Specification for Fire Test for End Connections

API SPECIFICATION 6FB
THIRD EDITION, MAY 1998

EFFECTIVE DATE: NOVEMBER 30, 1998

ERRATA 1: AUGUST 2006
SUPPLEMENT: DECEMBER 2006
ERRATA 2: DECEMBER 2008

REAFFIRMED, SEPTEMBER 2011

AMERICAN PETROLEUM INSTITUTE

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Upstream Segment

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FOREWORD

This specification is under the jurisdiction of the API Subcommittee on Standardization of Valves and Wellhead Equipment. This Third Edition if a reformatted, reissue of the Second Edition of this specification, which was reaffirmed by letter ballot in 1997.

This specification shall become effective on the date printed on the cover but may be used voluntarily from the date of distribution.

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Certain serious adverse health effects are associated with asbestos, among them the serious and often fatal diseases of lung cancer, asbestosis, and mesothelioma (a cancer of the chest and abdominal linings). The degree of exposure to asbestos varies with the product and the work practices involved.

Consult the most recent edition of the Occupational Safety and Health Administration (OSHA), U.S. Department of Labor, Occupational Safety and Health Standard for Asbestos, Tremolite, Anthophyllite, and Actinolite, 29 *Code of Federal Regulations* Section 1910.1001; the U.S. Environmental Protection Agency, National Emission Standard for Asbestos, 40 *Code of Federal Regulations* Sections 61.140 through 61.156; and the U.S. Environmental Protection Agency (EPA) rule on labeling requirements and phased banning of asbestos products (Sections 763.160-179).

There are currently in use and under development a number of substitute materials to replace asbestos in certain applications. Manufacturers and users are encouraged to develop and use effective substitute materials that can meet the specifications for, and operating requirements of, the equipment to which they would apply.

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CONTENTS

API Specification for Fire Test for End Connections

1 Scope

1.1 PURPOSE

This specification was formulated to establish procedures for testing and evaluating the pressure-containing performance of API end connections when exposed to fire. Valves, wellhead seals, or other related equipment, are not included in the scope of this document. The procedures are presented in two parts.

Part I represents conditions in an onshore or open offshore location.

Part II represents conditions in an offshore platform well bay.

Background information on fire-resistance of API end connections is contained in API Technical Report 6F1. Further background on fire-resistance improvements of API flanges is contained in API Technical Report 6F2.

1.2 APPLICATIONS

This specification covers API Spec 6A end connections, which include:

a. API Flanged End and Outlet Connections (6B, 6BX, and Segmented).
b. API Threaded End and Outlet Connections.
c. Other End Connections (OECs).

2 Referenced Standards

Referenced standards may be either the applicable edition shown herein or the latest revision, provided the manufacturer can show that the latest edition meets or exceeds requirements of the specific edition listed. When the latest edition is specified, it may be used on issue, and shall become mandatory six months from the date of the revision. This specification includes by reference, either in whole or in part, other API standards, as listed below:

API

Spec 6A	*Specification for Wellhead and Christmas Tree Equipment*
TR 6AF	*Technical Report on Capabilities of API Flanges Under Combinations of Load*
TR 6F1	*Technical Report on Performance of API and ANSI End Connections in a Fire Test According to API Specification 6FA*
TR 6F2	*Technical Report on Fire Resistance Improvements for API Flanges*

3 Part I—Fire Test for End Connections for Onshore Locations

3.1 GENERAL

3.1.1 Scope

It is the purpose of this part to establish a procedure for testing and evaluating the pressure-containing performance of API 6A end connections when exposed to a fire representing conditions in an onshore or open offshore location. The performance requirements of this part are intended to establish standard limits of acceptability regardless of size or pressure rating. This part is not intended to represent conditions which may be encountered in a fire in an offshore well bay.

The burn period has been established on the basis that it represents the maximum time required to extinguish most fires. Fires of greater duration are considered to be of a major magnitude with consequences greater than those anticipated by this test.

3.1.2 Description of Fire Test (See Figure A-1)

3.1.2.1 The connection shall be tested with water. The total volume of water which is isolated in the test fixture shall not exceed the volume of a cylinder whose diameter is the nominal test connection size and whose length is twice the nominal test connection size. The orientation of the axis of the bore may be vertical or horizontal. To qualify a connection design for bending as well as pressure, a second test is required.

3.1.2.2 Each connection shall be enveloped in flame and temperature measurements made by thermocouples and calorimeters. The test setup shall include a minimum of three calorimeter blocks and thermocouples equally spaced around the circumference in the plane of the joint, as shown in Figure A-2. The maximum spacing between calorimeters shall be 12 inches (300 mm) on the circumference. An additional calorimeter block and thermocouple shall be placed on each side of the joint, at a distance of $^3/_2$ of the length of the flange or twice the bore diameter, whichever is greatest, at a circumferential location which is furthest from any burner.

The calorimeter blocks shall be $1^1/_2$ inch (38 mm) cubes made of carbon steel with a thermocouple located in the center of each cube, as shown in Figure A-4.

3.1.2.3 The test pressure shall be 75% of the API rated working pressure.

3.1.2.4 The burn period shall be at least 30 minutes from ignition. Detailed procedures are in Section 3.2.

3.1.3 Description of the Bending Test

After 25 minutes of the burn period, an external bending moment shall be applied to one test connection. The moment which is sustained without causing leakage greater than the acceptable level shall be noted and reported. This will terminate testing on this connection.

Figures A-5 and A-6 show two suggested means of applying the bending moment. In using an arrangement like Figure A-5, the hydraulic ram will produce both a tension and a bending moment on the connection. The ram shall be sized

so that the additional tension is not greater than 10% of the total pressure end load through the connection. Any fixtures used to apply bending moment shall be designed to safely carry the test loads and shall be designed not to shield the connection from the flame.

