SPECIFICATION 435-2

FOR
FLEXIBLE JOINT ASSEMBLIES
FOR
BRAVO 2
MARK 10 TURBOPUMP TEST SYSTEM
AT
PROPULSION FIELD LABORATORY
SANTA SUSANA, CALIFORNIA

ROCKETDYNE
A Division of North American Aviation, Inc.

Facilities Engineering, Department 583

Approvals:

L. Skogstad
Chief Facilities Engineer

C. Anseiko, Jr.
Group Leader,
Large Engines III

7 October 1959
1. **SCOPE OF WORK**

1.1 The Seller shall provide all labor, materials, tools and equipment and perform all operations to design and fabricate thirty-seven (37) flexible joint assemblies as shown on the drawings listed in Paragraph 2 and described in this specification.

1.2 Installation of the assemblies is not included.

2. **APPLICABLE DRAWINGS**

2.1 The following drawings shall form a part of this specification:

<table>
<thead>
<tr>
<th>Drawing</th>
<th>Revision</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>435-440</td>
<td>0</td>
<td>8-13-59</td>
</tr>
<tr>
<td>435-441</td>
<td>0</td>
<td>8-24-59</td>
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<td>435-442</td>
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<td>9-1-59</td>
</tr>
<tr>
<td>435-443</td>
<td>0</td>
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</tr>
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</table>

3. **APPLICABLE CODES**

3.1 The latest revision of the ASME Boiler and Pressure Vessel Code, Sections VIII and IX, shall form a part of this specification.

4. **MATERIALS**

4.1 All material shall be new stock conforming to their respective designated specifications.

4.2 Electrodes for welding carbon steel to stainless steel shall be E-308.

4.3 Material designations are made on the applicable drawings and in Paragraph 7.

5. **DESIGN CALCULATIONS AND FABRICATION DRAWINGS**

5.1 Three (3) sets of all design calculations and fabrication drawings shall be submitted to the Buyer for approval. Fabrication shall not commence until the drawings have been approved.

5.2 Approval of design calculations and fabrication drawings shall in no way relieve the Seller of the responsibility of conforming in all respects with the requirements of the ASME Code and with this specification.

5.3 Six (6) copies of final certified as-built drawings shall be delivered to the Buyer prior to delivery of the completed joints.
6. **GENERAL DESIGN REQUIREMENTS**

6.1 The dimensions of the assemblies shall be as shown on the applicable drawings and as specified in Paragraph 7.

6.2 Liners shall not be used.

6.3 Deflection rates as described in Paragraph 7 shall be the maximum allowable in each case.

6.3.1 The deflection rate limitations as given in Paragraph 7 shall be verified by test.

6.3.2 The Seller shall submit to the Buyer with the design calculations and fabrication drawings, three copies of a method of test and test procedures for determining compliance with Paragraph 6.3.

6.3.3 Certified test results shall be submitted to the Buyer.

6.3.4 The term "deflection rate" as used in this specification is defined as the force or moment required for unit specified displacement of the completed assembly at working pressure. The maximum deflection rate values specified in Paragraph 7 shall apply over the entire range of deflections.

7. **SPECIFIC DESIGN REQUIREMENTS**

The following seven pages shall comprise the specific design requirements.
7.1 OXIDIZER INLET FLEXIBLE JOINTS

7.1.1 Nominal size 18 inch

7.1.2 Working Pressure 150 psig

7.1.3 Hydrostatic test pressure 300 psig (1)

7.1.4 Design burst pressure 500 psig (1)

7.1.5 Number required 5

7.1.6 Applicable drawing 435-122

7.1.7 Displacement and Deflection Rate:

<table>
<thead>
<tr>
<th>Displacement</th>
<th>Deflection Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial 0.5 inches</td>
<td>500 lbs/in²</td>
</tr>
<tr>
<td>Offset (3) 0.125 inches</td>
<td>500 lbs/in²</td>
</tr>
<tr>
<td>Angular + 2°</td>
<td>5000 in-lb/°</td>
</tr>
<tr>
<td>Axial and Angular (2) 0.5 inches + 2°</td>
<td>750 lbs/in²</td>
</tr>
</tbody>
</table>

7.1.5 Minimum design cyclic life shall be 3000 cycles.

7.1.6 The Item numbers for the assemblies described in this Paragraph are: 136, 137, 138, 139 and 307.

NOTES:

(1) Minimum value.

