ACF INDUSTRIES
INCORPORATED
ALBUQUERQUE DIVISION
ENGINEERING

PHOEBUS 2
PRESSURE VESSEL/NOZZLE
INTERFACE TEST

ACF-411-312

September 30, 1966

NOTICE
This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Energy Research and Development Administration, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

DISTRIBUTION:

W. W. Stagg, AEC-SAAO
S. A. Upson, AEC-ALO
W. J. Jackel
C. R. Garr
J. W. Neudecker, LASL
J. E. Fisher
R. E. Pozega
J. Stucki
S. E. Logan
H. L. Brammer
R. E. Wandrey
H. T. Ried (2)
Alameda Accountability Center (2) ←
R. O. Reade, LASL

Prepared by: H. T. Ried
H. T. Ried
Engineer

Approved by: J. E. Fisher
J. E. Fisher, Manager
Mechanical Development
and Test Engineering

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED EB

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

BLANK

ABSTRACT

The results of the tensile test conducted on the Phoebus 2 Pressure Vessel/Nozzle Interface Models, ACF Drawing Nos. 3-516006-000, 3-516007-000, and 3-516015-000, 3-516016-000 are presented. The models withstood loads equivalent to the full power design loads on a representative section of the Pressure Vessel/Nozzle Interface with no apparent yielding except for localized yielding in the seal groove radius. Included in this report are plots of surface stresses as a function of tensile loads for each strain gage location.

BLANK

TABLE OF CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>
1	INTRODUCTION	7
2	SUMMARY	7
3	TEST PROCEDURES	7
4	TEST RESULTS.	11
 <u>Table</u>		
1	TEST OUTLINE.	8
 <u>Figure</u>		
1	LOAD LINE RELATIONSHIP BETWEEN MODELS 1 AND 2	8
2	PHOEBUS 2 INTERFACE MODEL TEST SETUP.	9
3	PHOEBUS 2 INTERFACE MODEL INSTRUMENTATION	10
4	STRAIN GAGE LOCATIONS IN THE SEAL GROOVE RADIUS	13
5	STRESSCOAT TEST RESULTS ON MODEL 1.	14
 <u>Appendix</u>		
A	PHOEBUS II PRESSURE VESSEL/NOZZLE INTERFACE TEST PROCEDURE . . .	15
B	MEMORANDUM SA-66-70	27
C	MODEL TEST LOADS VERSUS FULL POWER LOADS	29
D	STRAIN GAGE PLOTS	33

BLANK

1. INTRODUCTION

- 1.1 This report presents the results of tests conducted on two dimensional models of the Phoebus 2 Pressure Vessel/Nozzle Interface region by ACF's Mechanical Development and Test Engineering Department. The tests were performed between January 9 and May 16, 1966.
- 1.2 The objectives of this test were:
 - (a) To evaluate the load carrying capacity of the nozzle shear lip.
 - (b) To verify the load carrying ability of the nozzle flange.
 - (c) To investigate the effect of a nominal gap between pressure vessel flange and the nozzle shear lip.
 - (d) To evaluate the shear-out loads on the pressure vessel flange.
 - (e) To evaluate the torque versus axial load characteristics of the bolts and inserts.

2. SUMMARY

Based on the results of the Phoebus 2 Pressure Vessel/Nozzle Interface Test, the design of the pressure vessel flange, the nozzle flange, the Slimsert insert P/N SPL628U-1, and the Aerojet bolts P/N UN-1115487-5 appears to be structurally adequate to withstand the maximum full power loads created by the Phoebus 2 operation.

3. TEST PROCEDURES

- 3.1 The test was conducted in accordance with "Phoebus II Pressure Vessel/Nozzle Interface Test Procedure, "ACF-411-282, February 28, 1966 (Appendix A) with the following additions and revisions.
 - 3.1.1 Bolt torque versus axial load determinations were discontinued because of the high cost and time considerations involved in machining the Hastelloy-X washers used to simulate the material properties of the nozzle.
 - 3.1.2 Two model configurations were built and subjected to the tensile tests in place of the three models specified by the procedure. The two models differed in the load offset from the intersection of the bolt axis and the interface. The load offset is illustrated by the dimension "d" in Figure 1. The effect of this difference is to change the interface moment.
 - 3.1.3 It was found that the Stresscoat lacquer attacked the insulation on the strain gage lead wires; therefore, the application of Stresscoat to strain-gaged models was deleted. A separate test was performed utilizing Stresscoat on Model 2.