3.1.4 Leakage Measurements

Leakage of the test connection is to be positively collected and measured by means of a system as shown in Figure A-7. The connection shall be provided with a secondary seal outside the main seal made of a high temperature material such as graphite or metal foil gasketing material. Two leakoff ports shall be drilled from the exterior of the connection to the region between primary and secondary seals, forming a closed chamber. The two connections shall be made on opposite sides of the test connection.

Two equal-length pieces of tubing shall be connected to the leakoff ports, and a third equal length of tubing shall be blanked off and mounted on the test vehicle similarly to the other two. This third dummy line will be used to compensate for expansion of air in the leakoff lines.

Each of the three lines shall pass in succession through a condenser, fluid trap and gas trap and shall terminate in a graduated cylinder for leakage measurements, as shown schematically in Figure A-7, if nitrogen gas is to be used to replace water in the valvebore, as provided for in 3.2.1j. If water is to be used throughout the test, the fluid and gas traps may be deleted and the discharge from the condensers connected directly to the graduated cylinder. The dummy line may also be deleted.

Leakage is calculated by adding the volumes accumulated from the two leakoff lines and subtracting twice the volume accumulated from the dummy line.

For the test with bending, the onset of leakage, as detected by a sustained loss of 200°F (93°C) or more in the indicated temperature of one or more thermocouples arrayed as shown in Figure A-8 may be used to indicate the bending moment which cannot be sustained without leakage, in lieu of the leakoff system described above.

3.2 TEST PROCEDURE

3.2.1 Stepwise Procedures (Item Numbers Refer to Figure A-1)

a. Pressure test the leakoff lines shown in Figure A-7 to 5 psig (0.034 MPa) minimum to ensure that the secondary seals are effective.

b. Purge the leakoff lines with dry nitrogen to verify communication and freedom from obstructions.

c. Open valve(s) (Items 5 and 6) at water source, and any necessary vent valves (Items 15 and 16) to flood the system and purge the air.

d. Close fill valve (Item 5) and close vent valves (Items 15 and 16). The system shall be completely water-filled.

e. Pressurize the system to the appropriate test pressure from Table 1. Maintain this pressure during the burn and cool-down periods. Momentary pressure losses are permissible, provided their cumulative recovery time is less than 2 minutes, and any resulting leakage is within the acceptance criteria.

f. Open the fuel supply, establish a fire and monitor the flame temperature. The average of the thermocouples (Item 14) must reach 1400°F (761°C) within 2 minutes. Maintain the average temperature between 1400 and 1800°F (761 and 980°C), with no reading less than 1300° F (704°C), until the average calorimeter temperature reaches 1200°F (650°C) per 3.2.1g. After that point, the flame temperature may be adjusted to any level as required to maintain the calorimeter temperatures per 3.2.1g.

g. The average temperature of the calorimeters (Item 13) shall reach at least 1200° F (650°C) within 15 minutes of fire ignition. For the remainder of the burn period, the calorimeters shall maintain a minimum average temperature of 1200°F (650°C), and no reading shall be below 1050°F (565°C).

h. Record instrument readings (Items 7, 13, and 14) at least every 30 seconds during the burn period.

i. At the end of the burn period, shut off the fuel.

j. Air cool the connection (or allow to cool) to 212°F (100°C) or less. Nitrogen may be used to maintain the pressure in the test connection during this time.

k. Depressurize the connection.

l. Increase pressure on the test connection to the test pressure in Table 1.

m. Hold the test pressure for 5 minutes minimum.

n. If the connection is to be tested in bending, repeat steps a through h for the unit to be tested in bending.

o. After 25 minutes of the burn period, begin the application of the bending moment to the connection being tested in bending.

p. As each bending moment increment is applied, pause for at least 15 seconds, record the moment, and observe for a total leakage volume in excess of the total leakage permitted in the test, or for the onset of leakage, if the thermocouple array of Figures A-8 or A-9 is used.

q. Record the maximum bending moment which is sustained without causing the total leakage to exceed the maximum allowable.

r. Record the duration of the burn and extinguish the flames. The connection may be depressurized at this time.

Table 1—Test Pressure

	Connection Rating		Test Pressure ± 10%	
	psig	(MPa)	psig	(MPa)
API Spec 6A Connections	2000	(13.8)	1500	(10.3)
	3000	(20.7)	2250	(15.5)
	5000	(34.5)	3750	(25.9)
	10000	(69.0)	7500	(51.7)
	15000	(103.5)	11250	(77.6)
	20000	(138.0)	15000	(103.5)

3.2.2 Test Adjustments

The test system, excluding the test connection itself, may be adjusted during the test period to keep the test within the limits specified herein.

3.3 PERFORMANCE REQUIREMENTS

3.3.1 Acceptance Criteria

3.3.1.1 Non-Bending Tests

The allowable leakage rate, as determined by the leakoff system shown in Figure A-7, is 1 ml/in. per min of mean primary gasket circumference during the burn and cooldown periods, and during the 5-minute period after depressurization and repressurization.

3.3.1.2 Tests With Bending

a. With Leakoff System: The allowable leakage rate, as determined by the leakoff system shown in Figure A-7, is 1 ml/in. per min of mean primary gasket circumference during the unloaded portion of the burn, and at each applied increment of bending moment.

b. With Thermocouple Array: The allowable leakage rate, as determined by the thermocouple array shown in Figure A-8, is that which results in a sustained drop of less than 200°F (93°C) in the indicated temperature of any of the thermocouples in the array during the unloaded portion of the burn, and at each applied increment of bending moment.

c. Bending Moment Criterion: The applied bending moment achieved without exceeding the allowable leakage rate shall be at least 75% of the end connection capacity, as determined either from the API TR 6AF values or from the manufacturer's documented design values.