(2) Combination of forces and moments for combined displacements.

(3) Combination of testing offset and axial or angular displacements not required.
7.2 OXIDIZER DISCHARGE FLEXIBLE JOINTS

7.2.1 Nominal Size 10 inch
7.2.2 Working pressure 2400 psig
7.2.3 Hydrostatic test pressure 3600 psig (1)
7.2.4 Design burst pressure 7200 psig (1)
7.2.5 Number required 1
7.2.6 Applicable drawing L135-L140
7.2.7 Displacement and Deflection Rate:

<table>
<thead>
<tr>
<th>Displacement</th>
<th>Deflection Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial</td>
<td>0</td>
</tr>
<tr>
<td>Offset</td>
<td>0</td>
</tr>
<tr>
<td>Angular</td>
<td>$2^\circ$</td>
</tr>
</tbody>
</table>

7.2.8 Minimum design cyclic life shall be 3000 cycles.

7.2.9 The Item Numbers for the assemblies described in this Paragraph are 308, 309, 140, 141, 142, 143, 144, 145, 146, 147, 148, 152, 153, 154, 155, and 156.

NOTE:

(1) Minimum value.
7.3 FULL INLET FLEXIBLE JOINTS

7.3.1 Nominal size
12 inch

7.3.2 Working pressure
150 psig

7.3.3 Hydrostatic test pressure
300 psig min. (1)

7.3.4 Design burst pressure
450 psig min. (1)

7.3.5 Number required
6

7.3.6 Drawing number
435-143

7.3.7 Displacement and Deflection Rate:

<table>
<thead>
<tr>
<th>Displacement</th>
<th>Deflection Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial</td>
<td>0</td>
</tr>
<tr>
<td>Offset</td>
<td>0</td>
</tr>
<tr>
<td>Angular</td>
<td>±2°</td>
</tr>
</tbody>
</table>

7.3.8 Minimum design cyclic life shall be 3000 cycles.

7.3.9 The Item Numbers for the assemblies described in this Paragraph are: 219, 220, 221, 222, 223, and 224.

NOTE:

(1) Minimum value
7.4.1 FULL DISCHARGE FLEXIBLE JOINT

7.4.1 Nominal size 8 inch
7.4.2 Working pressure 2500 psig
7.4.3 Hydrostatic test pressure 3750 psig (1)
7.4.4 Design burst pressure 7500 psig (1)
7.4.5 Number required 6
7.4.6 Applicable drawing 435-M41
7.4.7 Displacement and Deflection Rate:

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<thead>
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<th>Displacement</th>
<th>Deflection Rate</th>
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</thead>
<tbody>
<tr>
<td>Axial</td>
<td>0</td>
</tr>
<tr>
<td>Offset</td>
<td>0</td>
</tr>
<tr>
<td>Angular</td>
<td>$2^\circ$</td>
</tr>
</tbody>
</table>

7.4.8 Minimum design cyclic life shall be 3000 cycles.
7.4.9 The Item Numbers for the assemblies described in this Paragraph are: 209, 210, 211, 212, 217, and 218.

NOTE:

(1) Minimum value
7.5 OXIDIZER FLEXIBLE JOINTS

7.5.1 Nominal size
7.5.2 Working pressure
7.5.3 Hydrostatic test pressure
7.5.4 Design burst pressure
7.5.5 Number required
7.5.6 Displacement and Deflection Rate:

<table>
<thead>
<tr>
<th>Displacement</th>
<th>Deflection Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td></td>
<td>2000 lb/in/</td>
</tr>
<tr>
<td>Offset</td>
<td>3/8&quot;</td>
</tr>
<tr>
<td></td>
<td>2500 lb/in</td>
</tr>
<tr>
<td>Angular</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

7.5.7 Materials

7.5.7.1 Weld end (one only) A312 Schedule 10S pipe Type 317 or 321.
7.5.7.2 Flanged end (one only) 300 ASA Lap Joint SST Type 317 or 321.
7.5.7.3 Bellows Stainless steel Type 317 or Type 321.

