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ASME/ANSI B16.5 FLANGES

WITH PIKOTEK FLOWLOK VCS GASKETS

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1. INTRODUCTION

The electric insulation gasket type for the ASME/ANSI B16.5 flanges of rating classes 900#, 1500# and 2500# as included in the relevant NAM piping classes will be the PIKOTEK FLOWLOK VCS gasket. As lining material of the gaskets is selected the G-10 glass/epoxy laminate and for the bolting sleeves the "Mylar" material is selected.

In this report the mechanical suitability of these gaskets will be determined. All requirements and conditions like materials for flanges and bolts respectively, connecting pipe sizes, bolt tightening procedures etc. from the NAM Piping Classification NSS 12-D-7-00 will be taken into account and, where absolutely necessary, adapted accordingly.

The suitability assessments are made for flanges with RTJ-faces (Ring Type Joints) as presently used by the NAM for these rating classes. However, as the NAM contemplates the use of RF-flanges (Raised Face) in the 900#, 1500# and even the 2500# piping classes, assessments of PIKOTEK VCS gaskets in combination with RF-flanges have been made as well.

2. INTERNAL DESIGN PRESSURES

2.1 Applicable Rating Pressures

The relevant rating pressures of ANSI B16.5 flanges is not affected by the use of PIKOTEK VCS gaskets. After all, these gaskets are designed and dimensioned specifically for use with these ASME/ANSI B16.5 flanges.

In paragraph 2 of ANNEX E of ASME/ANSI B16.5 it is stated that: "Other gaskets, which result in no increase in both loads or flange moments over these resulting form the gaskets included in the respective groups in this Appendix, may be used and warrant the ratings of this Standard...".

From the description of the PIKOTEK VCS gaskets given in paragraph 3.1 one may conclude that the PTFE seals do neither require any bolt load to seat the gasket nor require a compressive joint-contact surface load during operating conditions because the PTFE seals are self-energizing. Both loads as well as flange moment will certainly not be increased by the use of these gaskets.

Hence, the maximum internal design pressure of flanges with PIKOTEK VCS gaskets shall be the ASME/ANSI B16.5 rating pressure for the relevant class, material group and temperature.

2.2 Internal Pressure in combination with External Loads

If external loads act on flange connections with PIKOTEK VCS gaskets then these loads shall be taken into account. For guidance in this matter one is referred to NAM's NSS 12-D-4-05 "Pressure Vessels", paragraph 3.6.2.2, though the rigorous analysis of external loads on flanges shall be performed in accordance with sheet D 0701 from the dutch "Rules for Pressure Vessels". See chapter III of this report.

Note that the recommendations given in paragraph 3.6.2.5 of NSS 12-D-4-05 regarding the selection of ASME/ANSI B16.5 rating classes apply to flanges with PILOTEK VCS gaskets too.

Remark: The way to introduce PIKOTEK VCS gaskets in calculations according to sheet D 0701 - Flange Connections (from the Dutch "Rules for Pressure Vessels") was agreed upon in a meeting held on 23 January 1996 in Rotterdam between Messrs. E.P.W. Boon and T. Muilman, both from Stoomwezen, C.B.A. (= Centrale Beoordelings Afdeling) and C.J. Dekker (Continental Engineering). For a full description how to do that one is referred to par. 3.1 and 3.2.