Figure 1. LOAD LINE RELATIONSHIP
BETWEEN MODELS 1 AND 2

Table 1. TEST OUTLINE

<u>DATE</u>	<u>MODEL NO.</u>	<u>TEST NO.</u>	<u>BOLT PRELOAD</u>	<u>MAX. LOAD</u>
4/27/66	1	1	25,000 lbs/bolt	60,000 lbs.
4/27/66	1	2	25,000 lbs/bolt	60,000 lbs.
4/28/66	1	3	18,000 lbs/bolt	60,000 lbs.
4/28/66	1	4	22,000 lbs/bolt	60,000 lbs.
4/18/66	2	1	25,000 lbs/bolt	60,000 lbs.
4/20/66	2	2	25,000 lbs/bolt	60,000 lbs.
4/21/66	2	3	18,000 lbs/bolt	60,000 lbs.
4/22/66	2	4	22,000 lbs/bolt	60,000 lbs.
5/13/66	2	5	25,000 lbs/bolt	60,000 lbs.
5/16/66	2	6	25,000 lbs/bolt	149,750 lbs.

3.2 The full power load of 60,000 pounds tensile load for a three-bolt sectional model was derived by J. W. Neudecker, LASL N-7, and the Analytical Support Group, ACF, from LASL Report No. P-2-66-1 "Phoebus 2 Pressure Vessel/Nozzle Interface Analysis, Part IV-Stress Analysis."

3.3 The tests performed and the respective load conditions are given in Table 1; the test setup and instrumentation are shown in Figures 2 and 3.

1. Test Assembly

2. Photostress Instrument

3. Load Control Console

Figure 2. PHOEBUS 2 INTERFACE MODEL TEST SETUP

Figure 3. PHOEBUS 2 INTERFACE MODEL INSTRUMENTATION

4. TEST RESULTS

- 4.1 Results of tensile tests performed on specimens taken from the same billet material that the models were fabricated from showed that the yield strength of the Hastelloy-X was 45,100 psi, and the yield strength of the 7039-T-64 Aluminum was 50,300 psi.
- 4.2 The maximum stress indicated on the nozzle shear lip at the full power load of 60,000 pounds was less than 25,000 psi at the shear lip radius. The Hastelloy yield stress was exceeded at approximately 100,000 pounds load at the shear lip radius only.
- 4.3 The gap between the pressure vessel flange and the nozzle shear lip was adjusted to a nominal 0.010 inch before torquing the bolts. As the load was applied to the model, the gap was measured at 1000-pound increments until completely closed. The gap started to close when the load was approximately 12,000 pounds and was completely closed at 30,000 pounds of load, i.e. the externally applied load of 12,000 pounds was sufficient to overcome the friction load on the interface imposed by the bolt preload. At 30,000 pounds load, when the pressure vessel flange and the nozzle shear lip came into contact, the nozzle shear lip loading began. Thus the loading on the nozzle shear lip was minor until 50% of the full power design load was applied.
- 4.4 The nozzle bolts were subjected to tensile tests while installed in their associated inserts. With one exception, the bolts were found to break before the inserts were pulled from the fixture. The average failure load of the unmodified bolts was 45,950 pounds. In addition, the representative configuration of two unmodified bolts and one modified bolt used in the Failure Mode Determination Test demonstrated the load carrying ability. The Model sustained a load of 149,750 pounds (249% of full power load) before the center bolt (modified by an enlarged coolant hole through the bolt) failed at the head. The other two bolts held a load of 110,000 pounds on the model.
- 4.5 The strain gage data indicates that the shear-out loads on the pressure vessel flange are of no concern.
- 4.6 The determination of the torque versus axial load characteristics of the bolts and inserts was discontinued because of the reasons specified in Paragraph 3.1.1. The data that was received is of no value since the lubrication specification has been changed. For this reason, the data is not presented in this report. The data from the torque versus axial load evaluation

was to have been used to select the best type of insert for installation in the Phoebus 2 Pressure Vessel as well as the Interface Model. The three types of inserts considered were Helicoil, P/N 1191-10CN-1.25; Keensert, P/N KNH 1018-22; and Slimsert, P/N SPL 6285U -1. The Slimsert was selected and used for the test because (1) one of the Helicoils tested pulled out of the fixture during the pull tests, (2) Helicoils can present installation problems, and (3) the installation hole required for the Keensert was significantly larger than the hole required for the Slimsert and thus would have a higher stress concentration factor.

- 4.7 The most significant stress concentration was observed to be in the seal groove radius adjacent to the nozzle shear lip on the pressure vessel flange. The photostress data from Model 2 indicated a stress of 33,040 psi at 60,000 pounds load. This radius was increased from 0.015 to 0.040 inch and additional strain gages were applied to the model in the seal groove area. During the subsequent tests, numbers 5 and 6 (Failure Mode Test), strains recorded on Strain Gages 31 and 32 located in the seal groove radius indicated stresses in excess of the yield stress at the full power load. Strain gage rosettes located immediately adjacent to the radius (Gages 41-42-43 and 44-45-46) indicated that the stress at this location was less than 16,500 psi at the full power load.