7.5.8 Dimensions

7.5.8.1 Maximum overall expanded length = 12-1/2"
7.5.8.2 Maximum overall neutral length = 12 inches.
7.5.8.3 Maximum overall compressed length = 11-5/8"
7.5.8.4 Maximum diameter of assembly = 15" (exclusive of flange).

7.5.9 Minimum design cyclic life shall be 3000 cycles.

7.5.10 The Item Numbers for the flex joints described in this Paragraph are 134 and 135.

NOTES:

(1) Minimum value
7.6 OXIDIZER FLEXIBLE JOINTS

7.6.1 Nominal size 18"
7.6.2 Working pressure 150 psig
7.6.3 Hydrostatic test pressure 225 psig (1)
7.6.4 Design burst pressure 450 psig (1)
7.6.5 Number required 3

7.6.6 Displacement and Deflection Rate:

<table>
<thead>
<tr>
<th>Displacement</th>
<th>Deflection Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial 1/2&quot;</td>
<td>1000 lb/in.</td>
</tr>
<tr>
<td>Offset 3/8&quot;</td>
<td>750 lb/in.</td>
</tr>
</tbody>
</table>

7.6.7 Configuration

7.6.7.1 Items Number 132 and 133: One 18" Lap Joint flange and one weld end per joint.

7.6.7.2 Item Number 139: Two weld ends.

7.6.8 Materials

7.6.8.1 Weld ends A312 Sch. 10S pipe Type 347 or Type 321
7.6.8.2 Bellows Stainless steel Type 347 or Type 321
7.6.8.3 Flanges 150# ASA Lap Joint Flanges stainless steel Type 347 or Type 321

7.6.9 Dimensions:

7.6.9.1 Maximum overall expanded length 2l=3/8"
7.6.9.2 Maximum overall neutral length 2l"
7.6.9.3 Maximum diameter of assembly (exclusive of flanges) 2l"

7.6.10 Minimum design cyclic life shall be 3000 cycles.

7.6.11 The Item Numbers for the assemblies described in this Paragraph are: 119, 133 and 132.

NOTES:

(1) Minimum value
7.7 OXIDIZER EXPANSION JOINT

7.7.1 Nominal size 12 inch
7.7.2 Working pressure 2400 psig
7.7.3 Hydrostatic test pressure 3600 psig (1)
7.7.4 Design burst pressure 7200 psig (1)
7.7.5 Number required 1
7.7.6 Displacement and Deflection Rate:

<table>
<thead>
<tr>
<th>Displacement</th>
<th>Deflection Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial</td>
<td>1-1/4&quot;</td>
</tr>
<tr>
<td>Offset</td>
<td>1/4&quot;</td>
</tr>
<tr>
<td>Angular</td>
<td>0</td>
</tr>
</tbody>
</table>

7.7.7 Materials

7.7.7.1 Weld ends A312 Sch 120S Pipe (1" wall) Type 347 or Type 321
7.7.7.2 Bellows Stainless steel Type 347 or 321.

7.7.8 Dimensions

7.7.8.1 Minimum overall expanded length 18-1/2"
7.7.8.2 Maximum overall neutral length 18"
7.7.8.3 Maximum overall compressed length 17-1/4"
7.7.8.4 Maximum diameter of assembly 21"

7.7.9 Minimum design cyclic life shall be 3000 cycles.

7.7.10 The Item Number for the expansion joint described in this Paragraph is 115.

7.7.11 Configuration: Item Number 115 shall have two weld ends.

NOTES:

(1) Minimum value
8. FABRICATION PROCEDURES

8.1 All design fabrication procedures, material and personnel qualifications shall be in accordance with Sections VIII and IX of the ASME Boiler and Pressure Vessel Code, and shall be approved by the Buyer.

8.2 Bellows shall be exempt from Code safety factor.

9. WELDING

9.1 All welding qualifications for welding operators and welding procedures shall be in accordance with Sections VIII and IX of the ASME Boiler and Pressure Vessel Code.