3. ANALYSIS OF FLANGES WITH PIKOTEK VCS GASKETS

3.1 Description of the PIKOTEK VCS gasket

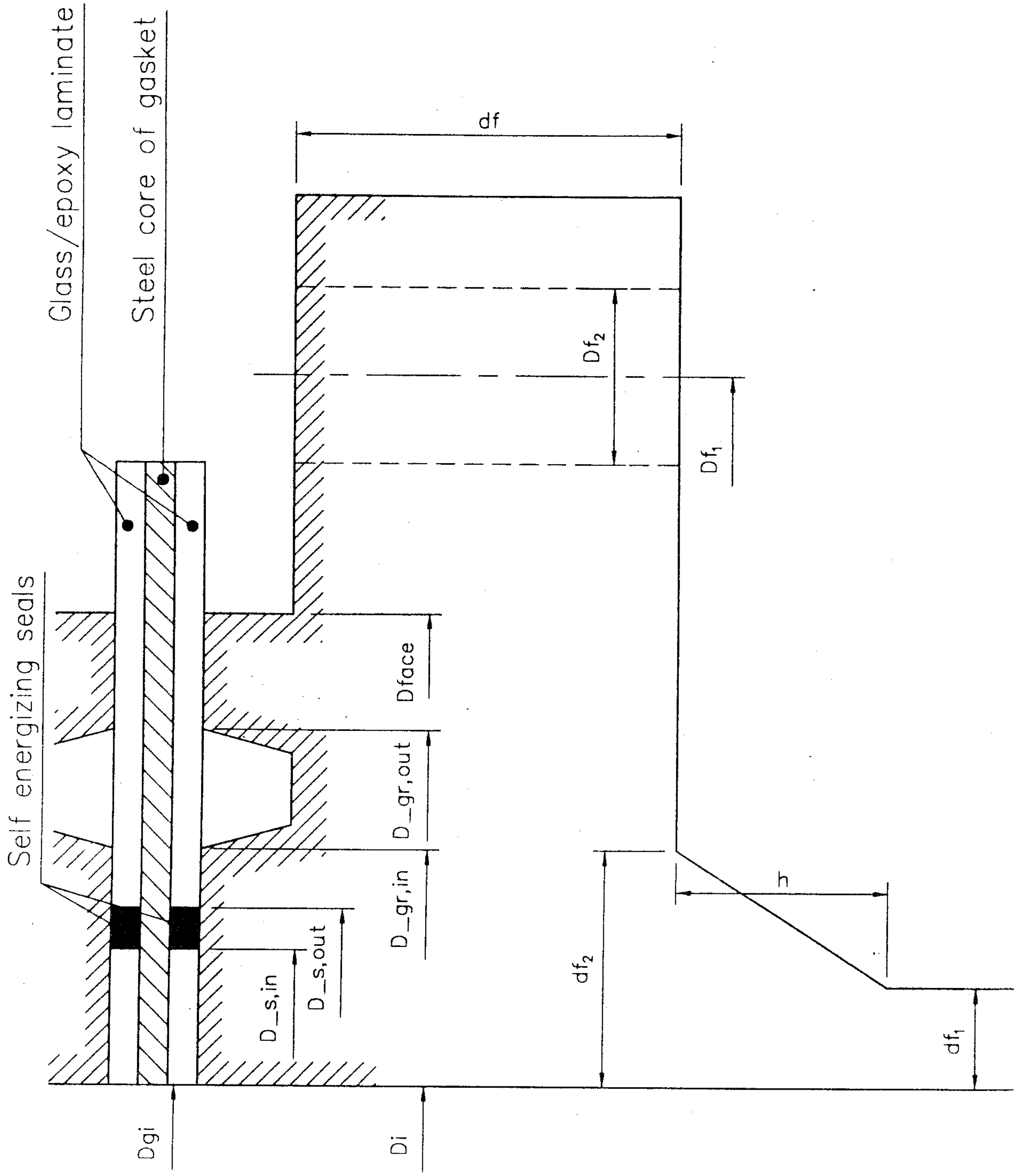
The PIKOTEK VCS gasket consists of a flat metal (stainless steel) plate which is covered at both sides with a glass reinforced expoxy laminate with special physical properties. To prevent any seepage along the strands of the glass fibers embedded in the epoxy, self energizing PTFE seals are placed in grooves machined out in the GRE laminate layers. These grooves reach down into the flat metal plate and break so any seepage as PTFE is impermeable.

These PTFE seals are self-energized and hence require no sealing force for proper functioning. Besides, they could not exercise any pressure of notice on their own as being to flexible in the axial direction. The GRE laminated area in direct contact with the flanges act as nut-stop area and prevent crushing of the PTFE self-energizing seals. If indeed the laminates were pressed hard enough then sealing would take place between the GRE laminates and the flange facings. The PTFE seals become "back-up" sealing devices or secondary seals.

With this in mind the normal flange calculation according to sheet D 0701 of the "Rules" shall be adapted for PIKOTEK VCS flanges as follows:

- The bolt force in the gasket sealing conditions shall be capable to compress the "nut-stop" GRE laminates so much as to achieve sealing between the flange facing and these GRE laminates.
- However, in no circumstance this nut-stop pressure shall become so much as to result in crushing of the GRE laminates.
- In the operating conditions as well as in the (hydrostatic-)testing conditions one may assume the sealing to be performed by the self-energizing PTFE seals.