3.4 SAFETY CONSIDERATIONS

3.4.1 Personnel Protection

Because of the possible design of the test connection and the nature of the test program, the potential may exist for a hazardous rupture of the pressure boundary components. Protection for test personnel shall be provided.

4 Part II—Fire Test for End Connections for Offshore Well Bay Conditions

4.1 GENERAL

4.1.1 Scope

It is the purpose of this part to establish a procedure for testing and evaluating the pressure-containing performance of API 6A end connections when exposed to a fire representing conditions in an offshore platform well bay. The performance requirements of this part are intended to establish standard limits of acceptability regardless of size or pressure rating. This part is not intended to represent conditions which may be encountered in a fire on a land or open offshore location.

The burn period has been established on the basis that it represents the maximum time required to extinguish most fires. Fires of greater duration are considered to be of a major magnitude with consequences greater than those anticipated by this test.

4.1.2 Description of Fire Test (See Figure A-1)

4.1.2.1 The connection shall be tested with water. The total volume of water which is isolated in the test fixture shall not exceed the volume of a cylinder whose diameter is the nominal test connection size and whose length is twice the nominal test connection size. The orientation of the axis of the bore may be vertical or horizontal. In order to qualify a connection design for bending as well as pressure a second test is required.

4.1.2.2 Each connection shall be exposed to a flame from one burner directed at the centerline of the flange as shown in Figure A-3. The test setup shall include a $1^1/_2$ inch (38 mm) cube calorimeter block made of carbon steel with a thermocouple located in the center of the block, as illustrated in Figure 4, and a flame temperature thermocouple.

4.1.2.3 The test pressure shall be 75% of the API rated working pressure.

4.1.2.4 The burn period shall be at least 30 minutes from ignition. Detailed procedures are in Section 4.2.

4.1.3 Description of the Bending Test

After 25 minutes of the burn period, an external bending moment shall be applied to one test connection. The moment which is sustained without causing leakage greater than the acceptable level shall be noted and reported. This will terminate testing on this connection.

Figures A-5 and A-6 show two suggested means of applying the bending moment. In using an arrangement like Figure A-5, the hydraulic ram will produce both a tension and a bending moment on the connection. The ram shall be sized so that the additional tension is not greater than 10% of the total pressure end load through the connection. Any fixtures used to apply bending moment shall be designed to safely carry the test loads and shall be designed not to shield the connection from the flame. The highest temperature flame shall be applied to the tension side of the connection in bending.

4.1.4 Leakage Measurements

Leakage of the test connection is to be positively collected and measured by means of a system as shown in Figure A-7. The connection shall be provided with a secondary seal outside the main seal made of a high temperature material, such as graphite or metal foil gasketing material. Two leakoff ports

shall be drilled from the exterior of the connection to the region between the primary and secondary seals, forming a closed chamber. The two connections shall be made on opposite sides of the test connection.

Two equal-length pieces of tubing shall be connected to the leakoff ports, and a third equal length of tubing shall be blanked off and mounted on the test vehicle similarly to the other two. This third dummy line will be used to compensate for expansion of air in the leakoff lines.

Each of the three lines shall pass in succession through a condenser, fluid trap, and gas trap, and shall terminate in a graduated cylinder for leakage measurements, as shown schematically in Figure A-7, if nitrogen gas is to be used to replace water in the valvebore, as provided for in 4.2.1j. If water is to be used throughout the test, the fluid and gas traps may be deleted and the discharge from the condensers connected directly to the graduated cylinder. The dummy line may also be deleted.

Leakage is calculated by adding the volumes accumulated from the two leakoff lines, and subtracting twice the volume accumulated from the dummy line.

For the test with bending, the onset of leakage, as detected by a sustained loss of 200°F (93°C) or more in the indicated temperature of one or more thermocouples arrayed as shown in Figure A-9 may be used to indicate the bending moment which cannot be sustained without leakage, in lieu of the leakoff system described above.

4.2 TEST PROCEDURE

4.2.1 Stepwise Procedures (Item Numbers Refer to Figure A-1)

a. Pressure test the leakoff lines shown in Figure A-7 to 5 psig (0.034 MPa) minimum to ensure that the secondary seals are effective.

b. Purge the leakoff lines with dry nitrogen to verify communication and freedom from obstructions.

c. Open valve(s) (Items 5 and 6) at water source, and any necessary vent valves (Items 15 and 16) to flood the system and purge the air.

d. Close fill valve (Item 5) and close vent valves (Items 15 and 16). The system shall be completely water-filled.

e. Pressurize the system to the appropriate test pressure from Table 1. Maintain this pressure during the burn and cool-down periods. Momentary pressure losses are permissible, provided their cumulative recovery time is less than 2 minutes, and any resulting leakage is within the acceptance criteria.

f. Open the fuel supply, establish a fire and monitor the flame temperature. The flame thermocouple (Item 14) must reach 2000°F (1093°C) within two minutes. Maintain the temperature between 2000 and 2500°F (1093 and 1371°C), with no reading below 1800°F (982°C) until the calorimeter temperature reaches 1800°F (982°C) per 4.2.1g. After that point, the flame temperature may be adjusted to any level as required to maintain the calorimeter temperature per 4.2.1g.

g. The temperature of the calorimeter (Item 13) shall reach at least 1800°F (982°C) within 15 minutes of fire ignition. For the remainder of the burn period, the calorimeter shall maintain a minimum temperature of 1800°F (982°C).

h. Record instrument readings (Items 7, 13, and 14) at least every 30 seconds during the burn period.

i. At the end of the burn period, shut off the fuel.

j. Air cool the connection (or allow to cool) to 212°F (100°C) or less. Nitrogen may be used to maintain the pressure in the test connection during this time.

k. Depressurize the connection.

l. Increase pressure on the test connection to the test pressure in Table 1.

m. Hold the test pressure for 5 minutes minimum.

n. If the connection is to be tested in bending, repeat steps a through h for the unit to be tested in bending.

o. After 25 minutes of the burn period, begin the application of the bending moment to the connection being tested in bending.

p. As each bending moment increment is applied, pause for at least 15 seconds, record the moment, and observe for a total leakage volume in excess of the total leakage permitted in the test, or for the onset of leakage, if the thermocouple array of Figures A-8 or A-9 is used.

q. Record the maximum bending moment which is sustained without causing the total leakage to exceed the maximum allowable.

r. Record the duration of the burn and extinguish the flames. The connection may be depressurized at this time.