9.2 All root passes and fit up tack welds in stainless steel shall be by the inert gas shielded arc method.

9.3 Weld inserts or backup rings shall not be used.

9.4 All weld joints inaccessible from the root side shall have inert gas backing throughout any period that the weld is above scaling temperature.

9.5 After completion of welds, all weld flux, splatter and scale shall be removed.

9.6 Brazing is not permitted.

10. INSPECTION AND TESTING

10.1 All butt and spot welds exposed to the contained fluid shall be 100% radiographically and visually inspected by the Buyer at his expense.

10.2 All other welds shall be dye penetrant and visually inspected by the Buyer at his expense.

10.3 Welds of paramagnetic materials shall be inspected by magnaflux methods.

10.4 STANDARDS OF ACCEPTANCE OF WELDS

10.4.1 Interpretations of radiographs and acceptance of all welds rests with the Buyer.

10.4.2 All cracks of any nature, whether crater, underbead, transverse, longitudinal or parent metal will be rejected.

10.4.2.1 Crater cracks which are determined to be only surface defects may be removed by machining or grinding. They need not be rewelded provided build-up is not less than 10% nor more than 30% of the metal thickness, nor if drop-through is not less than flush nor more than 30% of the metal thickness.
10.4.2.2 Normally acceptable defects occurring in conjunction with or adjacent to cracks will be rejected for a distance of two inches each way from the crack.

10.4.3 Butt joints shall have 100% penetration throughout 100% of the linear length of the weld.

10.4.4 Any lack of fusion will not be accepted.

10.4.5 Undercut, excessive drop-through and excessive roughness shall be cause for rejection. Folds in drop-through will be accepted if they are not greater in depth than 10% of the thickness of the parent metal.

10.4.6 Porosity or inclusions occurring in the weld metal, exclusive of the weld reinforcements in which any radiographic image is darker than the parent metal or larger in its greatest dimension than 15% of the parent metal thickness will be rejected.

10.4.7 Porosity and inclusions in the weld reinforcement will be acceptable provided they do not extend through the surface of the reinforcements and provided they do not result in an objectionable stress riser in the judgment of the Buyer.

10.4.8 Porosity and inclusions whose greatest dimensions are equal to or less than 15% of the parent metal thickness will be acceptable to the extent of one pore per inch of weld length.

10.4.9 Tungsten inclusions located in the penetration zone will be accepted provided the greatest dimension of any particle is not over 25% of the parent metal thickness.

10.5 Impact tests shall be conducted in accordance with the procedures of Section VIII of the ASME Boiler and Pressure Vessel Code.

10.6 All hydrostatic, impact and deflection rate tests shall be conducted by the Seller and witnessed by the Buyer.

11. CLEANING AND FINISHING

11.1 On all operations involving flame cutting, arc cutting, or arc-air gouging, one sixty-fourth inch of metal below the scarfing marks shall be removed.

11.2 All components except bellows, machined surfaces and plated surfaces shall be blast cleaned to remove all mill scale, weld flux or other foreign material.

11.2.1 Blast material shall be new, clean silica sand or alundum grit.

11.3 All surfaces of the assemblies shall be thoroughly cleaned with a hot detergent wash, flushed with clean tap water and air dried.
11.3.1 Following the detergent wash, the internal surfaces shall receive a thorough cleaning with a trichloroethylene spray or dip.

11.3.2 The procedures described in this paragraph shall be repeated until no evidence of foreign matter is detected on a clean, lint-free white cloth rubbed over the surfaces and until no evidence of foreign matter is detected when the cleaned surfaces are visually inspected with ultra-violet light.

11.4 All openings shall be sealed with 8 mil thickness polyethylene film after cleaning operations are completed.

11.5 Each completed assembly shall be suitably crated and restrained to prevent damage in handling and to preserve alignment during installation.

11.6 Each crate shall be identified by Item Number as specified in Paragraph 7.

12. MARKING

12.1 A name plate shall be attached to each expansion joint assembly which shall be permanently inscribed with the following information:

12.1.1 Manufacturer’s name and model number.

12.1.2 Buyer’s drawing number.

12.1.3 Design working pressure.

12.1.4 Hydrostatic test pressure.