It appears that there is very localized yielding in the seal groove radius; but because the total distortion of the seal groove after the Failure Mode Test was a maximum of 0.015 inch, it is felt that the yielding will not adversely affect the Phoebus 2 operation. (See Figure 4 for the locations of strain gages in the seal groove radius.)

- 4.8 A Failure Mode Determination Test was performed on Model 2 using a modified bolt with the enlarged center hole for the middle bolt and two unmodified bolts. The model sustained a load of 149,750 pounds (24% of full power load) before the modified bolt failed in shear at the intersection of the bolt head and the shank. After the modified bolt failed, the other two bolts maintained a load of 110,000 pounds on the model. All the bolts were in extreme bending prior to failure, and the bolts and the model were permanently distorted as a result of this test. This distortion is described by Memorandum SA-66-70 (Appendix B).
- 4.9 The results of the data from the photostress coatings and the interface friction analysis are detailed in Office Memorandum N-2-297, entitled, "Structural Test of Two-Dimensional Model of Pressure Vessel/Nozzle Interface for Phoebus 2," from J. W. Neudecker, LASL, and S. Logan, ACF, dated May 13, 1966.
- 4.10 A calculation comparing the test loads from the model tests with the current analysis for full power operating loads has been made by J. W. Neudecker, LASL. This comparison has been extracted from the reference of Paragraph 4.9 and is included in this report as Appendix C.
- 4.11 The results of the Stresscoat Test are shown in Figure 5. The strain data was reduced by the ACF D-115 program and plotted by the IBM 1627 Plotter. These strain gage plots are presented as Appendix D.

Figure 4. STRAIN GAGE LOCATIONS IN THE SEAL GROOVE RADIUS

Figure 5. STRESSCOAT TEST RESULTS ON MODEL 1

ACF INDUSTRIES

INCORPORATED

ALBUQUERQUE DIVISION

APPLIED RESEARCH AND DEVELOPMENT

Appendix A

Test Procedure**PHOEBUS II PRESSURE VESSEL/NOZZLE
INTERFACE TEST**

ACF-411-282

February 28, 1966

DISTRIBUTION:

W. W. Stagg, AEC-SAAO (2)
W. J. Jackel
J. W. Neudecker, LASL
J. E. Fisher
R. E. Pozega
J. M. Fowler
S. E. Logan
R. W. Randolph
H. L. Brammer
H. E. Hendricks (8)
R. E. Wandrey
H. T. Ried (2)
Alameda Accountability Center (2)

Prepared by:

H. T. Ried
H. T. Ried
Test Engineer

Approved by:

R. E. Wandrey
R. E. Wandrey
Supervisor, Test Operations

Approved by:

J. E. Fisher
J. E. Fisher, Manager
Mechanical Development &
Test Engineering

Concurrence:

H. L. Brammer
H. L. Brammer
Senior Project Engineer

TABLE OF CONTENTS

<u>Section</u>	<u>Title</u>	<u>Page</u>
1	INTRODUCTION	17
2	TEST OBJECTIVES.	17
3	TEST DESCRIPTION.	17
4	TEST PROCEDURE	18
<u>Table</u>		
1	PHASE I TESTS — INSERT EVALUATION DATA SHEET	21
<u>Figure</u>		
1	TEST SETUP FOR PHASE I TESTS	22
2	SKETCH OF PHOEBUS - II INTERFACE MODEL	23
3	STRAIN AND DISPLACEMENT GAGE LOCATIONS	24
4	STRAIN GAGE INSTRUMENTATION ON MODIFIED NOZZLE BOLTS . .	25
5	SKETCH OF AREA TO BE STRESSCOATED	26

1. INTRODUCTION

This procedure establishes the methods and sequence for evaluation of the Phoebus II Pressure Vessel/Nozzle Interface region as requested by Work Order 5-1630, dated August 5, 1965, and a specification letter dated July 15, 1965, from Mr. J. W. Neudecker of the Los Alamos Scientific Laboratory.

2. TEST OBJECTIVES

The objectives of these tests are as follows:

- (a) To evaluate the load carrying capacity of the nozzle shear lip.
- (b) To verify the nozzle flange load carrying ability.
- (c) To investigate the effect of a nominal gap between pressure vessel flange and the nozzle shear lip.
- (d) To evaluate the load carrying ability of the attachment bolts and associated inserts.
- (e) To evaluate the shear-out loads on the pressure vessel flange.
- (f) To evaluate the torque versus axial load characteristics of the bolts and inserts.

