TEST REPORT

FIRE TEST FOR EVALUATION OF PIPE FLANGE GASKET

PER MODIFIED API STANDARD 607, FOURTH EDITION, 1993

SIZE AND RATING: 4.00” - Class 150

MODEL NO.: CORR-A-SEAL/GRAFTEC

SwRI TEST NO.: 6-930

PREPARED FOR: M & P SEALING CO./INTERMECH
SEALING SOLUTIONS PTY (LTD.)
11125 IH 10 EAST
ORANGE, TEXAS 77630 US

SOUTHWEST RESEARCH INSTITUTE™

SAN ANTONIO, TEXAS · HOUSTON, TEXAS · DETROIT, MICHIGAN · WASHINGTON, DC

REVIEW AND APPROVAL

The contents of this Test Report for SwRI™ Test Number 6-930 are correct and accurate, and all performance test results and procedures conducted by this laboratory are in compliance with API Standard 607, Fourth Edition.

Prepared By:

Southwest Research Institute™
Mechanical & Fluids Engineering Department
P. O. Drawer 28510
San Antonio, Texas, USA 78228-0510

Test Report Reviewed By:

Robert Hart — 7/23/02

Robert Hart
Project Manager

Date

Management Review:

Chris Buck — 7/24/02

J. Christopher Buckingham
Manager, Multiphase Flow

Date

ADVERTISING, CONFIDENTIALITY AND RECORD RETENTION POLICY

SwRI policies specifically prohibit the use in advertising of its name, logo and results provided by our studies. The following paragraph, extracted verbatim from SwRI contractual documents clarifies this point:

> "SwRI shall not publish or make known to others the subject matter or results of the Project or any information obtained in connection therewith which is proprietary and confidential to Client without Clients' written approval. No advertising or publicity containing any reference to SwRI, or any of their employees, either directly or by implication shall be made use of by Client or on Client's behalf without SwRI's written approval. In the event Client distributes any report issued by SwRI on this Project outside its own organization, such report shall be used in its entirety, unless SwRI approves a summary of abridgment for distribution."

SwRI will retain a record copy of the test report for a period of five (5) years. This permits us to answer questions, which may be raised after a report has been mailed and provides a basis for additional work, if required. The contents of the report and any information, which comes into our possession during the course of a study, are held confidential to the company conducting the study and are not disclosed to anyone without client's prior permission.

GASKET FIRE TEST
PER MODIFIED API STANDARD 607, FOURTH EDITION

SwRI Test Number:	6-930	Test Date:	7/18/2002
Type:	Pipe Flange Gasket	Model:	Corr-a-Seal/Graftec
Gasket Rating:	Class 150	Gasket Size:	4.00 inch
Manufacturer:	M&P Sealing Co./Intermech Sealing Solutions PTY (Ltd.)		
Manufacturer's Representative(s):	Dan Coleman		

The purpose of this test was to evaluate the performance of a pipe flange gasket when exposed to fire conditions. Since API has not published a standard for gasket fire tests, this testing was conducted using a modified version of the valve fire test procedure given in American Petroleum Institute (API) Standard 607, Fourth Edition, 1993. The test procedure may be found in Appendix C of this report.

In this report, Side A refers to the upstream flange pair, and Side B refers to the downstream flange pair. Within each flange pair, the individual flanges are labeled as left-hand (LH) or right-hand (RH) to indicate that they are located on the upstream or downstream sides of the joint, respectively (see Appendix C, Figure 1).

1. Hydrostatic Test Prior to Burn

Average leakage rate of 0.0 ml/min/NPS occurred during the hydrostatic test at 314 psig. No leakage is allowed during this test.

2. Leakage During Burn and Cooldown

Average leakage rate of 0.0 ml/min/NPS occurred during the 40.00-minute burn and cooldown period. Allowable rate is 50.0 ml/min/NPS (25 ml/min/NPS for each gasket).

3. Leakage Following Cooldown

Average leakage rates of 0.9 ml/min/NPS (Side A) and 3.3 ml/min/NPS (Side B) occurred during the 5.00-minute test period at a pressure of 30 psig. Allowable rate is 25.0 ml/min/NPS for each side. Leakage rates at other pressures are given on the following page. There are no requirements for the leakage rates at pressures other than 30 psig.

