DESIGN AND REALIZATION OF REMOTE BAND PROOF LOADING SYSTEM (TECHNICAL)

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1. INTRODUCTION

This document aims to give the details involved in the design and realization of a band proof loading test rig, which will be used for characterizing the band system strength before its actual usage. This document will assist the competent parties to make an assessment of the work content as well as to access the cost involved in the realization. This document will also give an idea about the level of technical competency required in the area of design and manufacturing of hydraulic systems, structural design and testing, realization of hydraulic jack and other mechanical aspects. And gives overall idea about the system engineering required for the realization of this test rig.

2. DESCRIPTION OF BAND SYSTEM

The band system is a separation system between two different cylindrical structures and it consists of two maraging steel band halves passing over circumferentially positioned wedge blocks. The two half segments are connected at diametrically opposite locations by tension bolt assemblies. Required tension in the band is applied through the bolt assemblies, which gives the necessary clamping force/load to the joint interface. The separation of the system is achieved by severance of the bolts using pyro device. Conceptual description of a band is shown in figure 1.

Diameters of band used are 937mm, 1194mm and 2800mm and its width and thickness ranging from 30 to 55mm and 1.5 to 3 mm respectively, depending on the diameter of the band.

These bands are to be ground tested with the help of the band proof loading rig without any manual intervention near band loading mechanism. Through this rig the strength of the band has to be evaluated for the final acceptance. This test ring should be capable of doing repeated tests with minimum lead time.
3 DESCRIPTION OF THE TEST RIG

Major system elements of the test rig include:

I. A loading mechanism and fixture.
II. Hydraulic jacks and a dedicated hydraulic actuation system.
III. Instrumentation system

3.1 Loading mechanism and Fixture

The loading mechanism works on radially loading principle. The fixture consists of two rigid semi-discs of diameter 3m mounted on a base attachment structure (#1) as shown in the figure 1. The base structures can be made of structural steel material (box channels weld construction) which has to be grounded with proper foundation. The interface rings (#4) for the band of different diameters has to be simulated on the discs. The interface ring structure should be made of AA2014 T6 which will be mounted to the base structure by 12.9 grade fasteners (TVS/UNBRACKO). Test bed function can be limited to one band test at a time. Of the two discs, one semi-disc-1 (#2) is hinged to the base structure at the geometric center through a rotary bearing. Other semi-disc 2 (#3) can slide apart when it is actuated from the hinged semi-disc. The sliding disc is guided and supported by linear bearings (#5) which are minimum 3 in numbers. The linear motion of the semi-disc is achieved by centrally mounted hydraulic jack (#6), which in turn ensure loading on the band system.

3.2 Loading principle

The band unit consist of two semi bands which will assemble to the
interface ring through two connecting bolts. With a minimum torque on to the connecting bolt the band will experience proper butting to the interface rings which will lead an initial length \( L_b \) in the connecting bolt. When the hydraulic jack is pressurized, the sliding structure will start moving from the initial position \( L_b \) to a final position \( L_b + dL \). This change in strain will lead a tension load on to the entire band. Thus by varying the length \( dL \) by the sliding disc movement, loading of the band can be achieved. The stroke \( dL \) will vary for different bands and the loading will be controlled by the pressure on the jack. With the help of strain monitoring, tension on the band will be measured.

![Figure 2: Loading Principle](image)

### 3.3 Hydraulic Jacks and a Hydraulic Actuation System

Hydraulic jack will be mounted at the center of the fixed semi-disc 1 and pressurized at one chamber to achieve the linear motion to the semi-disc 2. The other chamber is used for retraction of the semi-disc 1 back to null position. Hydraulic jack shall have a load capacity of 50 tonnes. Loading of lower diameter bands like 2 tonnes shall be achieved by proper pressure controlling of the hydraulic jack.

Pressure loading for the jack is achieved through a dedicated hydraulic system as shown in figure. Hydraulic oil planned to be used is Servo prime 32 (33 Cst). The system consists of power pack (#2) having pump/motor unit, pressure line filter, oil tank (50 litre capacity), filler/breather unit, float switch, oil temperature sensor and manual safety relief valve. A proportional relief valve (#3) is provided in the system to set the
pressure remotely according to the loading pattern. 3/2 solenoid operated directional control valve (4) is provided in the pressure line to pressurize the jack during loading and to drain the jack pressure during unloading.