4.2.2 Test Adjustments

The test system, excluding the test connection itself, may be adjusted during the test period to keep the test within the limits specified herein.

4.3 PERFORMANCE REQUIREMENTS

4.3.1 Acceptance Criteria

4.3.1.1 Non-Bending Tests

The allowable leakage rate, as determined by the leakoff system shown in Figure A-7, is 1 ml/in. per min of mean primary gasket circumference during the burn and cooldown periods, and during the 5-minute period after depressurization and repressurization. 08

4.3.1.2 Tests With Bending

a. With Leakoff System: The allowable leakage rate, as determined by the leakoff system shown in Figure A-7, is 1 ml/in. per min of mean primary gasket circumference dur- 08

ing the unloaded portion of the burn, and at each applied increment of bending moment.

b. With Thermocouple Array: The allowable leakage rate, as determined by the thermocouple array shown in Figure A-8, is that which results in a sustained drop of less than 200°F (93°C) in the indicated temperature of any of the thermocouples in the array during the unloaded portion of the burn, and at each applied increment of bending moment.

c. Bending Moment Criterion: The applied bending moment achieved without exceeding the allowable leakage rate shall be at least 75% of the end connection capacity, as determined either from the API TR 6AF values or from the manufacturer's documented design values.

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4.4 SAFETY CONSIDERATIONS

4.4.1 Personnel Protection

Because of the possible design of the test connection and the nature of the test program, the potential may exist for a hazardous rupture of the pressure boundary components. Protection for test personnel shall be provided.

5 Equipment Marking

5.1 MARKING REQUIREMENTS

End connections qualified by the testing of this Specification shall be marked 6FB on the exterior surface, in addition to the other marking requirements of API Spec 6A.

6 Qualification by Scaling

6.1 SCALING

Scaling may be used to verify the members of a connection family in accordance with the requirements and limitations of this section.

6.2 CONNECTION FAMILY

A connection family shall meet the following design requirements.

a. Configuration: The design principles of physical configuration and functional operation are the same.

b. Design Stress Levels: The design stress levels in relation to material mechanical properties are based on the same criteria.

c. Materials: Qualification of designs utilizing materials other than those tested is beyond the scope of this document.

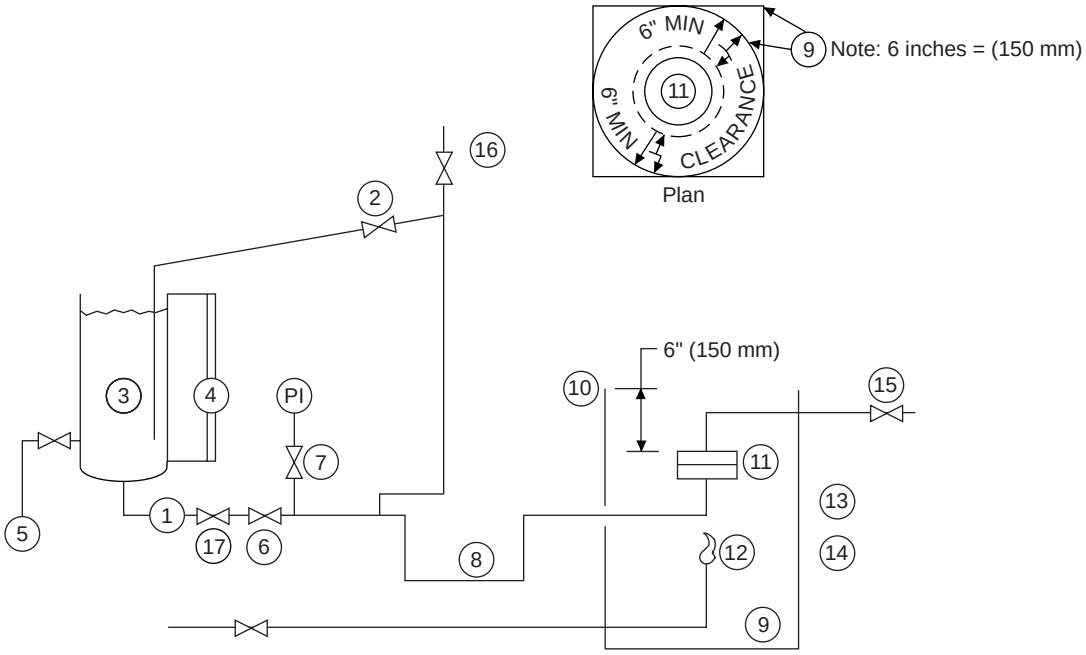
6.3 LIMITATIONS OF SCALING

Verification by scaling is subject to the following limitations.

a. Verification by Pressure Rating: The test connection may be used to qualify connections of the same family having the same pressure rating.

b. Verification by Size: Testing may be performed on individual sizes. Testing of two sizes of the same family also qualifies all nominal sizes between the two sizes tested, provided that the ratios of exposed external surface area to metal volume of the intermediate sizes fall between the values for the sizes tested. Calculation of the surface area/volume ratio shall be based on hub lengths equal to the bore diameter of the connection, up to a maximum of 12 inches (305 mm).