3. TEST DESCRIPTION

3.1 In order to obtain all of the objectives listed above, the tests will be performed in two phases. Phase I will consist of the insert selection and the determination of the bolt torque versus axial load characteristics, and Phase II will consist of the two dimensional model tests.

3.2 Phase I Tests

- 3.2.1 The three types of inserts to be evaluated are Helicoil P/N 1191-10CN-1.25, Keensert P/N KNH 1018-22, and Slimsert P/N SPL 628 SU-1. The test setup will include 7039-T61 Aluminum blocks internally threaded to accept the inserts.
- 3.2.2 The bolt head end of the test setup will be such that the surface mating with the bolt head simulates the hardness and surface finish of the Hastelloy-X used in the nozzle. The aluminum blocks and the bolt head fixtures will be fitted with adapters to make them compatible with the 400,000 pound capacity Riehle Testing Machine.

- 3.2.3 The test will consist of torquing the bolt head and recording the axial load from the Riehle Testing Machine. This test will be performed a minimum of four times for each insert.
- 3.2.4 After completing the tests described in Paragraph 3.2.3, an ultimate (or pullout) load test will be made on each insert to determine the failure mode and failure load.

3.3 Phase II Tests

- 3.3.1 Two dimensional models of the pressure vessel/nozzle interface, three bolts wide, will be fabricated. The ends of the model will be compatible (through the use of adapters) to the Riehle Testing Machine.
- 3.3.2 The interface models will be subjected to loads which duplicate the operational loads in magnitude and direction and interface moment values. This test will be performed a minimum of four times on each model.
- 3.3.3 Strain gages, displacement transducers, photostress, and Stresscoat will be used to determine the interface behavior.
- 3.3.4 After completing the tests of Paragraph 3.3.2, the interface models will be subjected to an ultimate load test in order to determine the failure mode.

4. TEST PROCEDURE

4.1 Phase I Tests

- 4.1.1 Test four (4) inserts of each type with an unused 7039-T61 Aluminum block (Dwg. Nos. 3-763778-000, 3-763779-000 or 3-763780-000) for each insert.
- 4.1.2 Verify the dimensional integrity of the insert installation threads with a plug gage before installation in the aluminum blocks.
- 4.1.3 A sketch of the test setup is shown in Figure 1.
- 4.1.4 Lubricate all bolt threads with Lubribond Type A and all "K" seals with Dow Corning No. 11.
- 4.1.5 Mount the test fixture in the Riehle Testing Machine, as shown in Figure 1.
- 4.1.6 Insert the bolt and aluminum block into the test fixture.
- 4.1.7 Torque the bolt into the test assembly in 50 ft-lb increments to 150 ft-lbs and continue torquing in 20 ft-lb increments until an axial load of 23,000 lbs (approximately 240 ft-lbs) is reached. Record the axial load observed on the Riehle at each torque value on the data sheet in Table 1.

- 4.1.8 Record the break-away torque and remove the bolt. Check bolt and insert for galling. Relubricate the bolt if necessary.
- 4.1.9 Perform the tests described in Paragraphs 4.1.6 through 4.1.8 a total of four times with each bolt and insert combination.
- 4.1.10 After completing the tests specified in Paragraph 4.1.9, perform an ultimate load (pullout) test on each bolt and insert combination. Record the maximum load and the failure mode. Run the chart on the Riehle continuously during this test.
- 4.1.11 Take photographs of the test setup and test specimen failures.
- 4.1.12 Transmit all data from Phase I tests to H. Hendricks, Department 431, for selection of the type insert to be used in Phase II tests.

4.2 Phase II Tests

- 4.2.1 Perform Phase II tests on three interface models as shown in Figure 2, using the insert selected from the Phase I tests (only two models, Dwg. Nos. 3-516006-000, 3-516007-000 and 3-516015-000, 3-516016-000, are presently defined). One configuration is a LASL concept and the other is an ACF concept.
- 4.2.2 The ACF Quality Control and Inspection Department will perform a comprehensive dimensional inspection of the interface models.
- 4.2.3 Serialize the interface Models 1 through 3.
- 4.2.4 Apply strain and displacement gages before assembly, as shown in Figure 3.
- 4.2.5 Mount four (4) strain gages, axially oriented 90° apart, as shown in Figure 4, on the middle bolt (modified) of each model to measure the axial and bending loads. Lubricate threads and seals as in Paragraph 4.1.4.
- 4.2.6 Apply Stresscoat before assembly to the models, as shown in Figure 5, to determine whether additional gages are needed in subsequent tests.
- 4.2.7 Apply photostress coating before assembly to the models, as shown in Figure 5. Displacement gages are not mounted on model face which is photostress coated.
- 4.2.8 Setup the Gilmore Model 114 to record the outputs of the strain and displacement gages.
- 4.2.9 Setup photostress instruments to record the data from the photostress coating on one flat face of the model.