The second chamber of the jack is connected to a line rupture safety valve (5) and a 3/2 solenoid operated directional control valve (6). Rupture valve is provided to avoid sudden flow rate change (exceeding the set value) in the return line, in case the band system fails during loading and also to avoid uncontrolled movement of the semi-disc during this phase. A gas-charged bladder type accumulator (5 litres capacity) (7) is also provided in the circuit, when the band system has to be loaded for a specified period at a particular set pressure without the support of pump.
3.4 Instrumentation system

A dedicated instrumentation system for commanding and controlling the system will be planned by the department which does not come under the scope of party. Party shall give terminal outlets and electrical junction boxes at proper interfaces for providing instrumentation lines.

For testing at party site, party shall arrange their own instrumentation for operating the system.

4. SYSTEM SPECIFICATION

Table 1: Loading mechanism components

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Component</th>
<th>Function</th>
<th>Specifications</th>
</tr>
</thead>
</table>
| 1      | Semi-disc Structures | To carry out the radial loading function.  
1. Sliding half disc, placed over the linear bearings.  
2. Fixed half disc, hinged at geometric center with a set of rotary bearing | Overall Diameter – 3m.  
Semi-discs – 2 nos.  
Material – ISJC 100/ Box Structural Steel Channels or equivalent with corrosion protective coating.  
Max. Design Load – 50 T.  
Supporting and load bearing frames with local stiffening to be provided. – as per drawing in Annexure 1.  
Mounting rings, stoppers, linear bearings, rotary hinges/ bearings interface to be transferred and assemble before the final integration. |
| 2      | Linear Bearing     | Guide semi-disc 1 in a linear motion and arrest motion in any other direction. | No. Of bearings required – 3 nos (location as shown in Drawing).  
Max load expected (for Ø 2800mm) – 100 kN.  
Pitching moment onto bearing – 17 kN-m.  
Load and moment capability of bearing shall be at least 3 times.  
Preferred spec: THK SHS 65LC (Ultra Heavy Duty). |
3 Main Hydraulic Jack

Double acting requirement. Actuate the mechanism and move semi-disc I parallel to the linear bearing by providing the required load. Retract back the semi-disc to null position, by pressurizing the opposite chamber of jack.

Design load considered – 250 kN.
Max. Design pressure on jack – 25 MPa.
Jack material: preferred SS304
Seal material: Viton
Design margin : 2

4 Base structure

To provide support interface and necessary stiffness for the entire elements. Provide common plane/platform for the semi disc assembly

Material preferred – ISJC 100 Structural Steel Channels or equivalent with corrosion protective coating. Supporting and load bearing frames with local stiffening to be provided. – as per drawing in Annexure 1.

5 Mechanical Stoppers

Control the maximum linear motion of semi-disc I.

Adding rupture safety to the structure

6 Interface Rings

Interfacing bands of different diameters to the mechanism.

Material- AA2014 T6 condition. Milled and turned to get the proper band interfaces and mounting interfaces to the base structure.

Table 2: Hydraulic system components

<table>
<thead>
<tr>
<th>SL No</th>
<th>Component</th>
<th>Function</th>
<th>Specifications</th>
</tr>
</thead>
</table>
| 1     | Power pack      | Oil storage, to provide the required flow rate to the system. | • Pump-motor unit: Rated for 350 bar and 1.5-2 lpm flow rate.  
• Oil tank : 100 litre tank, SS304L material. Provision for accessing and cleaning the tank inner surface shall be incorporated in the design. The reservoir shall have fluid level gauge, thermostat, float switch, air breather and suction strainers. Filling and draining ports shall also be provided in the reservoir.  
• Provision shall be given for filling and draining of the reservoir from/to a |


