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ON-LINE RESOURCES

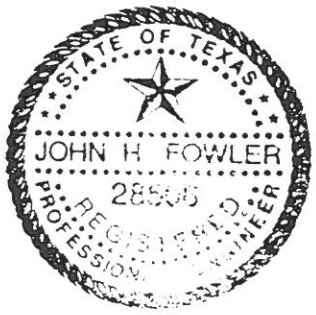
Mechanical Engineering Consulting Services and Software

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 PR1 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 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 PR1 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-11 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-11 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 preloading 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-11 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 unit leaks at the point when leakage is predicted for the API flange.

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. FIRE RESISTANT TEST REQUIREMENTS

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. EXISTING TEST DOCUMENTATION

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. QA REQUIREMENTS

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 605.2b(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 API 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.

ANALYSIS OF API 6B FLANGE BOLT LOADING

Size 2.06 **Pressure** 2,000 psig **Type** 6B

Bolt size 0.625 **No of bolts** 8 **Ring No.** 23 Test Pressure: 4,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 47,717 lbf

Force per bolt: 5,964 lbf Bolt Stress: 29,527 psi

With Pikotek Gasket:

Total force to make up connection: 44,752

Force per bolt: 5,594 lbf Bolt Stress: 27,693 psi

Size 2.56 **Pressure** 2,000 psig **Type** 6B

Bolt size 0.750 **No of bolts** 8 **Ring No.** 26 Test Pressure: 4,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 68,153 lbf

Force per bolt: 8,519 lbf Bolt Stress: 28,209 psi

With Pikotek Gasket:

Total force to make up connection: 63,546

Force per bolt: 7,943 lbf Bolt Stress: 26,302 psi

Size 3.12 **Pressure** 2,000 psig **Type** 6B

Bolt size 0.750 **No of bolts** 8 **Ring No.** 31 Test Pressure: 4,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 96,462 lbf

Force per bolt: 12,057 lbf Bolt Stress: 39,926 psi

With Pikotek Gasket:

Total force to make up connection: 79,808

Force per bolt: 9,976 lbf Bolt Stress: 33,033 psi

ANALYSIS OF API 6B FLANGE BOLT LOADING

Size 4.06 **Pressure** 2,000 psig **Type** 6B

Bolt size 0.875 **No of bolts** 8 **Ring No.** 37 Test Pressure: 4,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 134,707 lbf

Force per bolt: 16,838 lbf Bolt Stress: 40,187 psi

With Pikotek Gasket:

Total force to make up connection: 105,996

Force per bolt: 13,249 lbf Bolt Stress: 31,621 psi

Size 2.06 **Pressure** 3,000 psig **Type** 6B

Bolt size 0.875 **No of bolts** 8 **Ring No.** 24 Test Pressure: 6,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 83,038 lbf

Force per bolt: 10,379 lbf Bolt Stress: 24,772 psi

With Pikotek Gasket:

Total force to make up connection: 73,108

Force per bolt: 9,138 lbf Bolt Stress: 21,810 psi

Size 3.12 **Pressure** 3,000 psig **Type** 6B

Bolt size 0.875 **No of bolts** 8 **Ring No.** 31 Test Pressure: 6,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 133,794 lbf

Force per bolt: 16,724 lbf Bolt Stress: 39,914 psi

With Pikotek Gasket:

Total force to make up connection: 105,678

Force per bolt: 13,209 lbf Bolt Stress: 31,527 psi

ANALYSIS OF API 6B FLANGE BOLT LOADING

Size 2.06 **Pressure** 5,000 psig **Type** 6B

Bolt size 0.875 **No of bolts** 8 **Ring No.** 24 Test Pressure: 10,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 127,216 lbf

Force per bolt: 15,902 lbf Bolt Stress: 37,952 psi

With Pikotek Gasket:

Total force to make up connection: 73,108

Force per bolt: 9,138 lbf Bolt Stress: 21,810 psi

Size 5.12 **Pressure** 2,000 psig **Type** 6B

Bolt size 1.000 **No of bolts** 8 **Ring No.** 41 Test Pressure: 4,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 191,348 lbf

Force per bolt: 23,918 lbf Bolt Stress: 43,409 psi

With Pikotek Gasket:

Total force to make up connection: 165,348

Force per bolt: 20,668 lbf Bolt Stress: 37,511 psi

Size 7.06 **Pressure** 2,000 psig **Type** 6B

Bolt size 1.000 **No of bolts** 12 **Ring No.** 45 Test Pressure: 4,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 254,278 lbf

