FIRE TESTING VALVES AS A MEANS OF DETERMINING FIRE-SAFE CAPABILITY

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ABSTRACT

The fire-safe capability of a valve is becoming increasingly important when selecting valves for hydrocarbon processing service. In spite of this, "fire-safe" is one of the least understood attributes of a valve. One method of determining a valve's fire-safe capability is by fire testing. Various agencies have established test criteria by which a fire-safe valve can be certified. The specifying engineer can be aided in making the right valve selection by selecting the test criteria that most closely match his safety requirements and comparing these on test reports of all valves being considered for use.

INTRODUCTION

The fire-safe capability of a valve is becoming increasingly important when selecting a valve for hydrocarbon processing service. In spite of this, "fire-safe" is one of the least understood attributes of a valve. Various agencies have either by definition or by test standards established criteria by which the fire-safe performance capability of a valve can be measured. Certain valve manufacturers have developed various designs and techniques in order to meet these requirements.

In addition to reviewing the design and operating features of various valve types, the specifying engineer can be aided in selecting the proper valve by reviewing various fire test standards and selecting the test acceptance criteria that most closely match his safety requirements.

Valves such as the gate and globe type which utilize an all metal construction (metals of melting points above 1700°F) have generally been considered to be fire-safe. It is important to note, however, that there is no established test standard to measure the actual fire-safe capability of these valve types.

It is with valve types that employ resilient, elastomeric seats (ball, plug, and butterfly) that the term "fire-safe" becomes questionable and vague as to definition, testing, certification, and performance. It is for these types of valves that various agencies have by either definition or test standards defined "fire-safe."

TEST CRITERIA

The United States Coast Guard (USCG) is one agency that defines fire-safe requirements (Figure No. 1).[1] In addition to category A and B, reference is made to a third category, "positive shut-off." This category is not defined, as are A and B. Individual valve designs are subject to a review by the USCG for acceptance as being positive shut-off. One valve type employing a dual-seating technique (Figure No. 2) which "makes and maintains metal-to-metal sealing prior to, during and after exposure to a high temperature condition that destroys the resilient seal" has been accepted as being positive shut-off.

Factory Mutual Research by its approval standard class No. 6033 "Fire-Safe Valves" has established basic test requirements by which fire-safe valves can be judged.[2] "An approved FM fire-safe valve is one that can withstand a direct fire exposure equivalent to being 18 in. above the surface of free burning normal heptane in a 5 or 10 ft^2 pan for 15 minutes without leaking through the valve port if shut in excess of 0.1 qt/min (94.6 cc/min). External leakage, including leakage from flanged connections shall not exceed individual drops. Actuators may be damaged but shall not rupture or cause leakage in excess of closed port or external leakage requirements." This test normally is for valves with a maximum pressure rating of 125

MARINE ENGINEERING REGULATIONS

SUBCHAPTER F
TITLE 46 C.F.R. PARTS 50 to 63

Section

56.20–15 Valves employing resilient material.

(a) A valve in which the closure is accomplished by resilient non-metallic material instead of a metal to metal seat shall comply with the design, material and construction specified for valves in this part.

(b) Valves employing resilient material shall be divided into two categories, Category A and Category B.

(1) *Category A valves.* (i) Category A valves are those valves employing resilient material that would continue to provide effective closure of the line and would not allow appreciable leakage from the valve if the resilient material were damaged or destroyed.

(ii) Category A valves may be used in any piping system except as positive shutoff valves required by paragraph 56.50–60(d) for systems subject to internal head pressure from tanks containing flammable, combustible, or hazardous materials, or as otherwise exempted in the regulations in this subchapter.

(2) *Category B valves.* (i) Category B valves are those valves employing resilient material that would not provide effective closure of the line or would permit appreciable leakage from the valve if the resilient material were damaged or destroyed.

(ii) Category B valves may be used in any piping system except in any location in a fire-main system; in any location in the bilge system; as the positive closure for any opening in the shell of the vessel; in a position serving as the positive shutoff valve required by paragraph 56.50–60(d) for systems subject to internal head pressure from tanks containing flammable, combustible, or hazardous materials; or as otherwise exempted in the regulations in this subchapter.