<table>
<thead>
<tr>
<th></th>
<th>Component Description</th>
<th>Function and Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Pressure line filter</td>
<td>To maintain oil cleanliness in the system. Filter rating: 3 microns, 350 bar, 200 beta, with electrical clogging indicator.</td>
</tr>
<tr>
<td>3</td>
<td>Check valves (1 no) and ball valves (2 nos)</td>
<td>For one-way flow and for line isolation respectively. Pressure rating: 350 bar. From a reputed make. Size as per the optimal requirement.</td>
</tr>
<tr>
<td>4</td>
<td>3/2 Directional controlled solenoid valve</td>
<td>For providing the directional logic for oil flow during the system functioning. Pressure rating: 350 bar. From a reputed make. Poppet type.</td>
</tr>
<tr>
<td>5</td>
<td>Relief valve (manual)</td>
<td>Safety purpose. At any point of time, system pressure shall not exceed the set pressure. Pressure rating: 350 bar. From a reputed make.</td>
</tr>
<tr>
<td>6</td>
<td>Relief valve (proportional)</td>
<td>Main functional element. System Pressure setting remotely for the loading of jack. Pressure rating: 350 bar. Flow rate: 0.1 to 1.0 lpm. From a reputed make.</td>
</tr>
<tr>
<td>7</td>
<td>Gas charged accumulator</td>
<td>For long duration pressure holding, without the support of pump. Pressure rating: 350 bar. Bladder type, 5 litre capacity. From a reputed make.</td>
</tr>
<tr>
<td>8</td>
<td>Line rupture safety valve</td>
<td>To restrict sudden linear movement of the semi-disc, in the event of band failure. Pressure rating: 350 bar. From a reputed make.</td>
</tr>
<tr>
<td>10</td>
<td>Return line filter</td>
<td>To maintain oil cleanliness in the system. Filter element: 10 microns, 100 bar, with by-pass check valve.</td>
</tr>
<tr>
<td>11</td>
<td>Manifold blocks</td>
<td>For mounting valves and oil distribution, provision for pressure pickup assembly (1/4” BSP) Material: GGG40, Spheroidal cast iron.</td>
</tr>
<tr>
<td>12</td>
<td>Minimess couplings</td>
<td>To be provided in the system for oil bleeding at low pressure to remove the entrapped air in the system. 1/4” BSP. Pressure rating: 350 bar.</td>
</tr>
<tr>
<td>13</td>
<td>Pressure gauges</td>
<td>To check the system pressure. 4 nos. 4” Dial, Pressure range: 600 bar, Accuracy: 1% FS.1/4” BSP male.</td>
</tr>
</tbody>
</table>
5. **OTHER GENERAL REQUIREMENTS**

1. The loading mechanism and fixture shall be designed as per the layout proposed and with ergonomically and aesthetic manner.
2. Components design should consider human ergonomics so that it meets the accessibility and maintenance requirements.
3. The test rig shall be equipped with forklift provisions, sling lifting points and floor anchoring points. Also, the rig shall be designed for self-standing type.
4. Safety barricade/grills shall be provided at the periphery of the test structure to avoid fly-off debris in case of any sort of failure of band/ loading system while testing.
5. All electrical interfaces shall be routed at one junction box for easy accessibility.
6. The console shall be designed in such a way that all components for command, control and alerting devices are located in the front panels.
7. The hydraulic line / remote console to the loading system should have at least 20 m long safe distance.
8. Once the settings are made there shall not be a manual intervention for any correction the adjustments should be remotely controlled.
9. Party should procure the material and the standard components and produce test/product complain certificate before the testing. No material will be supplied by VSSC.
10. The finalized design should get approved from VSSC for the fabrication.
11. The test plan should be approved from VSSC and the party should adhere all the quality protocols as per VSSC.
12. The functional tests are to be done by the party before the delivery in presence of VSSC personnel.
13. Minor changes (cost within 10% of total) in the design, if suggested after the realization should be done by the party.
14. Instrumentation required for the tests (at work centre) should be supplied by the party.
15. The bearings and the functional elements used for the system should be of reputed brand.
16. Proper surface protection of the hardware's are to be given after the realization.
6. WORK CONTENT

1. The proposed data (drawing attached) is a concept

2. The dimensions given in the concept are tentative values, the values have to be confirmed based on detailed design

3. The design has to be worked out in totality as a test rig system. The detailed specifications of the sub system have to be worked out on the overall requirements specified by VSSC and have to be presented in the technical offer.