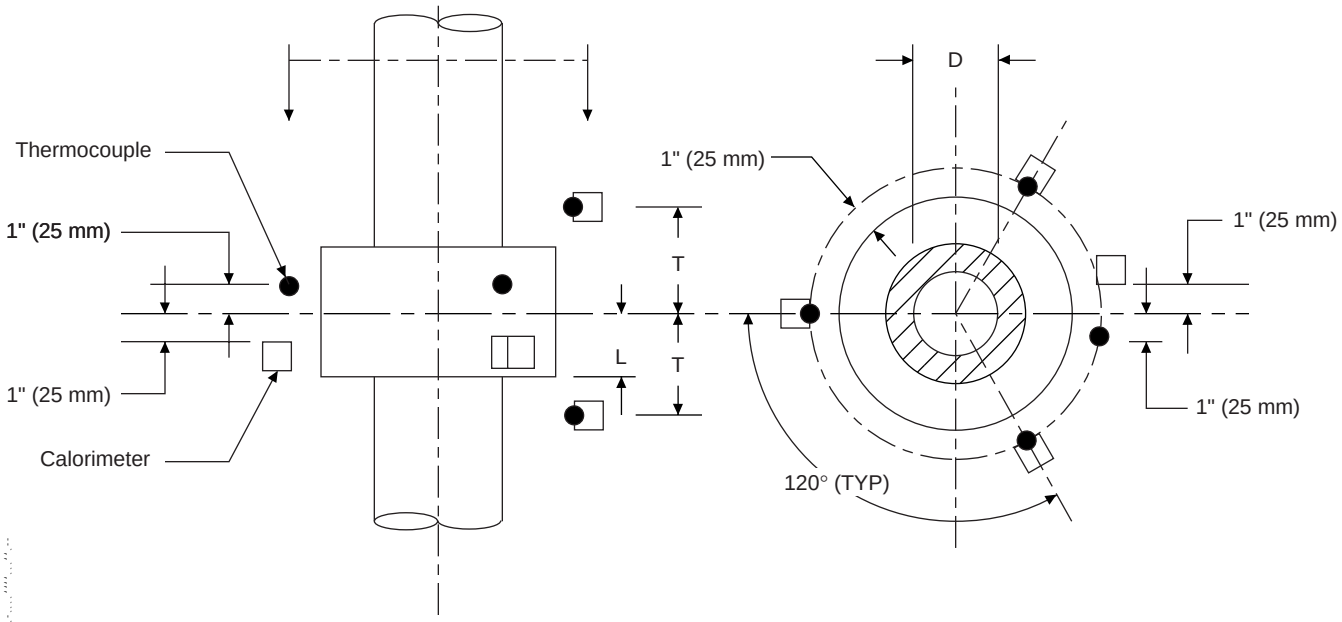
APPENDIX A—FIGURES



Legend

1. Pressure source
2. Pressure regulator and relief
3. Vessel for water
4. Calibrated sight gauge
5. Water supply
6. Shutoff valve
7. Pressure gauge
8. Piping arranged to provide vapor trap
9. Enclosure for test—horizontal clearance between any part of the end connection and the closure shall be a minimum of 6 inches (150 mm)
10. Minimum height of enclosure shall be 6 inches (150 mm) above the top of the end connection
11. Test connection mounted vertically or horizontally
12. Fuel gas supply
13. Calorimeter cubes (Ref. 3.1.2.2 or 4.1.2.2)
14. Flame temperature thermocouple (Ref. 3.1.2.2 or 4.1.2.2)
15. Shutoff valve
16. Vent valve
17. Check valve

Figure A-1—Schematic of Suggested Systems for Fire Testing of End Connections



Note: Three T/Cs and three calorimeters spaced uniformly around circumference of joint (minimum—see 3.1.2.2).
One T/C and one calorimeter on each side of joint at distance "T" (see 3.1.2.2).
T = 3/2 L, or 2D, whichever is greater