FIGURE 1—UNITED STATES COAST GUARD FIRE-SAFE REQUIREMENTS

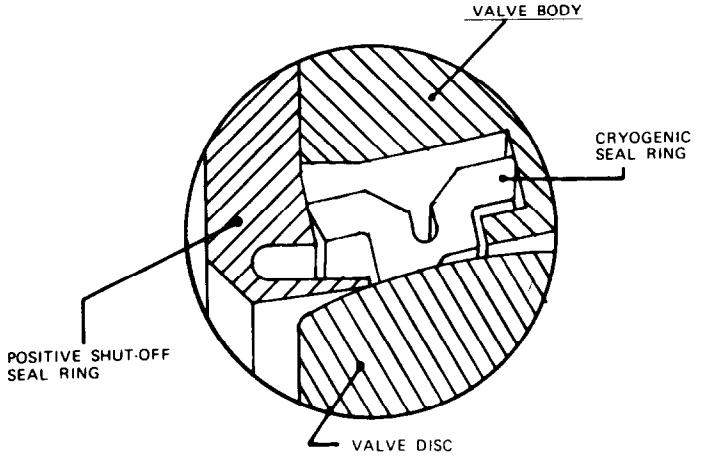


FIGURE 2—POSI-SEAL DYNAMIC DUO SEAL

psi, however, valves may be tested at higher pressures for approval. It is important to note that this test standard is the only one to include the valve actuator as part of the test.

The American Petroleum Institute, Division of Refining, has recently issued a tentative standard No. 607 "Fire test for soft seated ball valves."[3] This standard will remain tentative for up to two years. At the end of this period, manufacturers' test experiences will be used to either review or reaffirm it.

The basic test set-up is to envelop a valve in the shut position with the stem horizontal in a flame whose temperature is in the 1400° to 1600°F range for a period of 30 min. Using two thermocouples, one placed 1 in. beneath the valve body and the other within a 1 in. radius of the stem seal, the minimum temperature reading shall not be less than 1300°F. During the 30 min exposure the shut valve shall be filled with water and pressured to a pressure equal to the 1000°F class pressure rating for carbon steel material. The performance requirements for certification include a maximum seat leakage during the burn period of 40 ml/nominal in. of valve size/min for the total test period including cool down, and the ability to be cycled fully opened and shut against the test pressure.

A valve tested to these requirements qualifies valves of the same design two nominal pipe sizes larger and smaller and a pressure rating no less than one-half nor greater than twice the pressure rating of the test valve. A 4 in. Class 300 test valve would also qualify a 2, 3, 6, and 8 in. Class 150, 300, and 600 valve of the same design. This standard applies to all pressure classes but is limited to a maximum valve size of 16 in. It is also important to note that the valve/flange connection and actuator are not included in this test.

The American Petroleum Institute, Division of Production, is currently in the process of developing a fire test standard.[4] Draft No. 4 of this standard is similar to API 607, except for the following.

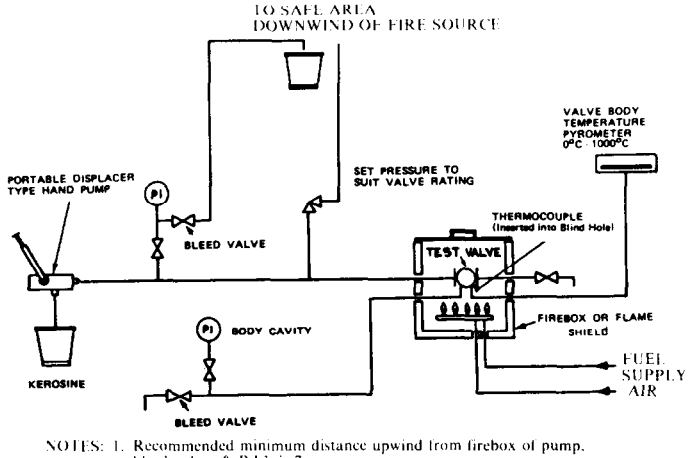
1. Valve type is not limited to resilient seated ball valves and covers all 6A and 6D valve types and sizes.
2. The valve is tested with the stem and bore in the horizontal position.
3. There are two test durations for qualification, 15 and 30 min.
4. The test pressure is equal to 75% of the CWP rating.
5. Maximum allowable seat leakage is 400

cc/nominal in. of valve size/min and the maximum allowable external leakage is 100 cc/nominal in. of valve size/min.

