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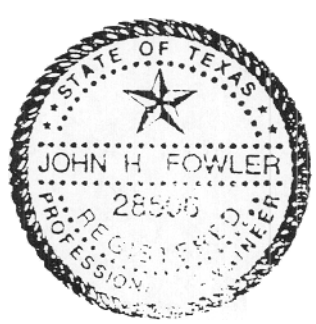
DESIGN REVIEW
OF
PIKOTEK FLANGE SEALS
FOR
API DRILLING AND PRODUCTION SERVICE

SUMMARY

This report is a design review of the Pikotek VCS flange gasket in API 6A flanges. The review includes a review of the gasket design and test documentation and an appraisal of the gasket as a structural and sealing element replacing the R, RX, or BX gasket in a flange. The Pikotek gasket, in combination with an API 6B or 6BX flange, constitutes an acceptable API OEC to PRl performance requirements level, providing that for PSL 2 or higher, the flange face inside the ring groove is inspected as a seal surface. Special markings shall be used to distinguish the Pikotek from standard API flanges.

BY

BY John H. Fowler, PE   February 9, 1994



P.O. BOX 925393 .HOUSTON, TEXAS 77292   PHONE (713) 688-0767   FAX (713) 688-7610

1. BACKGROUND

The Pikotek gasket is a composite structure including a stainless steel plate, one or more grooves on each side with pressure-energized seals, and a structural plastic backup material covering the remaining surface of the plate, which prevents seal extrusion. This design results in a zero-gap extrusion barrier for the soft seal, which in the event of pressure-energized seal failure can function as a flat gasket of the type commonly used on ANSI/ASME flanges.

This gasket has been tried and subjected to various tests in challenging API 6A/16A-type service. However, since the gasket does not conform to API 6A ring gasket dimensions, it is not a monogrammable API component. But when used in combination with a flange, it constitutes an OEC (Other End Connector) as defined in Spec. 6A.

It is an objective of this report to define how a manufacturer can meet API 6A requirements using a flange with this type of gasket.

Another objective of this report is to provide objective evidence of the design meeting API design requirements, thus satisfying the PRl requirements of Appendix F, API Spec 6A.

It is a further objective to define for Pikotek the actions needed on their part to qualify the connection for API 6A Appendix F PR2 performance verification, and how this qualification can be documented for manufacturers, in order that they can use Pikotek gasketed connections as an alternative to conventional ring gasketed connections. In addition, the fire resistance tests, which have been run, are compared to API 6FB requirements.

2. SCOPE OF REVIEW

The gasket design is reviewed to determine the effect of the spacer on API flange loading. The flange bolting is checked to determine the stresses and preload requirements.

The effect on flange bending strength is also reviewed in a semi-quantitative way to verify that flanges are at least as strong with the Pikotek configuration.

The review includes a study of existing test documentation to compare existing tests with API Spec 6A Appendix F requirements and with API 6FB connector fire tests.

QA requirements for flanges are also reviewed to confirm that no additional QA is required on an API flange in order for it to be used with the Pikotek gasket although the seal location is moved.

3. GASKET DESIGN

3.1. Preload

The key design element of the Pikotek gasket is the structural plastic G-ll material, which coats the faces of the gasket inside and outside of the pressure-energized seal. This material is initially made up with a minimum preload of 7,500 psi. The function of this preload is to coin the G-ll material into the surface finish of the flange faces. This gives a zero-gap anti-extrusion backup to the seals.

This preload must be exerted by the flange bolting, so the first phase of this design review was to determine whether the load requirement for this preload exceeded the bolt strength requirement for hydrostatic test conditions, or whether the maximum allowable stress for A193 Type B7 or B7M was exceeded.

Attachment A to this report is the analysis of all API 6B and 6BX flanges. Loading at hydrostatic test is calculated for the 6B flanges based on ASME Section VIII Division 2 Appendix 3, Flanges with Ring Type Gaskets.

As can be seen from the attachment, the bolt loading for pre loading of the Pikotek gasket is lower than that required for hydrostatic test in all cases.

3.2. Operating Conditions and Externally-Applied Loading

The Pikotek gasket has a pressure-energized primary seal which, per ASME Code requirements, may be considered to require zero force above that caused by the pressure acting over the seal.

Therefore, the bolt loading will be lower in all cases for the Pikotek sealed flange than for the R, RX, or BX gasket.

This has important implications regarding the flange's capacity to withstand externally applied tension or bending. The lower bolt loading from pressure will permit a higher applied load before leakage. The bending capacity of the flange is also enhanced for Type 6B flanges by the fact that the G-ll material provides contact out to the OD of the raised face of the flange, thus providing a wider footprint for the flange, which will improve bending stability.

3.3. Shear Loading

The capacity for shear loading of API flanges with metal ring gaskets is not documented in API bulletins. The effect of shear loading on metal ring gaskets is to increase the load on the OD of the seal on one side of the connection, and to decrease the load on the OD of the seal on the other side. This means that the sealing contact may be relieved on one side of the ring gasket if too much shear force is applied.