- 4.2.10 The effects of various torque values will be investigated; therefore, the torque values will be selected at test time by the cognizant test monitor.
- 4.2.11 Assemble the interface model in the Riehle, taking care that the instrumentation is monitored during assembly.
- 4.2.12 Load the interface model in 10% increments (6000 lbs) to the full power load of 60,000 lbs.
- 4.2.13 Record instrumentation data at each load increment on the data sheet.
- 4.2.14 Adjust torque according to Paragraph 4.2.10 and repeat Paragraph 4.2.12 under direction of monitor.
- 4.2.15 After the test data is evaluated, load the model until failure results. Record the failure load on the data sheet.
- 4.2.16 Take photographs of test setups and test specimen failures.

NOTE: A mechanical properties study shall be performed on the Hastelloy -X and the 7039-T61 Aluminum to determine that the materials used for these tests meet the proper specifications.

Table 1

PHASE I TESTS - INSERT EVALUATION DATA SHEET

Date		
Insert Type		
Torque Value (ft-lbs)	Load	Remarks
50		
100		
150		
170		
190		
210		
230

Figure 1. TEST SETUP FOR PHASE I TESTS

Figure 2. SKETCH OF PHOEBUS - II INTERFACE MODEL

NOTES:

1. Mount gages using C-2 Cement.
2. Gages 1-6 and 25-30 to be C-12-111.
Gages 7-24 to be C-9-111. .062" lgth.
3. Displacement gages to be 0-.050 inches range, sensitivity of 1×10^{-4} inch, such as Sanborn Model 581-25-1.

Figure 3. STRAIN AND DISPLACEMENT GAGE LOCATIONS

Figure 4. STRAIN GAGE INSTRUMENTATION ON MODIFIED NOZZLE BOLTS

Figure 5. SKETCH OF AREA TO BE STRESSCOATED

Appendix B

TO Analytical Support Group FROM Test Engineering Section
LOCATION AND DEPARTMENT LOCATION AND DEPARTMENT

ATT. H. L. Brammer DATE May 19, 19 66 BY HEH:ms

SUBJ. ULTIMATE LOAD TEST ON PHOEBUS SA-66-70
2 INTERFACE MODEL 2' OUR REFERENCE YOUR REFERENCE

The Phoebus 2 Interface Test Model 2' is shown in drawings 516015, 516016 and modified as described in memorandum SA-66-65. The model was loaded until failure occurred at 149,750 lbs. The center bolt with the enlarged center hole, AGC 1115487-7, failed in shear at the intersection of the shank and bolt head. All bolts were in extreme bending prior to the ultimate load. After the center bolt failed, the tensile machine indicated 110,000 lb. load being maintained on the model. Permanent distortion on the bolts was as follows:

There was noticeable brinelling of the 516015 model where contact was made with the nozzle shear lip. The seal groove was distorted a maximum of 0.015 inch. Coining of the hastelloy model under the bolt heads was negligible under the center bolt but quite pronounced under the outer bolts. Refer to the sketch on page 28 for additional dimensional failure data.

Photographs were made of the bolts and deformed areas. They will be available on May 23.

H. E. Hendricks
H. E. Hendricks

PHOEBUS 2 INTERFACE MODEL 2 DIMENSIONAL CHANGES

Appendix C

MODEL TEST LOADS VERSUS FULL POWER LOADSC.1 Load Calculations

The test load value and vector direction were selected on the basis of the analysis valid at the time the test specimens were designed and fabricated. The following calculation compares the test loads with the current analysis for full power operating conditions as shown in the following table:

<u>CONDITION AND LOADS</u>	<u>RADIAL COMPONENT, H, LB/IN</u>	<u>AXIAL MOMENT M_s, IN-LB/IN</u>
Case I, Mechanical loads only, 1.0 N. H. R.	12073	738
Case II, Mechanical + thermal loads, 1.0 N. H. R.	7724	150
Case III, Mechanical loads only, 1.25 N. H. R.	12061	738
Case IV, Mechanical + thermal loads, 1.25 N. H. R.	7649	974

The total ejection force, $F_{\text{total}} = 2,232,077 \text{ lb.}$

(Ref. Part I, load analysis, P2-65-6, Rev. "B", dated 3/1/66)

Assuming this load acts at a radius of 32 inches, then:

$$V = \frac{F_{\text{total}}}{2\pi R} = \frac{2,232,077}{64\pi} = 11,102 \text{ lb/in.}$$

This axial load is constant for the four cases of the above table.

