</td>
<td></td>
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<td></td>
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<tr>
<td>1st mode</td>
<td>10</td>
<td>0.01</td>
<td>6E-6</td>
<td>1</td>
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<tr>
<td>2nd Mode</td>
<td>2E-4</td>
<td>3E-5</td>
<td>--</td>
<td>5E-3</td>
</tr>
</tbody>
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