6. A valve tested qualifies valves no larger than twice the size of the test valve and with a pressure rating no less than one-half nor greater than twice the pressure rating of the test valve. A 4 in. Class 300 test valve would also qualify a 6 and 8 in. Class 150, 300, and 600 valve of the same design. In addition, there is no size limitation as to maximum valve size to be tested.

The Oil Companies Materials Association (OCMA) Specification No. FSV. 1, "Fire-Safe Test For Soft Seat Ball Valves," is also used to determine the fire-safe capability of a valve.[5] This specification is the same as British Standard No. BS5146, "Inspection and test of steel valves for the petroleum, petro-chemical, and allied industries."

For this test the valve is installed with the stem in the vertical position and with the ball in the open position. The valve body and bore of the ball is filled with kerosene or diesel oil pressurized to 2 bar (30 psi) and exposed to fire for a period of time sufficient to insure that the soft seats and stem seal (if fitted) have completely decomposed or disintegrated. However, the exposure time shall not be less than 15 minutes (Figure No. 3).



NOTES: 1. Recommended minimum distance upwind from firebox of pump, bleed valves & P.I.'s is 7 meters.
2. Installation for body cavity pressure is optional.

FIGURE 3 TYPICAL TEST RIG OCMA SPECIFICATION NO. FSV.1

The performance requirements for certification include an operability test consisting of shutting and opening a minimum of three times within 5 minutes of extinguishing the fire and a low-pressure test of 1 bar (15 psi) and a high-pressure test equal to the full rated hydrostatic seat test. A leakage rate across the seat in excess of 10 ml/min/in. of nominal valve size at either the low- or high-pressure test is cause for rejection. In no case, shall the leakage rate be greater than 100 ml/min/in.

No gland adjustment is allowed during the entire test and any appreciable leakage at the stem seal, body joint, or bonnet joint shall be cause for rejection at the discretion of the testing authority.

After completion of all testing, the valve is dismantled and inspected to insure that all resilient seal components have decomposed or disintegrated. Figure No. 4 shows a comparison of various test criteria.

FIRE TEST CRITERIA

TEST CRITERIA	OCMA FSV. 1	API 607	FM 6033
VALVE TYPE	SOFT SEAT BALL VALVES	SOFT SEAT BALL VALVES	FIRE SAFE VALVES
VALVE STEM POSITION	VERTICAL	HORIZONTAL	NOT SPECIFIED
VALVE BORE POSITION	HORIZONTAL	HORIZONTAL	NOT SPECIFIED
VALVE-OPEN OR SHUT	OPEN	SHUT	SHUT
TEST PRESSURE DURING BURN	30 PSI	1000F CLASS PRESSURE RATING	125 PSI
TEST MEDIA	KEROSINE OR DIESEL OIL	WATER	NOT SPECIFIED
VALVE BODY TEMPERATURE	NOT SPECIFIED- MUST DESTROY SOFT SEAT	1300F	NOT SPECIFIED
DURATION OF BURN	15 MINUTES	30 MINUTES	15 MINUTES
LEAKAGE MEASURED	AFTER TEST	DURING TEST	DURING TEST
ALLOWABLE EXTERNAL LEAKAGE	NO APPRECIABLE LEAKAGE	20 ML/MIN./IN. DIA.	.1 QT/MIN. (94.6 CC/MIN.)
ALLOWABLE SEAT LEAKAGE	10 ML/MIN./IN. DIA.	40 ML/MIN./IN. DIA.	LEAKAGE SHALL NOT EXCEED INDIVIDUAL DROPS
OPERABILITY TEST	3 CYCLES-OPEN TO SHUT	1 CYCLE-OPEN TO SHUT	MUST BE OPERABLE

FIGURE 4—FIRE TEST CRITERIA COMPARISON

FIRE-SAFE VALVE DESIGNS

Cast steel gate valves with metal-to-metal seating have generally been considered to be fire-safe. One seating arrangement (Figure No. 5) offers resilient seating for optimum shut-off under normal operating conditions in addition to back-up metal seating.