4. Post-Test Bolt Torques

After completion of the leakage tests, the pressure in the fixture was vented and the post-test bolt torques were measured. The torque required to loosen the stud bolts in each flange pair is given in the table on the following page. The studs in each flange were then torqued to 30 ft-lbs and the fixture was pressurized to 30 psig. No leakage was observed from either gasket for a period of 5 minutes.

5. Disassembly

After completion of the test, the flange joints were disassembled and the gaskets were found to be intact. The gaskets were removed without difficulty. Photographs of the gaskets taken after removal may be found in Appendix B.

6. Qualification

The gasket tested meets the performance requirements of the modified version of API Standard 607, Fourth Edition found in Appendix C of this report.

GASKET FIRE TEST
PER MODIFIED API STANDARD 607, FOURTH EDITION

SwRI Test Number:	6-930	Test Date:	7/18/2002
Gasket Size (NPS):	4.00 inches		

1. Test Conditions

Test pressure: 30 psig nominal (± 10%)

Time from ignition to 1400°F average flame temperature: 0.77 minutes

Time from start of test to a temperature of 1200°F on left-hand flange of Side A: 11.32 minutes

Time from start of test to a temperature of 1200°F on right-hand flange of Side A: 10.83 minutes

Time from start of test to a temperature of 1200°F on left-hand flange of Side B: 13.33 minutes

Time from start of test to a temperature of 1200°F on right-hand flange of Side B: 12.85 minutes

Duration of burn: 30.00 minutes

Duration of cooldown: 10.00 minutes

2. Upstream Water Reservoir Volumes

At beginning of burning period: 45800 ml.

At end of cooldown: 47773 ml.

3. Total Measured Leakage During Post-Cooldown Leak Tests

Test Pressure [psig]	Time [min]	Side A Leakage [ml]	Side B Leakage [ml]
30	5.00	17	65
50	5.00	15	115
100	5.00	64	515
200	5.00	405	1860

4. Bolt Torques

	Side A (Upstream) [ft-lbs]		Side B (Downstream) [ft-lbs]	
	Before Burn	After Test	Before Burn	After Test
Location 1	125	loose	137	5
Location 2	122	loose	127	5
Location 3	147	30	129	loose
Location 4	127	42	129	5

GASKET FIRE TEST
PER MODIFIED API STANDARD 607, FOURTH EDITION

SwRI Test Number:	6-930	Test Date:	7/18/2002
Gasket Size (NPS):	4.00 inches		

1. Leakage During Burn and Cooldown

A. Beginning reservoir level: 45800 ml.

B. Ending reservoir level: 47773 ml.

C. Burn duration: 30.00 minutes

D. Cooldown duration: 10.00 minutes

Average leakage rate = $\frac{A - B}{(C + D)xNPS}$ = -12.3 *ml/min/NPS* ***(1)***

