

Technical Report on Fire Resistance Improvements for API Flanges

API TECHNICAL REPORT 6F2
THIRD EDITION, APRIL 1999



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Upstream Segment

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IMPORTANT INFORMATION CONCERNING USE OF ASBESTOS OR ALTERNATIVE MATERIALS

Asbestos is specified or referenced for certain components of the equipment described in some API standards. It has been of extreme usefulness in minimizing fire hazards associated with petroleum processing. It has also been a universal sealing material, compatible with most refining fluid services.

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.

SAFETY AND HEALTH INFORMATION WITH RESPECT TO PARTICULAR PRODUCTS OR MATERIALS CAN BE OBTAINED FROM THE EMPLOYER, THE MANUFACTURER OR SUPPLIER OF THAT PRODUCT OR MATERIAL, OR THE MATERIAL SAFETY DATA SHEET.

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Technical Report on Fire Resistance Improvements for API Flanges

1 Scope

This document establishes recommended methods for improving the performance of standard API flanges when subjected to the adverse effects of external high temperatures induced by exposure to fires. It does not cover fire prevention, suppression, or fire fighting practices.

Innumerable factors contribute to flange failures under fire conditions, so it is difficult to formulate hard and fast engineering rules which will ensure fire resistant behavior under all circumstances. It is possible to formulate a generalized methodology to examine enhancements which will increase the probability of survival of API flanges under fire conditions.

1.1 COMPARATIVE TESTING

To provide a basis for comparing protection methods it is necessary to provide consistent testing criteria. Although primarily used for valves, API RP 6F and API Spec 6FA, as well as other test procedures, listed in the following, have been used for testing connection and seal performances.

- a. API RP 6F.
- b. API Spec 6FA (supersedes API RP 6F).
- c. User Modified API RP 6F, (Appendix A).
- d. API Spec 6FB—Should be considered as the standard test method.

It is not intended that the order of listing indicates test severity.

2 References

1. API Spec 6AF
Specification for Fire Test for Valves, American Petroleum Institute, latest edition.
2. Weiner, Peter D.
Analysis of Flange and Clamp Joints Exposed to a Fire Environment, Mechanical Engineering Department, Texas A&M University, October 1979 (PRAC-79-21).
3. Fowler, Joe R.
Effects of Fire Environment on Pressure Capability of Standard API and ANSI Connections, prepared for the American Petroleum Institute, March 1981 (PRAC-80-33).
4. Fowler, Joe R.
Effects of Fire Environment on Pressure Capability of Standard API and ANSI Connections—Testing and Revised Analytical Procedure, prepared for the American Petroleum Institute, July 1982 (PRAC-81-33).
5. Fowler, Joe R. and Young, David S.
Prediction of Performance of 2"–6" ANSI Flanges and 2¹/₁₆"–7¹/₁₆" Clamps and Flanges in a Standard Fire Environment, prepared for the American Petroleum Institute, July 1984 (PRAC-83-33).
6. API Spec 6A
Specification for Wellhead and Christmas Tree Equipment, American Petroleum Institute, latest edition.
7. API Spec 6D
Specification for Pipeline Valves (Gate, Ball, Plug and Check Valves), American Petroleum Institute, latest edition.
8. ANSI B16.5
Steel Pipe Flanges and Flanged Fittings, ASME.
9. ASME Boiler and Pressure Vessel Code, Section VIII, Divisions 1 and 2.
10. Sweet, Harry J.
Prediction of Seating and Retaining Loads for API Type RX Pressure Energized Ring Joint Gaskets, prepared for the Association of Wellhead Equipment Manufacturers, April 1974.
11. Simmons, W. F., and H. C. Cross
Elevated Temperature Properties of Wrought Medium Carbon Alloy Steels, ASTM Special Technical Publication No. 199.
12. Miller, R. F., and J. J. Heger
Report on the Strength of Wrought Steels at Elevated Temperature, ASTM Special Technical Publication No. 100.
13. Smith, G. W.
Elevation of the Elevated Temperature Tensile and Creep Rupture Properties of 12 to 27% Chromium Steels, ASTM DS59.
14. Moon, D. P., R. C. Simon, and R. J. Favarr
The Elevated Temperature Properties of Selected Superalloys, ASTM DS 7-S1.
15. Sweet, Harry J.
Summary of Design Equations for Clamp Type Connections prepared, for the Association of Wellhead Equipment Manufacturers.
16. Adamek, Frank, John J. Nutt, David S. Young
"Analysis of Bimetallic Clamp Type Connectors Subjected to Thermal Transients," prepared for the Fifth International Conference on Pressure Vessel Technology, September 9–14, 1984.
17. ASTM E-119
Standard Test Methods for Fire Test of Building Construction and Materials
18. ASTM E-84
Standard Test Method for Surface Burning Characteristics of Building Materials

3 Usage Considerations

3.1 DIVISIONS OF USE

It is important to recognize that API flanges utilized for conveying liquids as opposed to gases respond quite differently to fire environments. Rates of flow, as well as effluent composition, radically alter fire resistance.