One fire-safe ball valve seating arrangement (Figure No. 6) utilizes a main resilient seat and a secondary metal seal. This design is a typical one found in a floating-type ball valve. In the event of a fire, the complete sublimination of the resilient seat

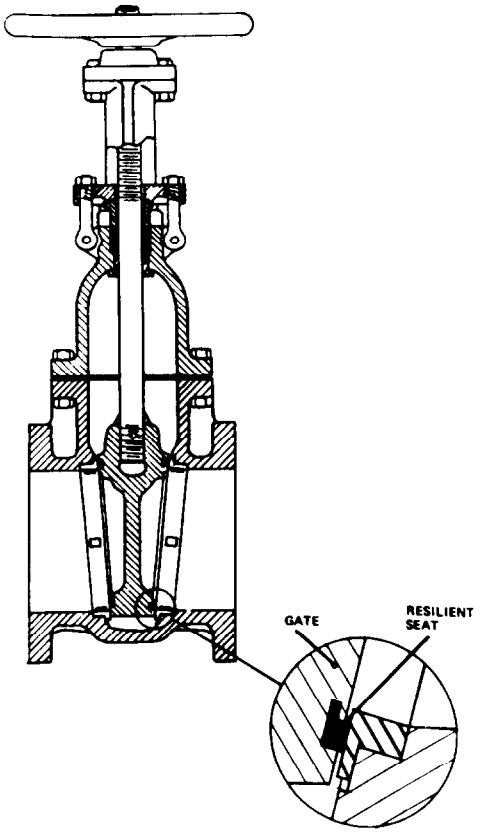


FIGURE 5—TYPICAL RESILIENT (SOFT) SEATED GATE VALVE

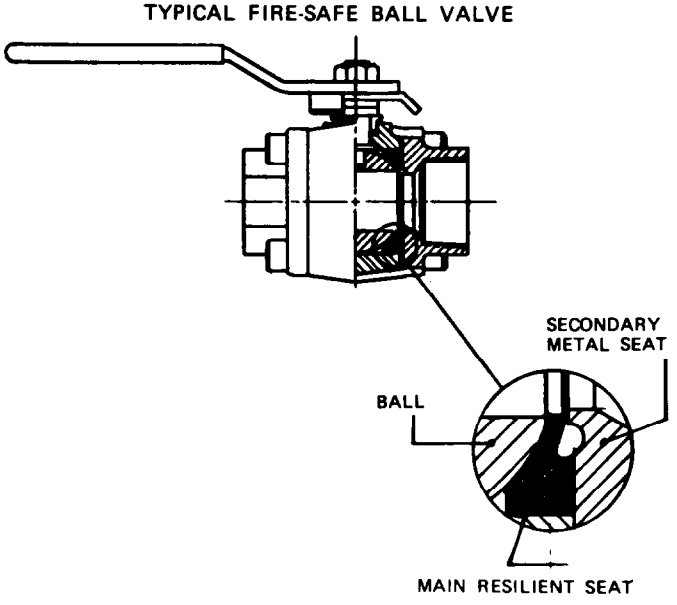


FIGURE 6—TYPICAL FIRE-SAFE BALL VALVE

allows the valve to achieve metal-to-metal seating due to the inherent float of the ball toward the downstream seat by system pressure. This method appears to work in the smaller sizes; however, for best results the valve should be installed in a vertical pipe run.

One trunnion mounted ball valve utilizes a spring-loaded metal back-up seal (Figure No. 7). Here again, complete sublimination of the main resilient seat is required to achieve metal-to-metal seating.