2. Leakage Test After Cooldown (30 psig)

E. Volume collected from Side A: 17 ml.

F. Volume collected from Side B: 65 ml.

G. Test duration: 5.00 minutes

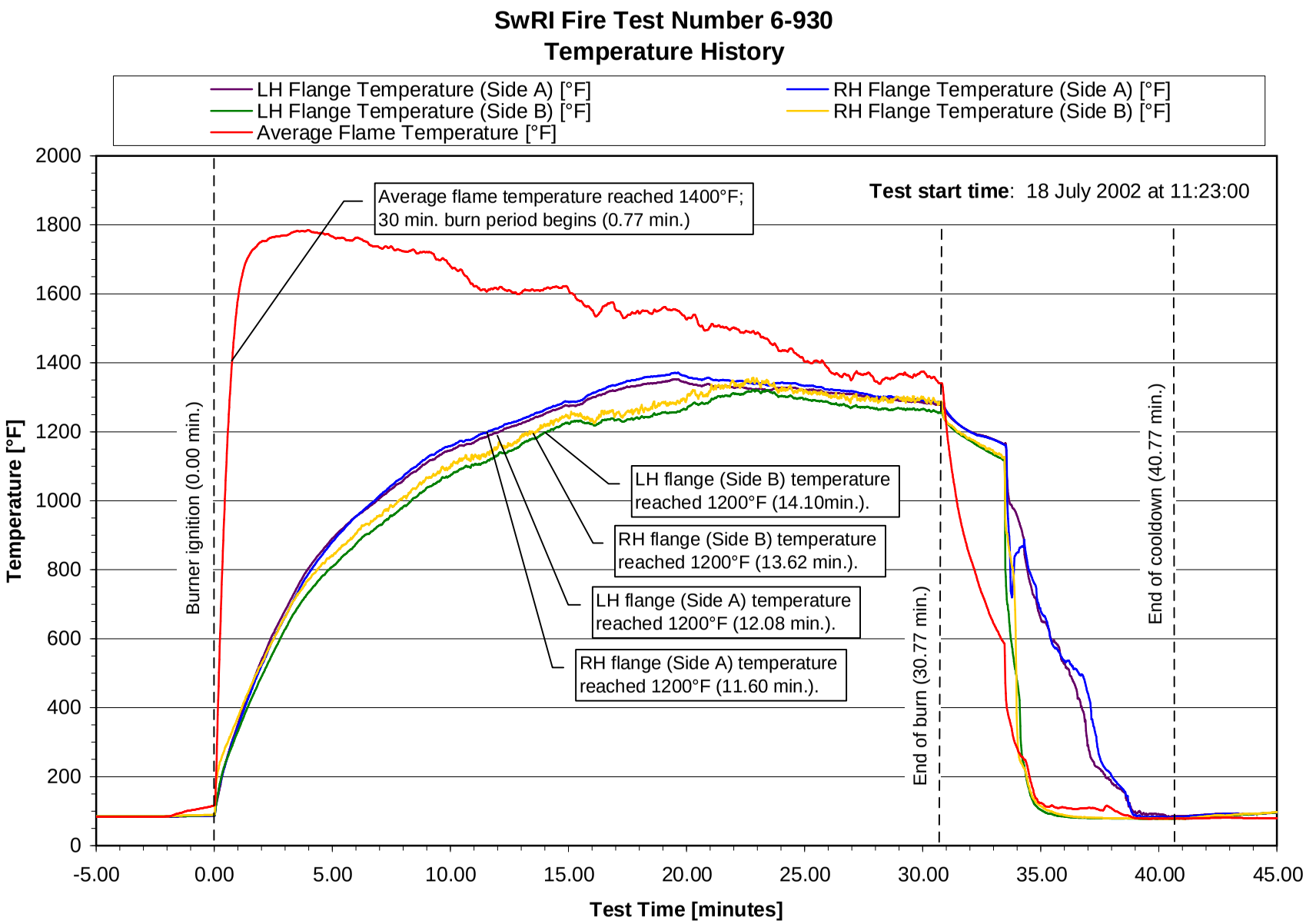
Average leakage rate for Side A = $\frac{E}{GxNPS}$ = 0.9 *ml/min/NPS*