Shear force on the Pikotek gasket is resisted by the shear strength of the G-11 to 316 SS bond, and by the contact friction between the G-11 material and the flange face. The bond strength between the G-11 and the 316 S is reportedly 4000 psi minimum. Pikotek have no experimental data on the friction force between the flange face and the G-11 material, however if the material is properly coined into the mating flange face, one would expect a moderately high coefficient of friction, on the order of 0.3-0.5. This would predict a minimum shear force capability of 0.3 (7500) = 2250 psi, providing the 7500 psi minimum preload is maintained under pressure. Shear strength of the connection is therefore controlled by the bolt loading.

Shear capacity can then be calculated by subtracting the pressure end load from the total bolt force and multiplying by the applicable friction coefficient.

A simple calculation of shear capacity for a standard API 2-1/16"--5000 psi flange and a 2-1/16"-5000 psi Pikotek flange is included as Attachment B. Assuming a friction coefficient of 0.5 for the Pikotek gasket, the two designs have comparable shear capacity.

4. PR2 TEST REQUIREMENTS

API Specification 6A is currently in the process of final revision in preparation for the issuance of the 17th Edition. The revision includes some changes to Appendix F, Performance Verification Procedures. This review was therefore conducted based on the draft Seventeenth Edition of Appendix F.

Appendix F requires three tests: pressure/temperature cycling, make and break tests, and bending tests. The pressure/temperature cycling test is a three-cycle thermal test with pressure tests at the extreme temperatures, and with pressure held on the connector during the second cycle. A low-pressure test is also run at the end of the test.

Make and break tests are to be conducted for the manufacturer's rated number of cycles. Since the Pikotek literature claims multiple uses are possible when the soft seal is replaced, a number of cycles should be decided for these tests. Ten cycles would be a reasonable number.

Bending tests are required as well. I would suggest bending the flanges to the maximum permissible full-pressure bending moment per API Bulletin 6AF. It would be helpful to document whether the Pikotek

The Pikotek design for 6B flanges could be qualified for sizes from 2-1/16" to 7-1/16" and ratings to 5000 psi by testing a 2-1/16"-5000 psi and a 5-1/8"-5000 psi flange. The Type BX design can be qualified for 1-13/16" to 7-1/16"-10,000 psi by testing a 2-1/16"- 10,000 and the 5-1/8"-10,000.

5. <u>FIRE RESISTANT TEST REQUIREMENTS</u>

A flange using the Pikotek VCS gasket has been successfully fire tested in the 2"-600 ANSI/ASME rating, in accordance with test procedures of API Specification 6FB, Second Edition, modified to account for the lower pressure rating of the Class 600 flange, and without the bending test.

Specification 6FB requires separate testing of each pressure rating of a design. Thus, to qualify 2000, 3000, and 5000\psi rated equipment would require six tests, one of the largest and one of the smallest of a given pressure rating. However, the 2-:-1/16" and 2-9/16" flanges are identical for 3000 and 5000 psi service. Therefore, the testing of a 2-1/16" 5000 psi flange should cover the low end for both 3000 and 5000 psi products, lowering the requirement to five total tests.

I would recommend testing the 2-1/16" 5000 psi flange first, since it is the lightest 5000 psi unit and thus will be the most challenging test.

6. <u>EXISTING TEST DOCUMENTATION</u>

The documentation of the fire tests on the 2" Class 600 flange included a number of severe tests that are not in the 6FB requirement, including testing of the connection to 14,000 psi internal pressure. Thus, while the fire test itself does not qualify the gasket for API 6A ratings, the performance of the gasket was nonetheless very impressive. The tests did not include the bending test required by 6FB.

7. <u>QA REQUIREMENTS</u>

Since API Specification 6A requires surface NDE on some surfaces of OECs, it is important to determine whether a flange, which is converted from a ring gasket seal to a Pikotek gasket still meets all applicable NDE requirements under 6A. In the Pikotek design, the flange face surface inside the ring groove, which was originally wetted by line fluid but not considered a seal surface, now becomes a seal surface.

Paragraphs 60S.2b(8) and (9) contain the requirements for wetted and seal surface NDE. The requirement for seal surfaces (no indications) is more stringent than the requirement for other wetted surfaces. Therefore, in order to be used as Pikotek OECs, all flanges manufactured for PSL 2 or higher must have the flange face inspected to these more stringent NDE requirements, or must be downgraded to PSL 1.

8. MARKING

Since the Pikotek flange is different in function from the API flange, the marking on the flange OD should identify this fact. Therefore, all flanges manufactured or converted to Pikotek VCS gaskets shall be marked on the flange OD with the words "Pikotek VCS" in addition to the required markings for the API flange. On new flanges, the ring groove size may be omitted from the markings.

9. CONCLUSIONS

The Pikotek gasket, when used with an API 6B or 6BX flange, constitutes an acceptable APT Other End Connection ("OEC") under the requirements of API Specification 6A, Sixteenth and draft Seventeenth Edition. It meets all applicable design strength requirements. However, as pointed out in Section 7 above, for PSL 2 or higher, the flange face must be inspected as a seal surface. Therefore the flange shall be marked as "Pikotek" to distinguish it from standard flanges