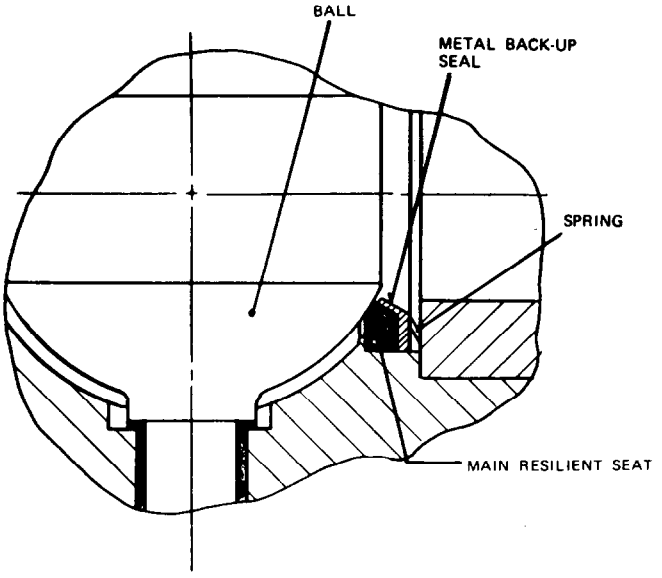


FIGURE 7—TYPICAL TRUNNION BALL VALVE WITH FIRE-SAFE SEAL

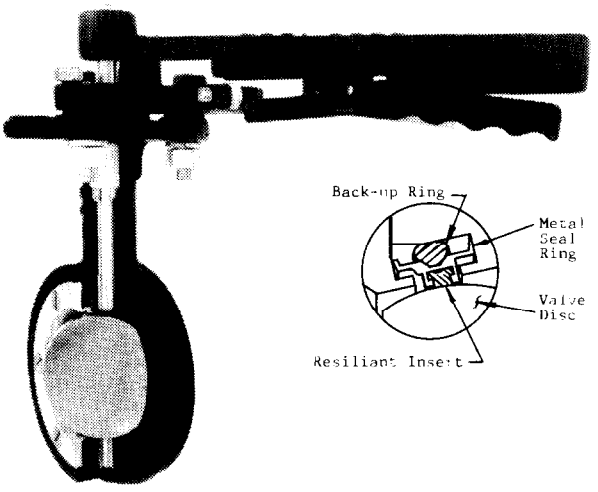


FIGURE 8—FIRE-SAFE TRUNNION VALVE

Another type of fire-safe valve (Figure No. 8) with a dual seating arrangement offers a combination of resilient and metal-to-metal seating. With this type of seat, complete sublimination of the resilient seal, spring-loading, or system pressure is not required to maintain metal-to-metal contact. A typical fire test conducted in accordance with OCMA Specification No. FSV.1 is shown in Figure Nos. 9-13. The test result of one 6 in. Class 300 is shown in Figure No. 14. A similar test set-up of a typical fire-safe ball valve, a metal-to-metal seated gate valve, and a trunnion valve is shown in Figure Nos. 15, 16, and 17.