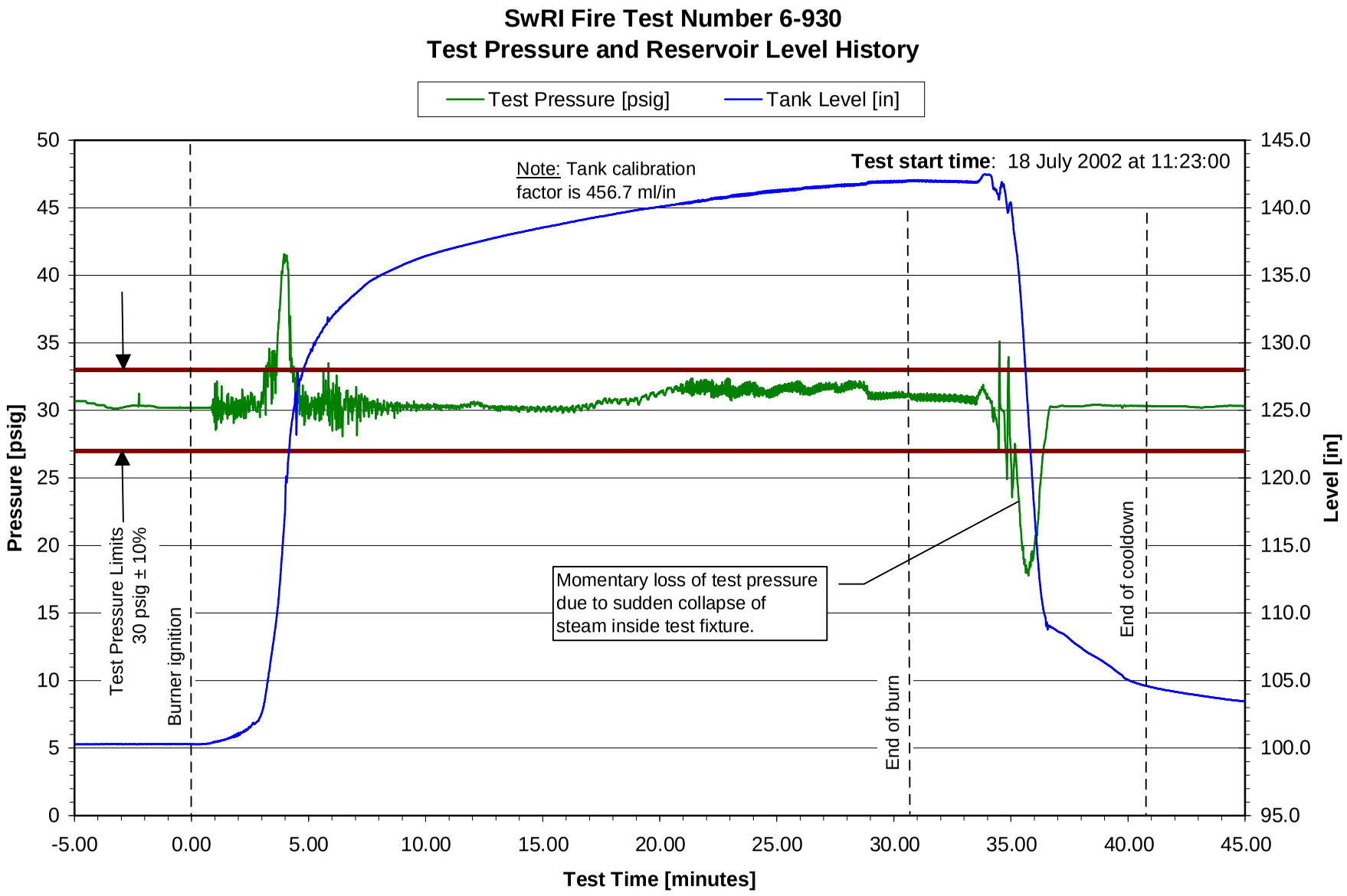
Average leakage rate for Side B = $\frac{F}{GxNPS}$ = 3.3 *ml/min/NPS*

(1) Leakage during the burn and cooldown is calculated by subtracting the ending reservoir level from the beginning reservoir level. When there is little or no leakage during the burn and cooldown, the upstream supply piping may not cool to its initial temperature by the end of the cooldown period. The resulting thermal expansion of the water in this piping can result in a higher reservoir level at the end of the test than was present at the beginning of the test. This condition will cause a negative result in this calculation for leakage. In these cases, the leakage is assumed to be zero.

APPENDIX A

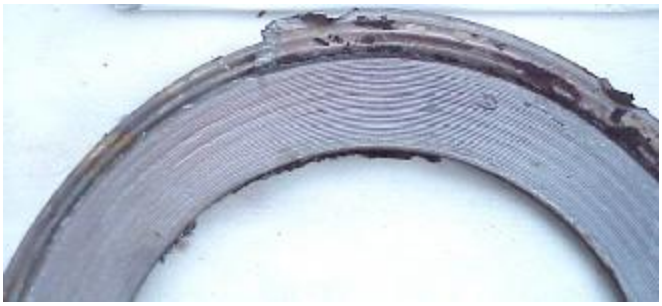
PRESSURE & TEMPERATURE DATA


SwRI Fire Test Number 6-930
Temperature History
LH Flange Temperature (Side A) [°F]
LH Flange Temperature (Side B) [°F]
Average Flame Temperature [°F]
RH Flange Temperature (Side A) [°F]
RH Flange Temperature (Side B) [°F]
Test start time: 18 July 2002 at 11:23:00
Average flame temperature reached 1400°F; 30 min. burn period begins (0.77 min.)
LH flange (Side B) temperature reached 1200°F (14.10min.).
RH flange (Side B) temperature reached 1200°F (13.62 min.).
LH flange (Side A) temperature reached 1200°F (12.08 min.).
RH flange (Side A) temperature reached 1200°F (11.60 min.).
Burner ignition (0.00 min.)
End of burn (30.77 min.)
End of cooldown (40.77 min.)
Temperature [°F]
Test Time [minutes]
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00