Force per bolt: 21,189 lbf Bolt Stress: 38,457 psi

With Pikotek Gasket:

Total force to make up connection: 137,774

Force per bolt: 11,481 lbf Bolt Stress: 20,836 psi

ANALYSIS OF API 6B FLANGE BOLT LOADING

Size 2.56 **Pressure** 3,000 psig **Type** 6B

Bolt size 1.000 **No of bolts** 8 **Ring No.** 27 Test Pressure: 6,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 104,123 lbf

Force per bolt: 13,015 lbf Bolt Stress: 23,621 psi

With Pikotek Gasket:

Total force to make up connection: 84,017

Force per bolt: 10,502 lbf Bolt Stress: 19,060 psi

Size 2.56 **Pressure** 5,000 psig **Type** 6B

Bolt size 1.000 **No of bolts** 8 **Ring No.** 27 Test Pressure: 10,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 160,868 lbf

Force per bolt: 20,108 lbf Bolt Stress: 36,494 psi

With Pikotek Gasket:

Total force to make up connection: 84,017

Force per bolt: 10,502 lbf Bolt Stress: 19,060 psi

Size 9.00 **Pressure** 2,000 psig **Type** 6B

Bolt size 1.125 **No of bolts** 12 **Ring No.** 49 Test Pressure: 4,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 402,171 lbf

Force per bolt: 33,514 lbf Bolt Stress: 46,036 psi

With Pikotek Gasket:

Total force to make up connection: 233,623

Force per bolt: 19,468 lbf Bolt Stress: 26,742 psi

ANALYSIS OF API 6B FLANGE BOLT LOADING

Size 4.06 **Pressure** 3,000 psig **Type** 6B

Bolt size 1.125 **No of bolts** 8 **Ring No.** 37 Test Pressure: 6,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 188,924 lbf

Force per bolt: 23,615 lbf Bolt Stress: 32,438 psi

With Pikotek Gasket:

Total force to make up connection: 125,788

Force per bolt: 15,723 lbf Bolt Stress: 21,598 psi

Size 7.06 **Pressure** 3,000 psig **Type** 6B

Bolt size 1.125 **No of bolts** 12 **Ring No.** 45 Test Pressure: 6,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 362,830 lbf

Force per bolt: 30,235 lbf Bolt Stress: 41,532 psi

With Pikotek Gasket:

Total force to make up connection: 137,774

Force per bolt: 11,481 lbf Bolt Stress: 15,770 psi

Size 3.12 **Pressure** 5,000 psig **Type** 6B

Bolt size 1.125 **No of bolts** 8 **Ring No.** 35 Test Pressure: 10,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 250,943 lbf

Force per bolt: 31,367 lbf Bolt Stress: 43,087 psi

With Pikotek Gasket:

Total force to make up connection: 137,675

Force per bolt: 17,209 lbf Bolt Stress: 23,639 psi

ANALYSIS OF API 6B FLANGE BOLT LOADING

Size 11.00 **Pressure** 2,000 psig **Type** 6B

Bolt size 1.250 **No of bolts** 16 **Ring No.** 53 Test Pressure: 4,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 567,724 lbf

Force per bolt: 35,482 lbf Bolt Stress: 38,194 psi

With Pikotek Gasket:

Total force to make up connection: 296,999

Force per bolt: 18,562 lbf Bolt Stress: 19,981 psi

Size 13.62 **Pressure** 2,000 psig **Type** 6B

Bolt size 1.250 **No of bolts** 20 **Ring No.** 57 Test Pressure: 4,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 773,939 lbf

Force per bolt: 38,696 lbf Bolt Stress: 41,654 psi

With Pikotek Gasket:

Total force to make up connection: 290,560

Force per bolt: 14,528 lbf Bolt Stress: 15,638 psi

Size 5.12 **Pressure** 3,000 psig **Type** 6B

Bolt size 1.250 **No of bolts** 8 **Ring No.** 41 Test Pressure: 6,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 271,090 lbf

Force per bolt: 33,886 lbf Bolt Stress: 36,476 psi

With Pikotek Gasket:

Total force to make up connection: 190,622

Force per bolt: 23,827 lbf Bolt Stress: 25,648 psi

ANALYSIS OF API 6B FLANGE BOLT LOADING

Size 9.00 **Pressure** 5,000 psig **Type** 6B

Bolt size 1.625 **No of bolts** 12 **Ring No.** 50 Test Pressure: 10,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 954,443 lbf

Force per bolt: 79,536 lbf Bolt Stress: 47,343 psi

With Pikotek Gasket:

Total force to make up connection: 275,846

Force per bolt: 22,987 lbf Bolt Stress: 13,682 psi

Size 11.00 **Pressure** 5,000 psig **Type** 6B

Bolt size 1.875 **No of bolts** 12 **Ring No.** 54 Test Pressure: 10,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 1,358,126 lbf

Force per bolt: 113,177 lbf Bolt Stress: 49,122 psi

With Pikotek Gasket:

Total force to make up connection: 347,068

Force per bolt: 28,922 lbf Bolt Stress: 12,553 psi

Size 20.75 **Pressure** 3,000 psig **Type** 6B

Bolt size 2.000 **No of bolts** 20 **Ring No.** 74 Test Pressure: 4,500 psig

With API Ring Gasket:

Total Force at Test Pressure: 2,045,767 lbf

Force per bolt: 102,288 lbf Bolt Stress: 38,570 psi

With Pikotek Gasket:

Total force to make up connection: 863,486

Force per bolt: 43,174 lbf Bolt Stress: 16,279 psi

ANALYSIS OF API 6BX FLANGE BOLT LOADING

Size 1.81 **Pressure** 10,000 psig **Type** 6BX

Bolt size 0.750 **No of bolts** 8 **Ring No.** 151 Test Pressure: 15,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 114,704 lbf

Force per bolt: 14,338 lbf Bolt Stress: 47,476 psi

With Pikotek Gasket:

Total force to make up connection: 51,541 lbf

Force per bolt: 6,442 lbf Bolt Stress: 21,333 psi

Size 2.06 **Pressure** 10,000 psig **Type** 6BX

Bolt size 0.750 **No of bolts** 8 **Ring No.** 152 Test Pressure: 15,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 140,795 lbf

Force per bolt: 17,599 lbf Bolt Stress: 58,276 psi

With Pikotek Gasket:

Total force to make up connection: 53,282 lbf

Force per bolt: 6,660 lbf Bolt Stress: 22,053 psi

Size 2.56 **Pressure** 10,000 psig **Type** 6BX

Bolt size 0.875 **No of bolts** 8 **Ring No.** 153 Test Pressure: 15,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 199,490 lbf

Force per bolt: 24,936 lbf Bolt Stress: 59,513 psi

With Pikotek Gasket:

Total force to make up connection: 73,570 lbf

Force per bolt: 9,196 lbf Bolt Stress: 21,948 psi

ANALYSIS OF API 6BX FLANGE BOLT LOADING

Size 2.56 **Pressure** 15,000 psig **Type** 6BX

Bolt size 1.000 **No of bolts** 8 **Ring No.** 153 Test Pressure: 22,500 psig

With API Ring Gasket:

Total Force at Test Pressure: 299,235 lbf

Force per bolt: 37,404 lbf Bolt Stress: 67,884 psi

With Pikotek Gasket:

Total force to make up connection: 77,260 lbf

Force per bolt: 9,657 lbf Bolt Stress: 17,527 psi

Size 1.81 **Pressure** 20,000 psig **Type** 6BX

Bolt size 1.000 **No of bolts** 8 **Ring No.** 151 Test Pressure: 30,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 229,408 lbf

Force per bolt: 28,676 lbf Bolt Stress: 52,043 psi

With Pikotek Gasket:

Total force to make up connection: 77,282 lbf

Force per bolt: 9,660 lbf Bolt Stress: 17,532 psi

Size 4.06 **Pressure** 10,000 psig **Type** 6BX

Bolt size 1.125 **No of bolts** 8 **Ring No.** 155 Test Pressure: 15,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 426,431 lbf

Force per bolt: 53,303 lbf Bolt Stress: 73,219 psi

With Pikotek Gasket:

Total force to make up connection: 127,603 lbf

Force per bolt: 15,950 lbf Bolt Stress: 21,909 psi

ANALYSIS OF API 6BX FLANGE BOLT LOADING

Size 7.06 **Pressure** 10,000 psig **Type** 6BX

Bolt size 1.500 **No of bolts** 12 **Ring No.** 156 Test Pressure: 15,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 1,093,483 lbf