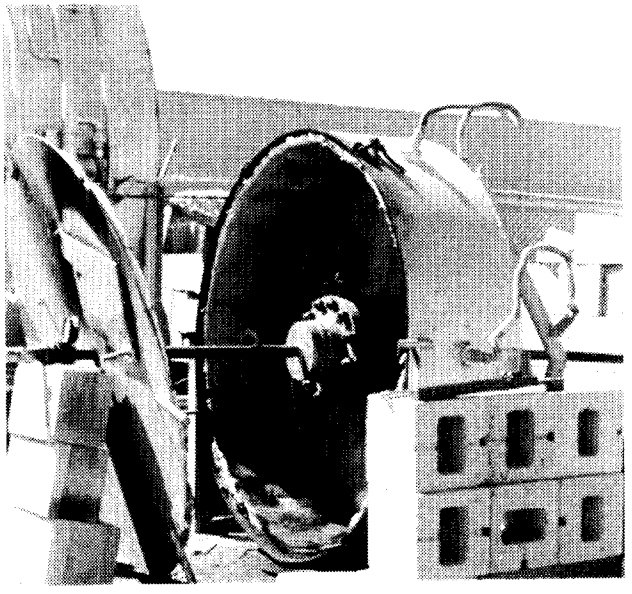


FIGURE 9—VALVE INSTALLED BETWEEN TEST FLANGES AND IN FURNACE

FIGURE 10—VALVE IS HEATED TO A BODY TEMPERATURE OF 1200°F

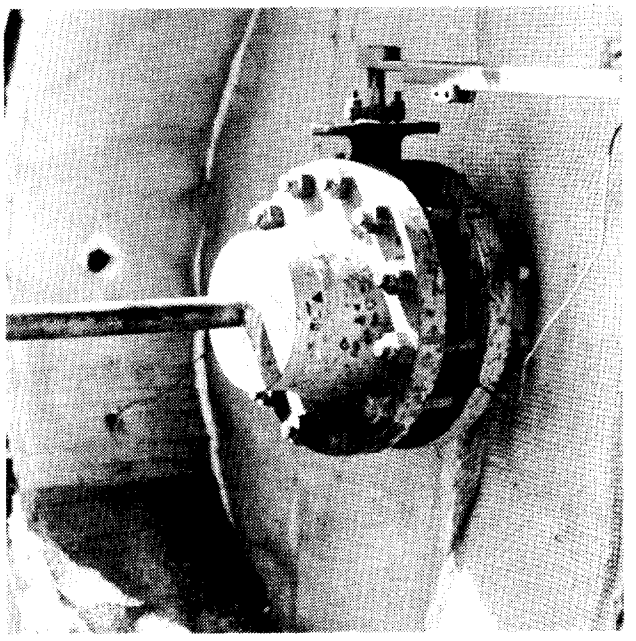


FIGURE 11—VALVE IS CYCLED 3 TIMES WITHIN 5 MINUTES AFTER COMPLETION OF BURN

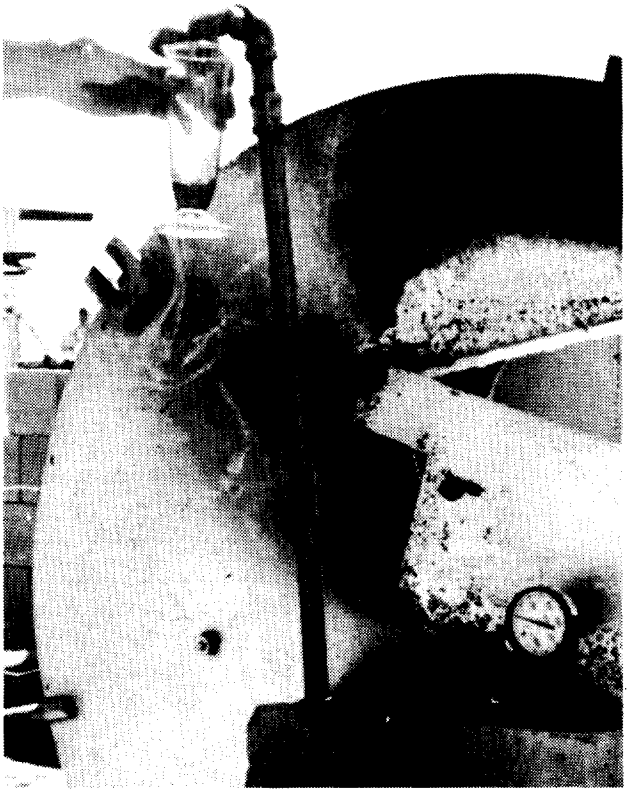


FIGURE 12—VALVE IS SEAT TESTED AT 15 PSI AND 750 PSI AND LEAKAGE COLLECTED AND MEASURED

FIGURE 13—VALVE IS DISASSEMBLED AND INSPECTED TO INSURE COMPLETE DESTRUCTION OF SOFT SEAT

POSESEAL INTERNATIONAL INC

FIRE TEST REPORT FORM

VALVE SIZE 6 in Class 300 | MEDIA Diesel Fuel | SPEC PoseSeal No. TP-802, OCMA No. FSV-1, Exxon RPT-14-1

TIME	TEMP EXT	TEMP INT	TEST PSIG	REMARKS
11:55			30	Start Fire
12:05	780	330	30	Very Heavy Fuel Oil
12:10	1040	540	30	Burning (Spilled Fuel Oil)
12:15	1160	700	30	Spilled Fuel Oil Consumed
12:25	1200	980	30	
12:30	1220	1100	30	
12:35	1220	1180	30	
12:40	1240	1200	30	Shut Down
				Cycled three (3) times within five (5)
				minutes after fire was out.

TIME	LEAKAGE	TEST PSIG	REMARKS
2:55	0	15 PSI	
3:00	0	750 PSI	

Tested By: Ray Marshall — Date: 4-13-77

Engineering — Date: 4-13-77

Inspection — Date:

Witnessed By — Date:

VALVE DESCRIPTION: 6 in Class 300 PoseSeal Trunnion Valve - Fire Safe, Water Type Type 18 Seal