SwRI Fire Test Number 6-930
Test Pressure and Reservoir Level History
Test Pressure [psig]
Tank Level [in]
Note: Tank calibration factor is 456.7 ml/in
Test start time: 18 July 2002 at 11:23:00
Test Pressure Limits 30 psig ± 10%
Burner ignition
End of burn
End of cooldown
Momentary loss of test pressure due to sudden collapse of steam inside test fixture.
Pressure [psig]
Level [in]
Test Time [minutes]
50
45
40
35
30
25
20
15
10
5
0
145.0
140.0
135.0
130.0
125.0
120.0
115.0
110.0
105.0
100.0
95.0
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00

APPENDIX B

POST-TEST GASKET PHOTOGRAPHS



Gasket from Side A (Upstream)

Gasket from Side B (Downstream)

APPENDIX C

MODIFIED VERSION OF THE API 607, FOURTH EDITION FIRE TEST PROCEDURE

FIRE TEST PROCEDURES FOR PIPE GASKETS
4 Inch – Class 150

A) **GENERAL**

- The fire test will consist of a modified API 607, Fourth Edition fire test.
- The fire test will require at least 3 flange thermocouples to reach 1200°F for 15 minutes. See Figure 1 for thermocouple locations.

B) **INSTALLATION PROCEDURES**

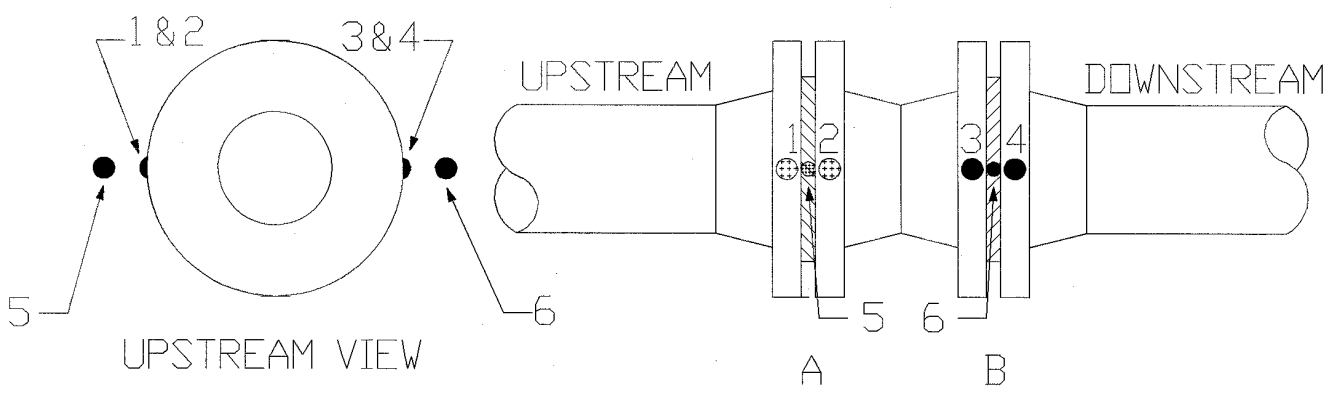
- The gasket shall be installed between two 4", raised-face ANSI 150 flanges (see page 2).
- 5/8" B7 bolts and 2H nuts shall be used torqued to 120 ft/lbs, which is 60% of yield (105 KSI).
- Thermocouples shall be installed in upstream flanges at the 9 o'clock position, and downstream flanges at the 3 o'clock position as shown in Figure 1.
- Hydro at 110% (1.1 * 285 PSI = 314 PSI). No leaks allowed. If a leak occurs, the test is terminated.
- The test flanges may be used **only once** in a fire test.

C) **FIRE TEST**

- Heat up, cool down, duration and leak testing (except as modified below) shall follow API 607, Fourth Edition.
- After flange temperatures reach 1200°F, adjust the flame temperature so as to maintain the flange temperatures of 1200°F without allowing flange temperatures to drop below 1200°F. For this period of the test, there are no restrictions on average or individual flame temperatures.
- Observe and record any leakage during fire test and cooldown.
- Perform leakage tests as follows after cooldown:
  - Pressure levels are: 30, 50, 100, and 200 psig.
  - Allowable leakage rates: For 30 psig tests = 100 ml/min maximum (25 ml/min/inch)
  - Note at what pressure 100 ml/min is exceeded. Reduce pressure to zero psig and measure the "after leak test" bolt torques. Increase the pressure again to 30 psig and try to stop the leak by tightening the bolts.