The test load was 60,000 lbs acting at an angle of 34° with the interface.

$$L = 60,000 \text{ lbs} - P_{\text{lb/in}} = \frac{L}{W} = \frac{60,000}{4.188} = 14,330 \text{ lb/in}$$

$$\text{Test load } V = 14,330 \cos 34^\circ = 11,880 \text{ lb/in}$$

$$\text{Test load } H = 14,330 \sin 34^\circ = 8,010 \text{ lb/in}$$

C.2 Determination of Test Loads

A sketch of the loading arrangement on the test specimen is shown. The pressure vessel only is shown but the nozzle loading is similar.

Two configurations were built, differing only in the dimension d , the load offset.

For Model - 1 $d = 0.184$ in.

For Model - 2 $d = 0.018$ in.

Model width, $W = 4.188$ in.

Width was determined as follows:

three bolts to be used

arc length between bolts = 1.396 in.

(Ref. Part IV, stress analysis, page 81)

Therefore total width of specimen, $W = (3)(1.396) = 4.188$ in.

Assume that horizontal component of load acts at a distance of 0.21 inch below interface surface. The vectorial relationship is:

Moment arm = S

$$S = d - 0.21 \text{ in.} \sin 34^\circ$$

$$= d - 0.117 \text{ in.}$$

$$\text{Moment, } M = (P)(S) = P(d - 0.117)$$

$$\text{For Model - 1 } M = P(0.184 - 0.117) = 0.067 P$$

$$\text{For Model - 2 } M = P(0.018 - 0.117) = -0.099 P$$

The interface moment will be different for models No. 1 and 2, as follows:

$$\text{Model - 1, } M_s = 0.067 P = (0.067)(14330) = +960 \text{ in-lb/in.}$$

$$\text{Model - 2, } M_s = -0.099 P = (-0.099)(14330) = -142 \text{ in-lb/in.}$$

Note: $+M_s$ value closes on the interface seal; conversely $-M_s$ value tends to open this seal.

By inspection of the loads shown above, the loads and moment on Model - 1 correspond approximately to the values shown in the table for Case IV: Mechanical + thermal loads, 1.25 N.H.R., and the loads and moment on Model - 2 correspond most closely to the values shown for Case II: Mechanical + thermal loads, 1.00 N.H.R.

C.3 Calculation of Interface "Liftoff"

The liftoff load is a function of bolt preload. For a zero moment condition, liftoff is assumed to occur when bolt preload equals axial component of test load.

When: bolt load = $T_o = 25,000$ lbs/bolt

$$\text{total } T_o = (3)(25000) = 75,000 \text{ lb.}$$

Then liftoff will occur when:

$$L \cos 34^\circ = 75,000 \text{ lbs.}$$

$$L = \frac{75,000}{\cos 34^\circ} = 90,500 \text{ lbs.}$$

The interface moment is low for Model - 2 specimen, therefore the test machine load at liftoff is calculated to be 90,500 lb. After liftoff, the total bolt load will be:

$$T = L \cos 34^\circ = \text{axial component of test load.}$$

BLANK

Appendix DSTRAIN GAGE PLOTS

<u>Test No.</u>	<u>Model 1</u>	<u>Tab</u>
1		1
2		2
3		3
4		4
 <u>Model 2</u>		
1		5
2		6
3		7
4		8
5		9
FM		10

Mod 1 Tests

Test 2

Test 4

Mod 2 Tests

Test 1

Test 2

Test 3

Test 4

Test 5 & FM

NOTES:

1. All gages are 90° apart.
2. All gages were re-zeroed after the bolt pre-load was applied.

BOLT STRAIN GAGE ORIENTATION

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1 GAGE NUMBER 1

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBER 2

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBER 3

PHOEBUS C INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBER 41

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBER A2

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBER A3

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBER A4

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBER A5

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBER A6

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBER A7

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBER AB

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBER A9

ENDURUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBER A10

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBER A11

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBER A12

LOAD IN KSI

PHOBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBERS B1 AND B2

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBERS B5 AND B6

PHOEBUS 2 INTERFACE TEST, TEST 1
 MODEL 1, GAGE NUMBERS B7 AND B8

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBERS B9 AND B10

PHOEBUS 2 INTERFACE TEST, TEST 1
 MODEL 1, GAGE NUMBERS 13 AND 14

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBERS 19 AND 20

PHOEBUS 2 INTERFACE TEST, TEST 1
 MODEL 1, GAGE NUMBERS 23 AND 24

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 1, GAGE NUMBERS 25 AND 26

PHOEBUS 2 INTERFACE TEST, TEST 1
 MODEL 1, GAGE NUMBERS 27 AND 28

PHOEBUS 2 INTERFACE TEST. TEST 2
MODEL 1. GAGE NUMBER 1

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBER 2

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBER 3

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBER A1

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBER A2

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE A3

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE A4

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBER AS

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBER AG

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBER A7

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBER AB

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBER A9

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBER A10

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBER A11

LORD IN KSI

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBER A12

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBERS B1 AND B2

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBERS B3 AND B4

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBERS B5 AND B6

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBERS 87 AND 88

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBERS 13 AND 14

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBERS 15 AND 16

PHOEBUS 2 INTERFACE TEST, TEST 2
 MODEL 1, GAGE NUMBERS 17 AND 18

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBERS 19 AND 20

PHOEBUS 2 INTERFACE TEST, TEST 2
 MODEL 1, GAGE NUMBERS 21 AND 22

PHOEBUS 2 INTERFACE TEST, TEST 2
 MODEL 1, GAGE NUMBERS 25 AND 26

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBERS 27 AND 28

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBERS 29 AND 30

PHOEBUS 2 INTERFACE TEST, TEST 2
MODEL 1, GAGE NUMBERS 31 AND 32

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBER 1

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBER 3

STRAIN IN MICROINCHES PER INCH

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBER A1

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBER A2

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBER A3

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBER A4

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBER A5

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBER A6

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBER A7

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBER AB

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBER A9

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBER A10

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBER A11

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBER A12

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBERS B1 AND B2

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBERS B3 AND B4

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBERS B7 AND B8

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBERS B9 AND B10

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBERS B11 AND B12

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBERS 13 AND 14

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBERS 15 AND 16

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBERS 17 AND 18

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBERS 19 AND 20

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBERS 21 AND 22

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBERS 23 AND 24

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBERS 25 AND 26

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBERS 27 AND 28

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBERS 29 AND 30

PHOEBUS 2 INTERFACE TEST 3
MODEL 1, GAGE NUMBERS 31 AND 32

LOAD IN KSI

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBER A1

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBER A2

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBER A3

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBER A4

PHILIPS 2 INTERFACE TEST, TEST 4
MODEL 1.6-3E NUMBER AS

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBER A6

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBER A7

PHOEBUS 2 INTERFACE TEST. TEST 4
MODEL 1, GAGE NUMBER AB

PHOEBUS 2 INTERFACE TEST. TEST #
MODEL 1, GAGE NUMBER AS

PHOEBUS 2 INTERFACE TEST. TEST #
MODEL 1, GAGE NUMBER A10

PHOEBUS 2 INTERFACE TEST. TEST 4
MODEL 1, GAGE NUMBER A11

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBER A12

PHOENIX 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBER 81 AND 82

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBERS B5 AND B6

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBERS B7 AND B8

PHOEBUS 2 INTERFACE TEST, TEST 4
 MODEL 1, GAGE NUMBERS B9 AND B10

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBERS 811 AND 812

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBERS 13 AND 14

LOAD IN KSI

PHOEBUS 2 INTERFACE TEST TEST 4
MODEL 1 GAGE NUMBER 1 AND 1P

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBERS 19 AND 20

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBERS 21 AND 22

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBERS 23 AND 24

PHOENIX 2 INTERFERE TEST, TEST 4
MODEL 1, GAGE NUMBERS 25 AND 26

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBERS 27 AND 28

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBERS 29 AND 30

PHOEBUS 2 INTERFACE TEST, TEST 4
MODEL 1, GAGE NUMBERS 31 AND 32

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBER 2

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBER 3

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBER A1

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBER A2

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBER A3

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBER A4

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBER AS

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBER A6

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBER A7

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBER AB

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBER A9

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBER A10

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBER A11

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBER A12

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBERS B1 AND B2

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBERS B3 AND B4

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBERS B7 AND B8

PHOEBUS 2 INTERFACE TEST, TEST 1
 MODEL 2. GAGE NUMBERS B9 AND B10

PHOEBUS 2 INTERFACE TEST, TEST 1
 MODEL 2. GAGE NUMBERS B11 AND B12

PHOEBUS 2 INTERFACE TEST, TEST 1
 MODE. 2, GAGE NUMBERS 13 AND 14