Force per bolt: 91,123 lbf Bolt Stress: 64,856 psi

With Pikotek Gasket:

Total force to make up connection: 348,622 lbf

Force per bolt: 29,051 lbf Bolt Stress: 20,677 psi

Size 9.00 **Pressure** 10,000 psig **Type** 6BX

Bolt size 1.500 **No of bolts** 16 **Ring No.** 157 Test Pressure: 15,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 1,668,760 lbf

Force per bolt: 104,297 lbf Bolt Stress: 74,233 psi

With Pikotek Gasket:

Total force to make up connection: 431,295 lbf

Force per bolt: 26,955 lbf Bolt Stress: 19,185 psi

Size 7.06 **Pressure** 15,000 psig **Type** 6BX

Bolt size 1.500 **No of bolts** 16 **Ring No.** 156 Test Pressure: 22,500 psig

With API Ring Gasket:

Total Force at Test Pressure: 1,640,225 lbf

Force per bolt: 102,514 lbf Bolt Stress: 72,963 psi

With Pikotek Gasket:

Total force to make up connection: 365,502 lbf

Force per bolt: 22,843 lbf Bolt Stress: 16,259 psi

ANALYSIS OF API 6BX FLANGE BOLT LOADING

Size 30.00 **Pressure** 2,000 psig **Type** 6BX

Bolt size 1.625 **No of bolts** 32 **Ring No.** 303 Test Pressure: 3,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 2,732,202 lbf

Force per bolt: 85,381 lbf Bolt Stress: 50,822 psi

With Pikotek Gasket:

Total force to make up connection: 1,381,450 lbf

Force per bolt: 43,170 lbf Bolt Stress: 25,696 psi

Size 13.62 **Pressure** 5,000 psig **Type** 6BX

Bolt size 1.625 **No of bolts** 16 **Ring No.** 160 Test Pressure: 10,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 2,047,692 lbf

Force per bolt: 127,980 lbf Bolt Stress: 76,179 psi

With Pikotek Gasket:

Total force to make up connection: 526,454 lbf

Force per bolt: 32,903 lbf Bolt Stress: 19,585 psi

Size 26.75 **Pressure** 2,000 psig **Type** 6BX

Bolt size 1.750 **No of bolts** 20 **Ring No.** 167 Test Pressure: 3,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 2,167,353 lbf

Force per bolt: 108,367 lbf Bolt Stress: 54,731 psi

With Pikotek Gasket:

Total force to make up connection: 1,067,380 lbf

Force per bolt: 53,369 lbf Bolt Stress: 26,954 psi

ANALYSIS OF API 6BX FLANGE BOLT LOADING

Size 11.00 **Pressure** 10,000 psig **Type** 6BX

Bolt size 1.750 **No of bolts** 16 **Ring No.** 158 Test Pressure: 15,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 2,377,128 lbf

Force per bolt: 148,570 lbf Bolt Stress: 75,035 psi

With Pikotek Gasket:

Total force to make up connection: 612,118 lbf

Force per bolt: 38,257 lbf Bolt Stress: 19,321 psi

Size 4.06 **Pressure** 20,000 psig **Type** 6BX

Bolt size 1.750 **No of bolts** 8 **Ring No.** 155 Test Pressure: 30,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 852,863 lbf

Force per bolt: 106,607 lbf Bolt Stress: 53,842 psi

With Pikotek Gasket:

Total force to make up connection: 253,106 lbf

Force per bolt: 31,638 lbf Bolt Stress: 15,978 psi

Size 30.00 **Pressure** 3,000 psig **Type** 6BX

Bolt size 1.875 **No of bolts** 32 **Ring No.** 303 Test Pressure: 4,500 psig

With API Ring Gasket:

Total Force at Test Pressure: 4,098,303 lbf

Force per bolt: 128,071 lbf Bolt Stress: 55,586 psi

With Pikotek Gasket:

Total force to make up connection: 1,619,153 lbf

Force per bolt: 50,598 lbf Bolt Stress: 21,961 psi

ANALYSIS OF API 6BX FLANGE BOLT LOADING

Size 16.75 **Pressure** 5,000 psig **Type** 6BX

Bolt size 1.875 **No of bolts** 16 **Ring No.** 162 Test Pressure: 10,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 2,811,107 lbf

Force per bolt: 175,694 lbf Bolt Stress: 76,256 psi

With Pikotek Gasket:

Total force to make up connection: 652,885 lbf

Force per bolt: 40,805 lbf Bolt Stress: 17,710 psi

Size 13.62 **Pressure** 10,000 psig **Type** 6BX

Bolt size 1.875 **No of bolts** 20 **Ring No.** 159 Test Pressure: 15,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 3,481,028 lbf

Force per bolt: 174,051 lbf Bolt Stress: 75,543 psi

With Pikotek Gasket:

Total force to make up connection: 872,685 lbf

Force per bolt: 43,634 lbf Bolt Stress: 18,938 psi

Size 16.75 **Pressure** 10,000 psig **Type** 6BX

Bolt size 1.875 **No of bolts** 24 **Ring No.** 162 Test Pressure: 15,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 4,216,661 lbf

Force per bolt: 175,694 lbf Bolt Stress: 76,256 psi

With Pikotek Gasket:

Total force to make up connection: 1,072,951 lbf

Force per bolt: 44,706 lbf Bolt Stress: 19,403 psi

ANALYSIS OF API 6BX FLANGE BOLT LOADING

Size 9.00 **Pressure** 15,000 psig **Type** 6BX

Bolt size 1.875 **No of bolts** 16 **Ring No.** 157 Test Pressure: 22,500 psig

With API Ring Gasket:

Total Force at Test Pressure: 2,503,140 lbf

Force per bolt: 156,446 lbf Bolt Stress: 67,902 psi

With Pikotek Gasket:

Total force to make up connection: 582,243 lbf

Force per bolt: 36,390 lbf Bolt Stress: 15,794 psi

Size 26.75 **Pressure** 3,000 psig **Type** 6BX

Bolt size 2.000 **No of bolts** 24 **Ring No.** 168 Test Pressure: 4,500 psig

With API Ring Gasket:

Total Force at Test Pressure: 3,304,839 lbf

Force per bolt: 137,701 lbf Bolt Stress: 51,923 psi

With Pikotek Gasket:

Total force to make up connection: 1,386,746 lbf

Force per bolt: 57,781 lbf Bolt Stress: 21,787 psi

Size 18.75 **Pressure** 5,000 psig **Type** 6BX

Bolt size 2.000 **No of bolts** 20 **Ring No.** 163 Test Pressure: 10,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 3,902,562 lbf

Force per bolt: 195,128 lbf Bolt Stress: 73,577 psi

With Pikotek Gasket:

Total force to make up connection: 1,011,301 lbf

Force per bolt: 50,565 lbf Bolt Stress: 19,066 psi

ANALYSIS OF API 6BX FLANGE BOLT LOADING

Size 21.25 **Pressure** 5,000 psig **Type** 6BX

Bolt size 2.000 **No of bolts** 24 **Ring No.** 165 Test Pressure: 10,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 4,915,360 lbf

Force per bolt: 204,806 lbf Bolt Stress: 77,227 psi

With Pikotek Gasket:

Total force to make up connection: 1,224,784 lbf

Force per bolt: 51,032 lbf Bolt Stress: 19,243 psi

Size 11.00 **Pressure** 15,000 psig **Type** 6BX

Bolt size 2.000 **No of bolts** 20 **Ring No.** 158 Test Pressure: 22,500 psig

With API Ring Gasket:

Total Force at Test Pressure: 3,565,693 lbf

Force per bolt: 178,284 lbf Bolt Stress: 67,226 psi

With Pikotek Gasket:

Total force to make up connection: 816,871 lbf

Force per bolt: 40,843 lbf Bolt Stress: 15,401 psi

Size 7.06 **Pressure** 20,000 psig **Type** 6BX

Bolt size 2.000 **No of bolts** 16 **Ring No.** 156 Test Pressure: 30,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 2,186,967 lbf

Force per bolt: 136,685 lbf Bolt Stress: 51,540 psi

With Pikotek Gasket:

Total force to make up connection: 652,101 lbf

Force per bolt: 40,756 lbf Bolt Stress: 15,368 psi

ANALYSIS OF API 6BX FLANGE BOLT LOADING

Size 18.75 **Pressure** 10,000 psig **Type** 6BX

Bolt size 2.250 **No of bolts** 24 **Ring No.** 164 Test Pressure: 15,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 6,179,083 lbf

Force per bolt: 257,461 lbf Bolt Stress: 75,215 psi

With Pikotek Gasket:

Total force to make up connection: 1,705,425 lbf

Force per bolt: 71,059 lbf Bolt Stress: 20,759 psi

Size 13.62 **Pressure** 15,000 psig **Type** 6BX

Bolt size 2.250 **No of bolts** 20 **Ring No.** 159 Test Pressure: 22,500 psig

With API Ring Gasket:

Total Force at Test Pressure: 5,221,543 lbf

Force per bolt: 261,077 lbf Bolt Stress: 76,271 psi

With Pikotek Gasket:

Total force to make up connection: 1,101,070 lbf

Force per bolt: 55,053 lbf Bolt Stress: 16,083 psi

Size 21.25 **Pressure** 10,000 psig **Type** 6BX

Bolt size 2.500 **No of bolts** 24 **Ring No.** 166 Test Pressure: 15,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 7,760,864 lbf

Force per bolt: 323,369 lbf Bolt Stress: 75,342 psi

With Pikotek Gasket:

Total force to make up connection: 2,121,641 lbf

Force per bolt: 88,401 lbf Bolt Stress: 20,596 psi

ANALYSIS OF API 6BX FLANGE BOLT LOADING

Size 9.00 **Pressure** 20,000 psig **Type** 6BX

Bolt size 2.500 **No of bolts** 16 **Ring No.** 157 Test Pressure: 30,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 3,337,520 lbf

Force per bolt: 208,595 lbf Bolt Stress: 48,600 psi

With Pikotek Gasket:

Total force to make up connection: 1,036,191 lbf

Force per bolt: 64,761 lbf Bolt Stress: 15,088 psi

Size 11.00 **Pressure** 20,000 psig **Type** 6BX

Bolt size 2.750 **No of bolts** 16 **Ring No.** 158 Test Pressure: 30,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 4,754,257 lbf

Force per bolt: 297,141 lbf Bolt Stress: 56,501 psi

With Pikotek Gasket:

Total force to make up connection: 1,261,722 lbf

Force per bolt: 78,857 lbf Bolt Stress: 14,994 psi

Size 18.75 **Pressure** 15,000 psig **Type** 6BX

Bolt size 3.000 **No of bolts** 20 **Ring No.** 164 Test Pressure: 22,500 psig

With API Ring Gasket:

Total Force at Test Pressure: 9,268,625 lbf

Force per bolt: 463,431 lbf Bolt Stress: 73,281 psi

With Pikotek Gasket:

Total force to make up connection: 2,034,586 lbf

Force per bolt: 101,729 lbf Bolt Stress: 16,086 psi

ANALYSIS OF API 6BX FLANGE BOLT LOADING

Size 13.62 **Pressure** 20,000 psig **Type** 6BX

Bolt size 3.000 **No of bolts** 20 **Ring No.** 159 Test Pressure: 30,000 psig

With API Ring Gasket:

Total Force at Test Pressure: 6,962,057 lbf

Force per bolt: 348,102 lbf Bolt Stress: 55,044 psi

With Pikotek Gasket:

Total force to make up connection: 1,872,961 lbf

Force per bolt: 93,648 lbf Bolt Stress: 14,808 psi

Flange Shear Strength Calculation

API Dimensions

Flange Size	B =	2.06	in
Pressure	WP =	5000	psi
R–24 PD	P =	3.75	in
Bolt Size	Db =	0.875	in
Root Area	A =	0.419	in^2
No. of Bolts	Nb =	8	
Total Area	Ab =	3.352	in^2

Pikotek Dimensions

Seal OD	Ds =	2.506	in

Calculations for Both Designs

Makeup load at 40 ksi bolt stress	Fb =	134080	lb

API Flange Calculations

Pressure End Load	Fp =	55,223	lb	$.7854 \cdot WP \cdot P^2$
Net Gasket Load	Fg =	78,857	lb	Fb – Fp
Gasket Load/inch	w =	6,694	lb/in	Fg/(3.14 P)
Horizontal comp./side	Hw =	7,885	lb/in	w/2•tan 23°
Shear Load to unseat	Fs =	59,138	lb	2•Hw•P

Pikotek Calculations

Pressure End Load	Fp =	24,662	lb	$.7854 \cdot WP \cdot Ds^2$
Net Gasket Load	Fg =	109,418	lb	Fb – Fp
Coefficient of Friction	f =	0.5		
Shear Capacity	Fs =	54,709	lb	f•Fg