Figure A-2—Location of Thermocouples and Calorimeters—Onshore Conditions

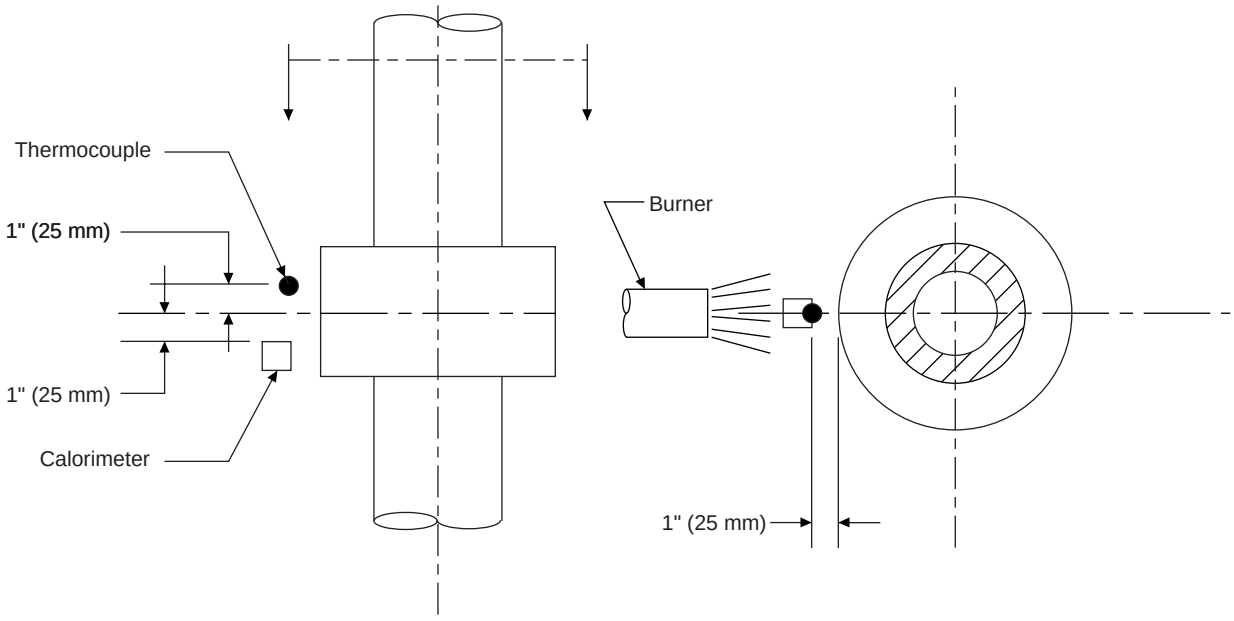
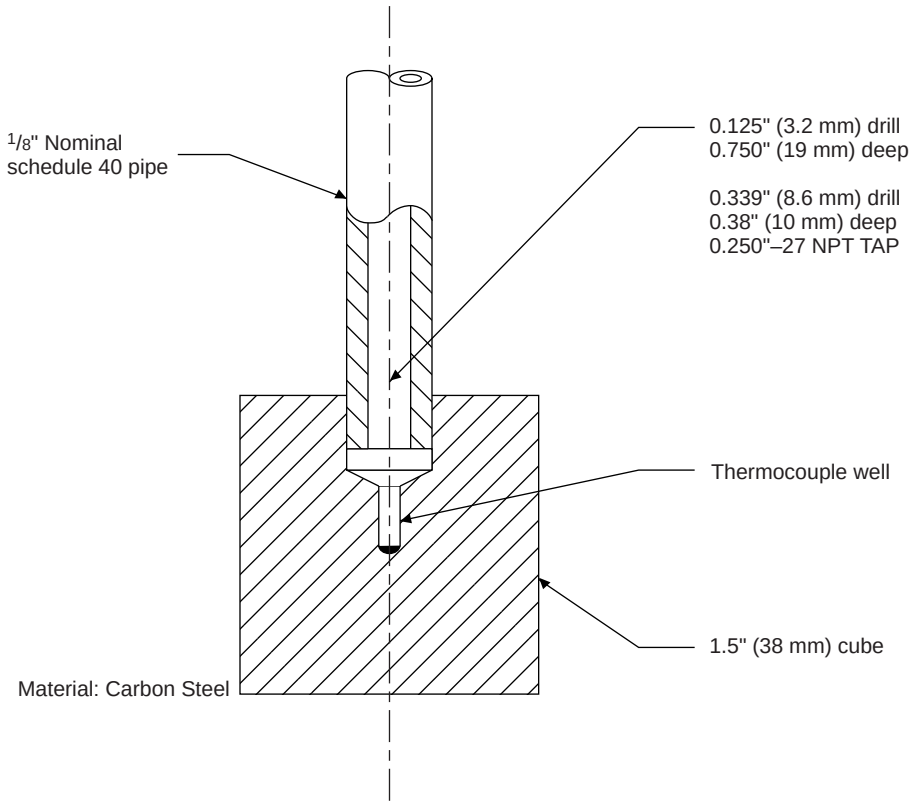


Figure A-3—Location of Burner, Calorimeter, and Thermocouple—Offshore Well Bay Conditions



General Tolerance: ±0.03" (±0.8 mm)