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBERS 15 AND 16

PHOEBUS 2 INTERFACE TEST, TEST 1
 MODEL 2, GAGE NUMBERS 19 AND 20

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBERS 21 AND 22

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBERS 23 AND 24

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBERS 25 AND 26

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBERS 27 AND 28

PHOEBUS 2 INTERFACE TEST, TEST 1
MODEL 2, GAGE NUMBERS 29 AND 30

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBER A1

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBER A2

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBER A3

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBER A4

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBER A5

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBER A6

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBER A7

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBER AB

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBER A9

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBER A10

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBER A11

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBER A12

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBERS 83 AND 84

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBERS 87 AND 88

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBERS B11 AND B12

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBERS 15 AND 16

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBERS 17 AND 18

PHOEBUS 2 INTERFACE TEST 2
 MODEL 2, GAGE NUMBERS 19 AND 20

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBERS 21 AND 22

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBERS 23 AND 24

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBERS 25 AND 26

PHOEBUS 2 INTERFACE TEST 2
MODEL 2, GAGE NUMBERS 27 AND 28

LOAD IN KSI

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBER 1

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBER 2

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBER 3

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBER A1

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBER A2

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBER A3

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBER A4

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBER AS

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBER A6

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBER A7

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBER AB

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBER A9

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBER A10

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBER A11

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBER A12

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBERS B3 AND B4

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBERS B5 AND B6

PHOEBUS 2 INTERFACE TEST 3
 MODEL 2, GAGE NUMBERS 87 AND 88

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBERS B9 AND B10

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBERS B11 AND B12

PHASE 2 INTERFACE TO 3
 LOAD 1, GAGE 1, PHASE 1, 3, 4

PHOEBUS 2 INTERFACE TEST 3
 MODEL 2, GAGE NUMBERS 15 AND 16

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBERS 17 AND 18

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBERS 19 AND 20

PHOEBUS 2 INTERFACE TEST 3
 MODEL 2, GAGE NUMBERS 21 AND 22

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBERS 23 AND 24

PHOEBUS 2 INTERFACE TEST 3
MODEL 2, GAGE NUMBERS 27 AND 28

PHOEBUS 2 INTERFACE TEST 2
 MODEL 2, GAGE NUMBERS 29 AND 30

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBER 1

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBER 2

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBER 3

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBER A1

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBER A2

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBER A3

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBER A4

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBER AS

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBER A6

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBER A7

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBER AB

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBER A9

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBER A10

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBER A11

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBER A12

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBERS B3-B4

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBERS B7-BB

PHOEBUS 2 INTERFACE TEST 4
 MODEL 2, GAGE NUMBERS B9-B10

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBERS B11-B12

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBERS 15-16

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBERS 17-18

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBERS 19-20

PHOEBUS 2 INTERFACE TEST 4
 MODEL 2, GAGE NUMBERS 21-22

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBERS 23-24

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBERS 27-28

PHOEBUS 2 INTERFACE TEST 4
MODEL 2, GAGE NUMBERS 29-30

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, GAGE NUMBER AS

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, GAGE NUMBER #6

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, GAGE NUMBER A7

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, GAGE NUMBER A8

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, GAGE NUMBERS 3 AND 4

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, GAGE NUMBERS 5 AND 6

PHOEBUS 2 INTERFACE TEST, TEST 5
 MODEL 2, GAGE NUMBERS 7 AND 8

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, GAGE NUMBERS 9 AND 10

PHOEBUS 2 INTERFACE TEST, TEST 5
 MODEL 2, GAGE NUMBERS 11 AND 12

PHOEBUS 2 INTERFACE TEST, TEST 5
 MODEL 2, GAGE NUMBERS 17 AND 18

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, GAGE NUMBERS 19 AND 20

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, GAGE NUMBERS 21 AND 22

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, GAGE NUMBERS 25 AND 26

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, GAGE NUMBERS 27 AND 28

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, NUMBERS 29 AND 30

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, GAGE NUMBER 32

PHOBUS 2 INTERFACE TEST, TEST 5
 MODEL 2, GAGE NUMBERS 33 AND 34

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, GAGE NUMBERS 35 AND 36

PHOEBUS 2 INTERFACE TEST, TEST 5
 MODEL 2, GAGE NUMBERS 37 AND 38

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, GAGE NUMBERS 41-42 AND 43

PHOEBUS 2 INTERFACE TEST, TEST 5
 MODEL 2, GAGE NUMBERS 44-45 AND 46

PHOEBUS 2 INTERFACE TEST, TEST 5
MODEL 2, GAGE NUMBERS 47-48 AND 49

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBER A 5

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBER A6

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBER A7

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBER A8

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 1 AND 2

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 3 AND 4

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 7 AND 8

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 9 AND 10

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 11 AND 12

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
 MODEL 2, GAGE NUMBERS 13 AND 14

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 15 AND 16

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 17 AND 18

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 19 AND 20

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 21 AND 22

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 23 AND 24

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 25 AND 26

LOAD IN KSI

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 29 AND 30

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBER 31

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBER 32

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 33 AND 34

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 37 AND 38

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 39 AND 40

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 41-42-43

PHOEBUS 2 INTERFACE TEST, FAILURE MODE TEST
MODEL 2, GAGE NUMBERS 44-45-46