D) Dismantle, take pictures, and make note of condition of gasket in reports.

Note: Thermocouples 1, 2, 3 and 4 are welded to the flange. Thermocouples 5 and 6 are for flame temperature located 1" away from flange thermocouples respectively.



THERMOCOUPLE LOCATIONS

Figure 1

INSTALLATION, LUBRICATING, AND TORQUING PROCEDURES
FIRE TEST FOR GASKETS
4 Inch – Class 150

1. Make sure studs, nuts, and flange surfaces, which will be in contact with the nuts, are free from burrs and debris. Flange raised-face surface finish shall be per ASME B16.5 paragraph 6.4.4.1 or equivalent. No radial grooves or similar damage in the sealing area of the gasket is allowed. New ASTM A193 B-7 studs and ASTM A194, 2H nuts shall be used for each fire test. The test shall consist of two 4" Class 150 flange joints in conformance with ASME B16.5 and made of ASTM A-105 material.

2. Coat entire surface of each stud with Anti-Seize.

3. Cover coat the flange nut-bearing surface around each bolthole with a coating of Anti-Seize.

4. Install bolt numbers (4, 6, 2, and 7) and place the gasket between the flange faces. See Figure 2.

5. Install the remaining studs and nuts and tighten finger tight.

6. Using a calibrated torque wrench, torque the 5/8" B-7 studs in the sequence provided in Figure 2.
   a) to 40 ft/lbs (outboard nuts)
   b) to 70 ft/lbs (outboard nuts)
   c) to 120 ft/lbs (outboard nuts)

7. A bolt-to-bolt torque check is required to even out bolt stresses. One revolution is required per the bolt sequence shown in Figure 3. Perform this tightening on the inboard nuts. Torque to 120 ft/lbs.

8. Repeat Step 7 but on the "outboard" nuts.

9. Check final torque on the outboard nuts at 1, 2, 3 and 4 and record. See Figure 2. (The target torque is a minimum 105 ft/lbs, maximum 135 ft/lbs. Nuts shall not be loosened if 135 ft/lbs is exceeded.)

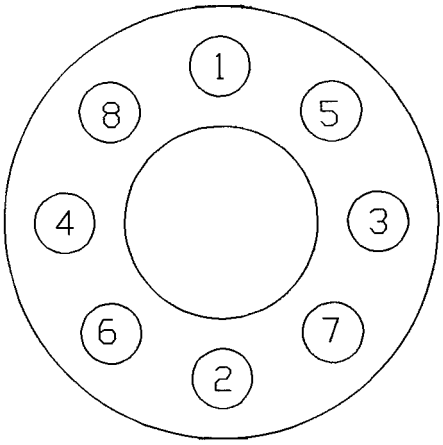


Figure 2

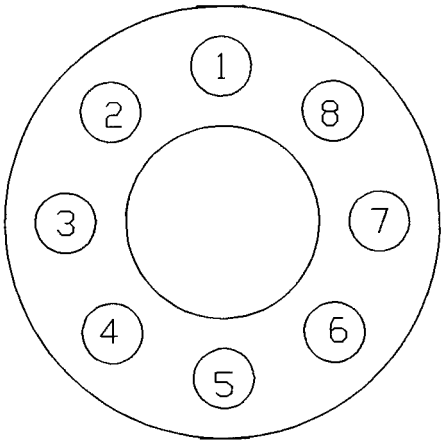


Figure 3

APPENDIX D

SwRI FACILITY DESCRIPTION

SWRI FIRE TEST FACILITY

1. General

1.1 Facility Configuration. The test facility is located outdoors under a 34-foot high roof. For personnel protection, the fire test stand is surrounded on three sides by 8-foot high concrete walls. Portable insulated screens are placed around the test item to form a four-sided enclosure, as shown in Figure 1. These screens are designed to reduce heat loss and minimize the effect of wind gusts. The area above the test item is partially closed by baffles that direct the burner flames to uniformly envelop the test item.