4. The design shall be presented to VSSC after placement of order. This includes preliminary design review before realization of the system and critical design review after the initial running of the test rig

5. Supply and installation of the machine including the hydraulic rig at Aerospace Mechanism Group, Valiamala complex, VSSC. Party should submit detailed drawings for foundation, electrical supply. The anchor bolts and all other support fixtures shall be supplied and installed by the party

6. Testing of the sample test band and training of the VSSC personnel for the test rig operations at VMC

7. List of documents to be furnished

   7.1 Preliminary design review document
   7.2 Test rig operation manual
   7.3 Service and maintenance manual
   7.4 Detailed part listing of the rid and its subsystem
   7.5 Acceptance test reports/ compliance certificates
   7.6 Quality control plans
   7.7 Schedule
   7.8 Warranty and maintenance
7. QUALIFICATION AND ACCEPTANCE PLAN

i. The contractor shall submit detailed qualification plan system level based on the guidelines given in the qualification plan in the Table 1. The qualification plan shall be in detail with number of tests, type of tests, environmental levels with tolerance on various parameters. The contractor shall get the plan approved by the department before Purchase Order placement.

ii. Proof pressure test (upto 2 times MEOP) to be carried out at PARTY’S SITE, in the presence of the department personnel. And burst pressure of the piping/hoses shall be designed for 4 times MEOP.

iii. The contractor shall prepare the test reports and get the approval from the Engineer identified by the department for the system level tests.

iv. During the testing operation, if there is any failure of any component of hydraulic system, the contractor shall replace the component free of cost, with VSSC consultation and failure analysis of the component, and offer the system to department in good working condition.

v. After completion of tests at Contractor’s site, surface protection shall be given for the elements.

8. INSTALLATION AND TESTING AT SITE

Installation of the test rig shall be carried out by the Contractor. The following tests are to be carried out by the contractor at work site:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Activities</th>
<th>Procedure</th>
<th>Agency</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Checking of connections</td>
<td>As per circuit</td>
<td>Contractor</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Flushing of total system after integrating all components and valves</td>
<td>As per circuit</td>
<td>“</td>
<td>All the lines are pressurized using hydraulic oil to proof pressure in step and hold for 5 minutes.</td>
</tr>
<tr>
<td>3</td>
<td>Proof pressure test.(2 times the operating pressure)</td>
<td>As per circuit</td>
<td>“</td>
<td></td>
</tr>
<tr>
<td>No.</td>
<td>Test Description</td>
<td>Method</td>
<td>Duration</td>
<td>Notes</td>
</tr>
<tr>
<td>-----</td>
<td>------------------------------------------------------</td>
<td>-------------------------</td>
<td>---------------</td>
<td>---------------------------------------------------------</td>
</tr>
<tr>
<td>4</td>
<td>Cycle test</td>
<td>As per circuit</td>
<td></td>
<td>“</td>
</tr>
<tr>
<td>5</td>
<td>Leak testing at 1.1 times the operating pressure for 24 hours</td>
<td>Hold for 24 hours</td>
<td>“</td>
<td>To qualify leak tightness of lines.</td>
</tr>
<tr>
<td>6</td>
<td>Integrated structural loading</td>
<td>As per test plan</td>
<td>“</td>
<td>To demonstrate the structural capability with a dummy ring.</td>
</tr>
<tr>
<td>7</td>
<td>Integrated functional testing</td>
<td>As per test plan</td>
<td>“</td>
<td>To demonstrate functional capability.</td>
</tr>
</tbody>
</table>

**9. SUMMARY**

Over all specification requirements for realizing the test rig are given. Technical quote shall contain detailed specification of each sub system/element, manufacturer etc. Supplier has to design and realize the item with in stipulated time. Detailed design is to be presented to VSSC. Specified acceptance tests for sub system level should be done before final assembly. Complete installation and testing to be done by the supplier at our site.