Land wellheads and Christmas trees provide good heat sinks and consequently can be less vulnerable than flowlines.

Those multiple and adjacent wellheads, Christmas trees, and flowlines which are in confined or contained spaces, such as offshore platform installations, are an entirely different matter. Flame impingement from proximate wellheads may occur and convective cooling may be materially reduced. Drafting (convective air flow) may aid combustion with the realization of higher, more concentrated temperatures and total heat input. Conversely, under some fire conditions, this drafting effect can materially reduce ambient temperatures.

Other engineering problems must be addressed which do not come within the scope of this document, but should be considered when improving flange fire resistance. As an example, it does little good to protect the flanged connections of a short liquid flowline connecting two closed valves engulfed in a fire. Two events which may occur: (a) the overpressure induced by liquid expansion might cause flange separation, or (b) the flowline might catastrophically destruct resulting in damage greater than that experienced by a flange failure. The consequences of massive fire involvement are too numerous to discuss, but should be considered in designing for fire resistance of systems.

3.2 LIQUID AND GAS SERVICE

Installation and equipment considerations:

- a. Onshore—Platform Offshore.
- b. Flowing or Static—Effluent.
- c. Wellhead—Size and Components.
- d. Christmas Tree—Size and Components.
- e. Flowline.

4 Testing

4.1 RELATIVE FIRE VULNERABILITY OF API FLANGES:

The performance of API and ANSI flanges in fire testing per API RP 6F and API Spec 6FA has been studied and is the subject of API Technical Report 6F1. Excerpts from that Technical Report are contained in Appendix B, and serve as a basic guideline to determine which flanges require protection.

4.2 MANUFACTURER'S TESTING:

At the present time, extensive testing has not been performed in accordance with API Spec 6FB. Various manufac-

turers have conducted tests in accordance with "user modified" API RP 6F, with a general concurrence that most or all API flanges will not survive without leakage or irreparable damage.

5 Improvements

5.1 METHODS OF IMPROVEMENT

5.1.1 Shielding

The most obvious protection is "shielding" or preventing the involvement of the flange with the fire environment. Metal shielding alone is not considered effective unless it is used with adequate insulation. Insulation inhibits heat transfer by radiation and convection. Used in conjunction, shielding and insulation can provide effective protection for flanges subjected to the testing outlined in API, Spec 6FA and API Spec 6FB. Shielding must be of sufficient thickness and made of an appropriate material to prevent "burn through" and to be self-supporting during a fire. Appendix C may be used to determine insulation requirement and provides information on some insulating materials. Many insulations are available; and information on physical properties can be obtained from the manufacturers.

Some important usage factors should be considered, including resistance to environmental deterioration; high insulating value; ease of installation; service life; and chemical interaction with flanges, studs, nuts, and shielding.

Shielding must cover the entire flanged connection and, in particular, studs and nuts.

5.1.2 Shielding Coatings

Coatings for fire protection have been widely used for construction members in refineries, and industrial and chemical plants. Many are used as external insulation for fired vessels. They are available in several forms: solid sheet materials; spray applied "gunite" or troweled types; batting (fiber); and wrapping-type materials. Most of these materials are rated in accordance with UL¹ and ASTM² specifications. ASTM-E 1119/ASTM-E 84 would be typical specifications. Numerous compositions are available, but generally fall into several categories: aluminum oxides blended with silica, or magnesium oxychlorides are typical. Trade compounds providing reactive bonding characteristics are added to make cementitious mixes for application. Common fiberglass and mineral woods are used. Consideration should be given to environmental considerations, water absorption, abrasion, impact resistance and compatibility with the materials being coated. To avoid covering studs and nuts, high temperature bolting materials may be used (see Appendix D).

¹Underwriters Laboratories, 333 Pfingsten Road, Northbrook, Illinois 60062.

²American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428-2959.