Figure RTJ–Flange with PIKOTEK VCS Gasket



Area between Di and D_s,in is called nut–stop area 1
Area between D_s,out and D_gr,in is called nut–stop area 2
Area between D_gr,out and Dface is called nut–stop area 3
These three nut–stop areas together form the total nut–stop area

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This can be done most conveniently by using the following gasket data (symbols are conform to sheet D 0701 of the "Rules") :

- D_g the mean diameter of the PTFE self-energizing seals
- b_g a "fictitious" gasket width determined from the requirement that $\pi.D_g.b_g$ equals the total nut-stop area of the PIKOTEK VCS gasket.
- c_g gasket factor for test conditions and operation conditions which is zero for self-energizing seals.
- Pgm; min the minimum pressure to seat the GRE laminates on the flange facing in order to achieve sealing.
- Pgm; max the maximum allowable gasket pressure during seating conditions.
- Pgw; max the maximum allowable gasket pressure during operation conditions.

According the PIKOTEK VCS gasket documentation (see the appendices):

- Pgm; min = 52 MPa (7500 psi)
- Pgm; max = 275 MPa (40,000 psi)
- Pgw; max = 275 MPa at 175°C.

The maximum compressive pressure for the G-10 gasket lining is stated as being 40 000 psi (= 275 MPa) in operating conditions. And being a thermo setting material, the maximum pressure values are the same for 20°C (= seating conditions) as well as for the highest allowable temperature of 175°C (350°F). Note that the compressive strength of the G-10 gasket lining material is given as 80 000 psi in the PIKOTEK brochure. Using a safety factor of 2 one arrives at a maximum gasket pressure value of 275 MPa (40 000 psi) for design purposes.

n.b. The maximum allowable temperature for flange connections with PIKOTEK VCS gaskets is also dependent on the sleeve material and on the insulating washer material. For instance, sleeves made from "Mylar" can be used up to 300°F (= 150°C). However, the maximum temperature as used for the flange assessment calculations will be based on the (higher) temperature as allowed for the PIKOTEK VCS gaskets with sleeves from G-11 material.

3.2 Rigorous Analysis of Internal Pressure and External Load

To show that a flange connection with a PIKOTEK VCS gasket is capable to absorb the external load in combination with the internal pressure, one has to perform a calculation in accordance with sheet D 0701 from the dutch "Rules for Pressure Vessels".
The external load, consisting of a tensile external axial force F_e and an external bending moment M_e, is to be introduced into the calculation conform par. 2.1 of said sheet. Note that any compressive axial force shall not be introduced into the flange assessment as this would mean in effect an alleviation of the force F_1!

The PIKOTEK VCS gasket shall be introduced in the calculation as detailed in the previous paragraph of this report.

All tightening of bolts in the flanges shall be in accordance with section 5 of NAM's NSS 12-D-7-00 "Piping Classification". Bolts in the 900, 1500 and 2500 class flanges will be tightened using either torque wrenches or strain controlled hydraulic bolt tensioning equipment depending on both flange class and bolt size. The resulting stress in the bolts, called in section 5 of NSS 12-D-7-00 either "stress basis" (for torque wrenches) or "associated bolt residual tightening stress", shall be used to calculate the bolt force in gasket seating conditions, i.e. $F_{4m} = n_b * A_{bmin} * \sigma_{bolt}$ with σ_{bolt} above bolt stress.
This bolt force shall be introduced in the D 0701 flange calculation.

However, as torque wrenches do not allow tightening in a controlled way in the sense of par. 2.4 of sheet D 0701, the following provisions shall be made. The underachievement in bolt force ("negative" scatter) shall be set at 30% which is conform the draft standard prEN 1591 (ontwerp NEN-EN 1591, september 1994). Hence, 70% of the calculated F_{4m} ($= n_b * A_{bmin} * \sigma_{bolt}$) shall be at least equal to the F_{3m} value. Though crushing of the GRE laminated nut-stop area of the gasket shall be checked against the full value of the F_{4m} value.

Remarks

- Contrary to prEN 1591, positive scatter, i.e. the actual achieved bolt force being higher than the intended bolt force, need not to be taken into account.
- Hydraulic bolt tensioning equipment shall be assumed to have a negligible scatter conform the implicit assertion in par. 2.4 of D 0701 where in case of controlled tightening F_{4m} equals the aimed for total bolt force. This is inspite of prEN 1591 where scatter values of 20% and 15% are mentioned for hydraulic tensioners.