1.2 Test Item Installation. Test items are installed as shown in Figure 1. A short length of pipe is attached to both the upstream and downstream ends to support the item in the test stand and to allow for connection of supply, drain, and vent lines. The test fixture is pressurized with water from the upstream side during the test. The downstream pipe is connected to a drain and condenser system for collection of any through leakage. The test fixture is supported on two pedestals, as shown in the elevation view of Figure 1. The upstream pipe is clamped in a pipe vise located on top of the pedestal. The downstream pipe rests in a pipe vise on top of a second pedestal. The downstream pipe is left unclamped to allow for thermal movement of the test fixture during the test. The entire test fixture is slightly sloped toward the downstream end to ensure complete drainage. For valve fire tests, the valve is placed in the test stand so that the valve stem is horizontal (i.e., parallel to the floor).

1.3 Burners. Fire conditions are simulated using four natural gas burners located below the test item. Four 3-inch self-aspirating burners are individually mounted on portable stands with adjustable tilt angles. The burner stands are positioned to provide full envelopment of the test item by the flames.

1.4 Preparation. Upon request, all materials needed for preparation of an item for testing will be supplied by SwRI. Assembly will be performed by SwRI personnel per the manufacturer's instructions.

2. System Plumbing

2.1 Pressurization System. Water for the testing is supplied from a series of five pressurized reservoirs of different diameters. Depending on test item size, different combinations of the reservoirs are used in order to minimize uncertainty of the level measurements. For low-test pressures (<50 psig), the reservoirs are connected directly to the test item. For higher test pressures, the reservoirs are connected to a system in which a triplex pump and a back-pressure regulator are used to establish the test pressure.

2.2 Downstream System. Piping from the downstream end of the test fixture is routed through a condenser consisting of a copper coil in a running water bath. The discharge from the condenser is mounted on a swinging arm whose position is set from the control room via the data acquisition/control system. The first position is over the container in which any discharge during the burning period is collected. The second position is over another container for collection of any discharge during the cooldown. The third position is away from both containers.

2.3 Body Cavity Vent and Relief System. This system is required for all dual-seated valves, which may trap liquid in the body cavity when the valve is in the closed position. The manufacturer will have provided a tapped port in the topmost part of the test valve body for connection of the body cavity relief system. The relief system consists of a pressure transducer used for recording the cavity pressure and a remotely controlled valve, which is actuated at the manufacturer's recommended maximum allowable body cavity pressure.

2.4 Water Quenching System. For water quenching, a moveable arm, containing spray nozzles on a manifold, is positioned over the test item. The spray arm and water flow are operated remotely from the control room.

3. Instrumentation

3.1 Test Pressure. The upstream test pressure is measured with a transducer of appropriate range tapped into the pressurization line about 20 feet upstream of the test item connection.

3.2 Temperature. All temperatures are measured with Type K (Chromel/Alumel) thermocouples (T/Cs). The flame temperature T/Cs are 1/4" diameter rigid probes with stainless or inconel sheaths. The thermocouples for sensing valve body and bonnet temperatures are 1/8" diameter probes similar to the flame thermocouples. Calorimeters (if required) consist of 1/16" diameter probe embedded in 1-1/2" carbon steel cubes. If calorimeters are used, a bare wire thermocouple with braided ceramic insulation is spot-welded to the test item in order to obtain a direct measure of surface temperature.

3.3 Upstream Reservoir Level. The water level in the upstream reservoirs is measured with a differential pressure transducer that is calibrated to read in inches of water. Using the known calibration factor for each reservoir (volume per unit height), the level measurement allows for determination of the change in the volume of water that occurs over the period of the burn and cooldown. This volume change is used to determine external leakage. While continuous recordings of the reservoir level are given in the test report, values between the beginning of the burn and the end of the cooldown may not be accurate due to the presence of steam in the piping. The applicable calibration factor for the reservoirs is shown on the plot.

3.4 Data Acquisition. A HP 34970A Data Acquisition Unit is used to log data during the test and to remotely operate the test equipment. Data is acquired from all sensors every second. The data acquisition unit is connected to a personal computer in the control room, which runs software that allows the operator to record and visualize all data and control the test.

3.5 Calibration. Pressure transducers are calibrated periodically at the SwRI calibration lab. The data logger input calibrations are also checked periodically against traceable voltage references. Thermocouple calibrations are assumed to be within standard commercial tolerances.