FIGURE 14 TEST REPORT OF A FIRE-SAFE TRUNNION VALVE

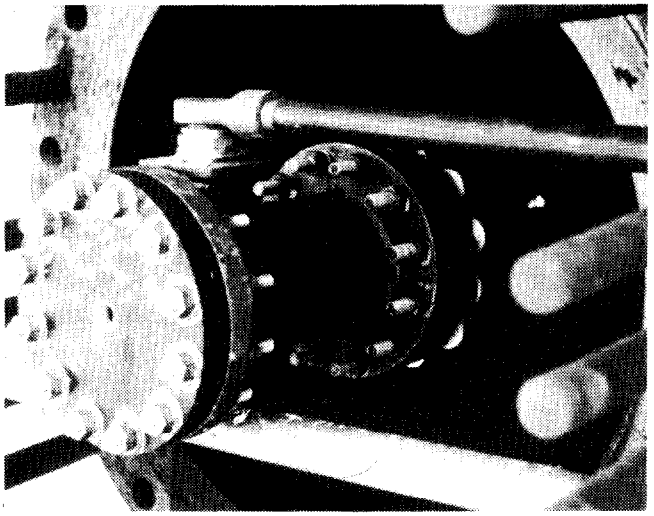


FIGURE 15 TEST SET-UP OF 6 IN. CLASS 300 FIRE-SAFE BALL VALVE

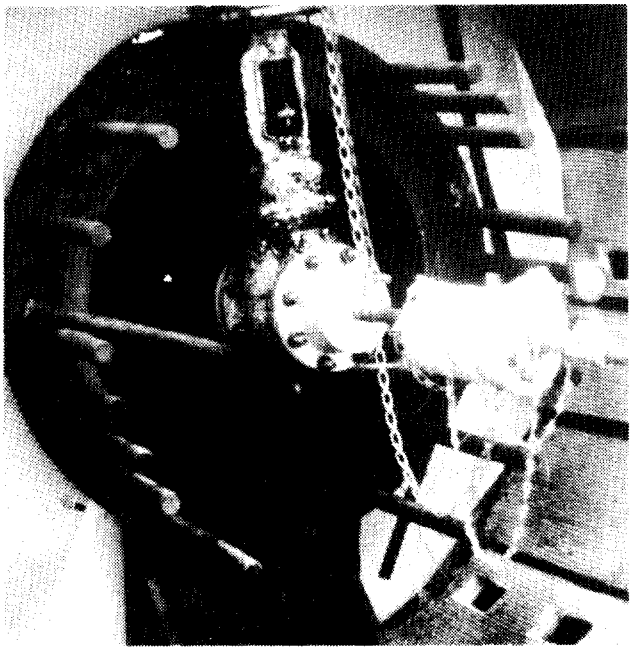


FIGURE 16—TEST SET-UP OF A 6 IN. CLASS 150 CAST STEEL GATE VALVE

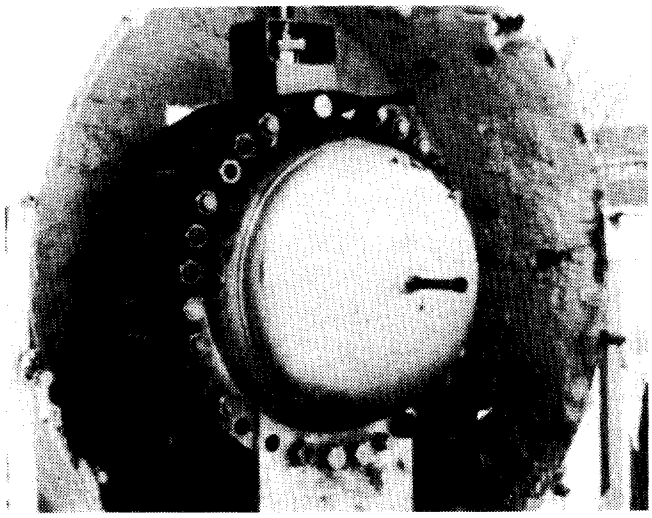


FIGURE 17 TEST SET-UP OF A 36 IN. CLASS 300 TRUNNION VALVE

CONCLUSION

Not one type of fire-safe valve is ideally suited for all process applications. Service conditions, operational requirements, and fire safety all come into play when selecting the right valve for the application. Along with the basic valve's operational capabilities and pressure/temperature limitations, its fire-safe capability must be known. As we have seen, by either definition or various different test standards, a valve's fire-safe capability can be determined. The specifying engineer using this data as it suits his application is able to intelligently select the proper valve type for the application.

REFERENCES

1. Marine Engineering Regulations, Subchapter F, Title 46 C.F.R., Parts 50 to 63.
2. Factory Mutual Research, Approval standard, Fire-Safe Valves, Class Number 6033.
3. American Petroleum Institute, Division of Refining, Standard No. 607, Fire test for soft seated ball valves.
4. American Petroleum Institute, Division of Production, Draft No. 4, Fire test for API 6A and 6D valves.
5. Oil Companies Materials Association, Specification No. FSV. 1, Fire-safe test for soft seated ball valves.