4. FLANGE ASSESSMENTS

4.1 General

All flanges with PIKOTEK VCS insulating gaskets in the appropriate piping classes of NAM's NSS 12-D-7-00 "Piping Classification" will be assessed here for internal pressure in combination with external loads in accordance with sheet D 0701 from the "Rules for Pressure Vessels" with all the adaptations as described in chapter III of this report.

External loads on the flange connection not being known in the operating conditions, will be approximated according to par. 2.1 of sheet D 0701. Hence, any flange connection for which the actual external load is less than this approximated load, i.e.
$F_e + 4.M_e/D_g \leq 0.25 * \pi * D_i^2 * P_d$ is covered by the following flange assessments. In these instances one could suffice with showing that indeed the actual load is not exceeding the approximated load and to submit for approval by the authorities the relevant flange calculation as included in this report.

The flange assessments proper have been made with Continental Engineering's program E104, revision 5.02, which is fully in agreement with the adapted sheet D 0701 flange calculation as described in chapter 3.

4.2 Numerical Data for Flange Calculations

4.2.1 Design Conditions

The design conditions are per NAM Piping Classification NSS 12-D-7-00 but limited by the maximum temperature of 175°C (= 350°F) as allowed for the PIKOTEK VCS gaskets.

4.2.2 Dimensions

4.2.2.1 Flanges

All dimensions of the welding neck flanges are per ASME/ANSI B16.5.

The inside flange diameter is equal to the corresponding pipe, i.e. the 6" flange in the 15-CS-15 piping class is welded to 6" schedule 160 piping:
I.D. flange = O.D. pipe - 2 * nominal pipe thickness = 131.75 mm.

The height of the conical hub is based on the shortest possible length when the hub has an angle of 45°, see figures 8 and 9 respectively of ASME/ANSI B16.5.

4.2.2.2 Bolts

The cross sectional areas of the bolts are determined in accordance with Section 11 of ANSI B1.1 (1982) for both UNC bolts as well as UN-8 bolts.

4.2.2.3 Gaskets

The PIKOTEK VCS gaskets are assumed to have an inside diameter equal to the inside diameter of the flange diameter. The diameters of the PTFE self-energizing seals as per PIKOTEK's data sheets which are included in the appendices.

n.b. In all instances is the O.D. gasket larger than the outside diameter of either RTJ-faces or raised faces and hence not required for the flange assessment calculations. The effective outside diameter of the gasket is formed by this facing diameter.

4.2.3 Flange materials, stress figures

4.2.3.1 Material ASTM A-105

R_e (20°C) = 250 MPa, source ASTM A-105
R_e (100°C) = 226 MPa, source M0601-Appendix of the "Rules"
R_e (150°C) = 220 MPa, source M0601-Appendix of the "Rules"
R_e (200C) = 214 MPa, source M0601-Appendix of the "Rules"
R_m = 485 MPa, source ASTM A-105

Young's modulus at 20°C: 192 000 MPa.

n.b. Yield stresses at temperature for thicknesses over 100 mm but not exceeding 200 mm, are 10 MPa less than above mentioned values.

4.2.3.2 Material ASTM A-350 grade LF2

As for material A-105 except R_e (200°C) = 213 MPa.

n.b. Yield stresses at temperature for thicknesses over 100 mm but not exceeding 200 mm., are 10 MPa less than mentioned values.

4.2.3.3 Material T.St.E. 355 (DIN Werkstoffnummer 1.0566)

The determining heat treatment thickness of flanges is assumed to be the flange thickness because the relevant flanges can best be considered as a disc.

Flange thickness (in mm)	$t \leq 33$	$33 < t \leq 67$	$67 < t \leq 100$	$100 < t \leq 250$
R_e (20°C)	355	335	315	295
R_e (100°C)	304	294	275	255
R_e (150°C)	284	275	255	235
R_e (200°C)	255	255	235	216
R_m (°C)	490	490	470	470

All stresses in MPa's.

n.b. This material is specified in DIN 17103.

4.2.3.4 Material X 2 CrNiMoN 22 5 (= "Duplex")

This material has "Werkstoff Nummer" (= material identification number) 1.4462 and is specified in "Werkstoffblatt" VdTÜV 418 (= VdTÜV material specification sheet 418).