3.6 Video. Two video cameras are used to monitor the tests. One, mounted under the facility roof, provides an overhead view of the test chamber. The other camera is mounted at floor level for close-up viewing of the downstream collection containers. This camera can also be used to provide a front view of the test item during the post-cooldown operational and hydrostatic tests. A split-screen video system in the control room allows simultaneous recording and viewing of both camera angles. The output from both cameras is recorded on a VCR to provide a visual record of the test.

ELEVATION SHOWING TEST VALVE INSTALLATION

PLAN VIEW OF TEST CHAMBER

SECTION THROUGH TEST CHAMBER

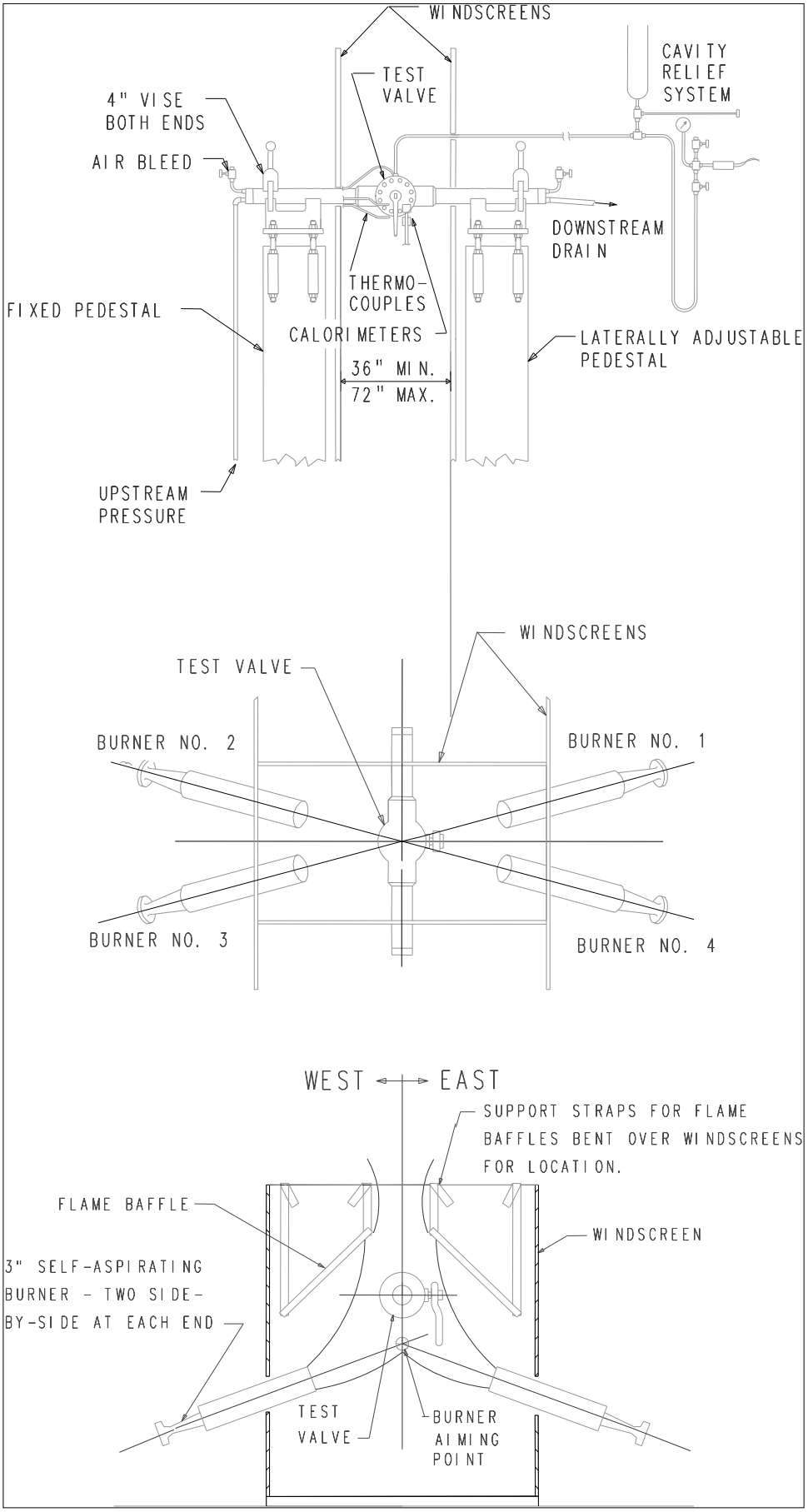


Figure 1