Figure A-4—Calorimeter Cube Design Details

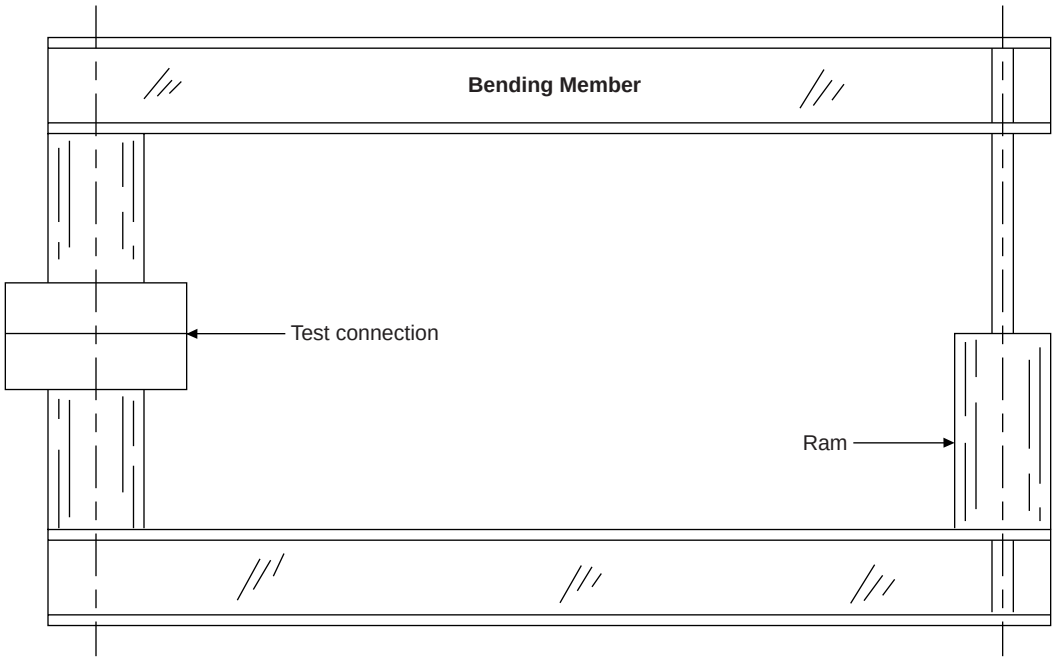


Figure A-5—Typical Bend Test Arrangement With One Ram Cylinder

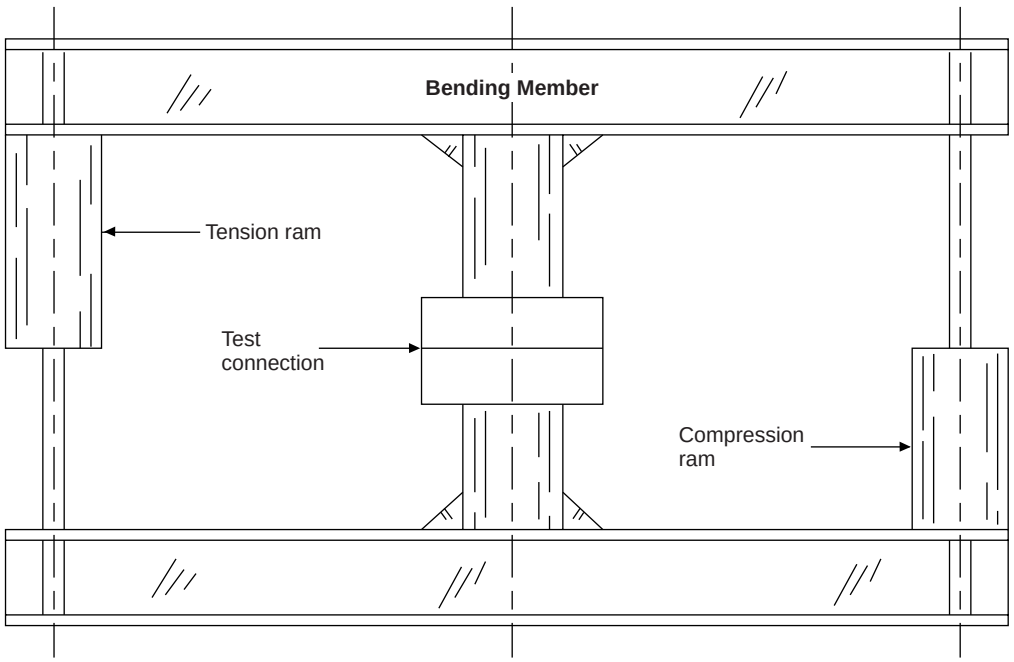


Figure A-6—Typical Bend Test Arrangement With Two Ram Cylinders

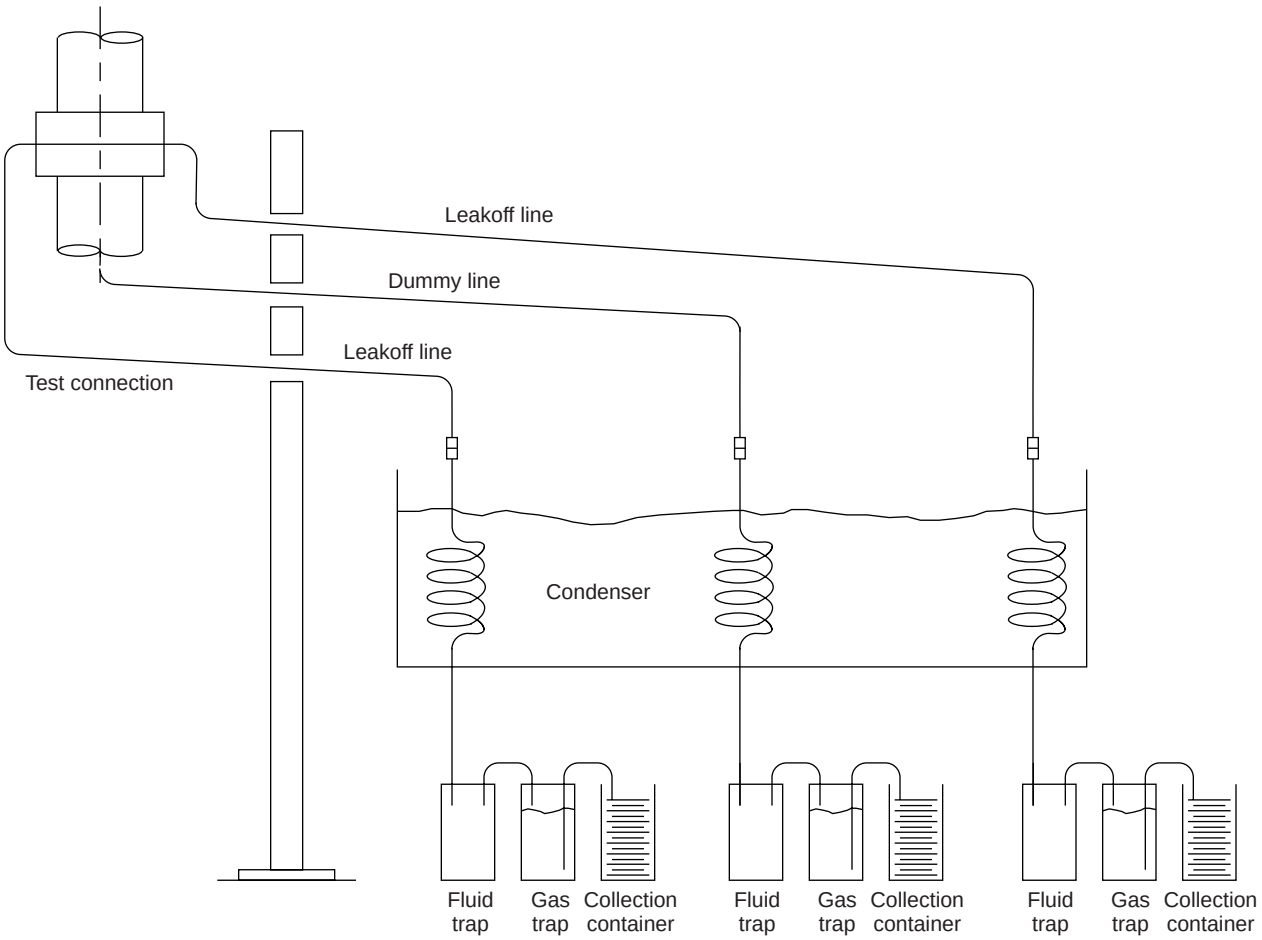
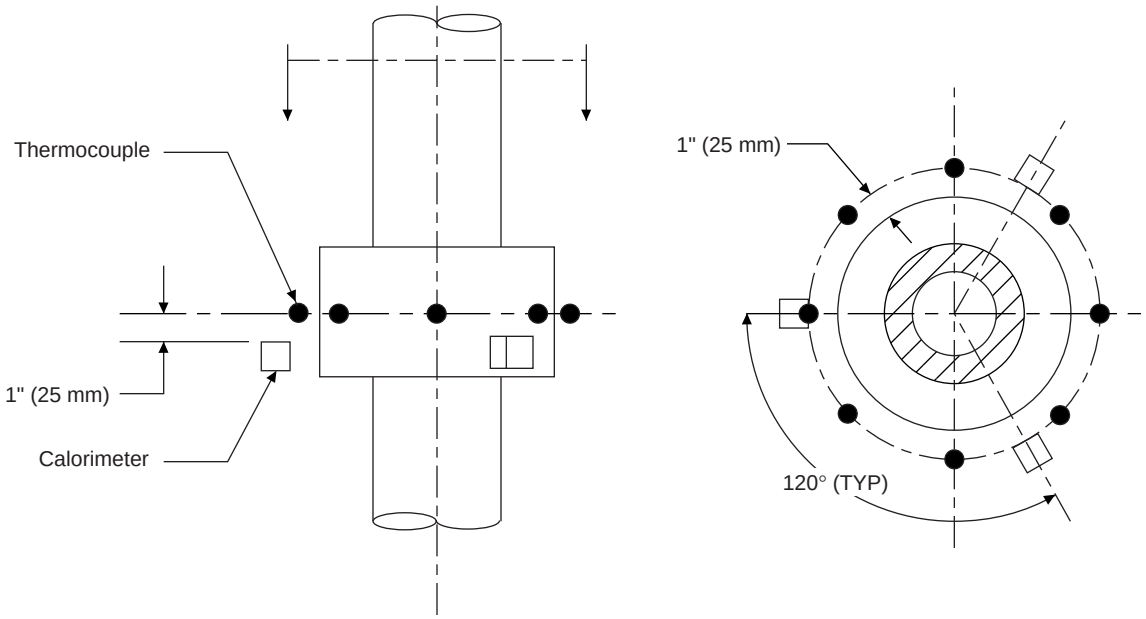
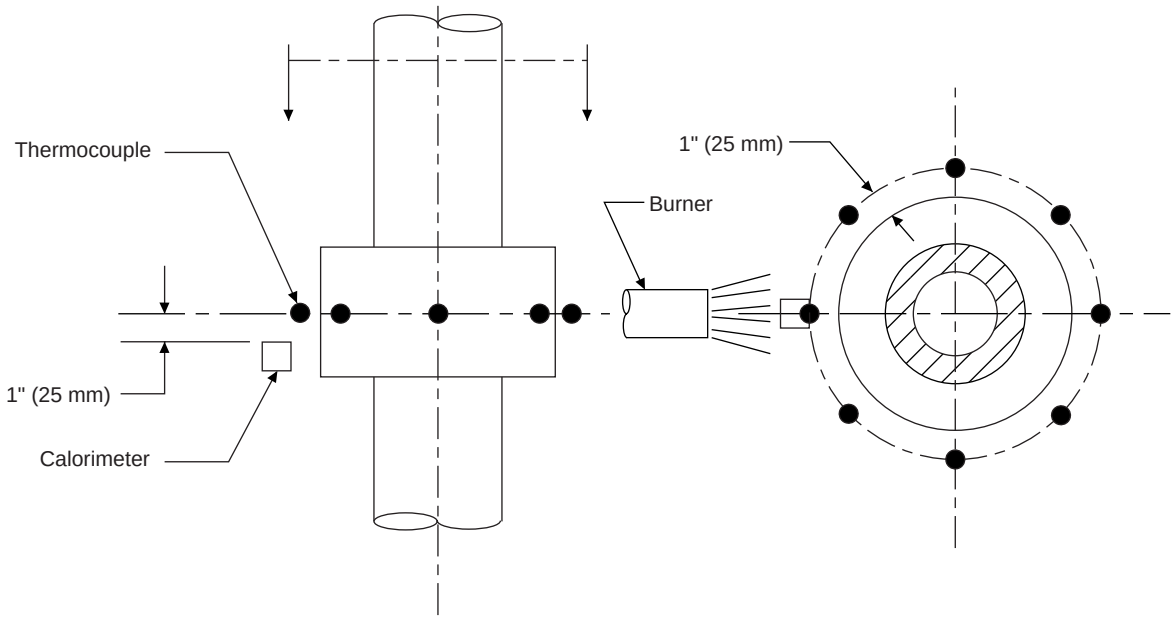


Figure A-7—Schematic of Suggested Leak Measurement System



Note: Three calorimeters spaced uniformly around circumference of joint (minimum—see 3.1.2.2).
Thermocouples spaced at 45° max. for $7^{1}/_{16}$" (179 mm) and smaller connections, or at 30° max. for larger connections.

Figure A-8—Location of Thermocouples and Calorimeters for Bending Tests—Onshore Conditions



Note: Thermocouples spaced at 45° max. for $7^{1}/_{16}$" (179 mm) and smaller connections, or at 30° max. for larger connections.

Figure A-9—Location of Burner, Calorimeter, and Thermocouples for Bending Tests—Offshore Well Bay Conditions

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