R_e (20°C) = 450 MPa
R_e (100°C) = 360 MPa
R_e (150°C) = 335 MPa
R_e (200°C) = 310 MPa
R_m = 640 MPa

n.b. In this VdTÜV material specification maximum dimensions are stated for forgings. Although for the larger sizes the flange forgings exceed this limit the same stress figures are applied nevertheless.

4.2.4 Bolting Materials, stress figures

4.2.4.1 Material ASTM A-193 grade B7, $\phi \leq 63.5$ mm

R_e (20°C) = 720 MPa, source ASTM A-193

R_e (100°C) = 470 MPa, source M 0802-Appendix of the "Rules"

R_e (150°C) = 453 MPa, source M 0802-Appendix of the "Rules"

R_e (200°C) = 442 MPa, source M 0802-Appendix of the "Rules"

R_m = 860 MPa, source ASTM A-193

4.2.4.2 Material ASTM A-320 grade L7, $\phi \leq 63.5$ mm

Stress figures for relevant temperatures are exactly the same as for A-193 grade B7 with $\phi \leq 63.5$ mm.

4.2.4.3 Material ASTM A-320 grade L43, 63.5 mm $< \phi \leq$ 101.6 mm

R_e (20°C) = 725 MPa, source ASTM A-320

R_m = 860 MPa, source ASTM A-320

The "Rules" do not provide yield stresses at elevated temperatures in sheet M 0802-Appendix 1. However, table Y-1 of ASME II-D provide yield stresses at elevated temperatures.

R_e (100°C = 212°F) = 98.6 ksi (= 680 MPa)

R_e (150°C = 302°F) = 95.6 ksi (= 659 MPa)

R_e (175°C = 347°F) = 93.9 ksi (= 647 MPa)

Nevertheless for the D 0701 flange assessment calculation we will use the lower stress values for bolting material A-193 grade B7 with 63.5 mm $< \phi \leq$ 101.6 mm.

R_e (20°C) = 655 MPa, source ASTM A-193
R_e (100°C) = 425 MPa, source M 0802-Appendix of the "Rules"
R_e (150°C) = 409 MPa, source M 0802-Appendix of the "Rules"
R_e (200°C) = 399 MPa, source M 0802-Appendix of the "Rules"
R_m = 790 MPa, source ASMT A-193

4.2.4.4 Material ASTM A-193 grade B7M, $\phi \leq$ 63.5 mm

R_e (20°C) = 550 MPa, source ASTM A-193
R_e (100°C) = 357 MPa, source M 0802-Appendix of the "Rules"
R_e (150°C) = 344 MPa, source M 0802-Appendix of the "Rules"
R_e (200°C) = 336 MPa, source M 0802-Appendix of the "Rules"
R_m = 690 MPa, source ASTM A-193

4.2.4.5 Material ASTM A-320 grade L7M, $\phi \leq$ 63.5 mm

Stress figures for relevant temperatures are exactly the same as for A-193 grade B7M with $\phi \leq$ 63.5 mm.

For the 2 $^3/_4$" bolt of A-320 grade L7M as applied in the 2500 class flanges in the sour service, the stress values as applicable to bolts with $\phi \leq$ 63.5 mm will be applied. See information received from bolt manufacturer regarding such bolts, fax included in the appendices.

4.3 Results

4.3.1 The 900# Flange Rating classes

For the following 900# flanges adaptations have to be made with respect to the bolt tightening procedure as described in section 5 of NAM's NSS 12-D-7-00.

flange size	bolt size	stress basis	make-up torque
DN 15	$^3/_4$"	184 MPa	135 N.m
DN 80	$^7/_8$"	340 MPa	399 N.m
DN 200	1 $^3/_8$"	305 MPa	1462 N.m
DN 250	1 $^3/_8$"	305 MPa	1462 N.m
DN 300	1 $^3/_8$"	305 MPa	1462 N.m

Remark

This means that the bolt stress exceeds the 50% yield stress basis for A-193 grade B7M bolts as recommended in API Spec. 6A/NSS 12-D-7-00 issue 6 for both $^7/_8$" bolts as well as for 1 $^3/_8$" bolts. It is not clear if these higher bolt stresses are desirable at all in view of sour service. Besides, the value of 30% negative scatter in achieved bolt force for torque tightened bolts (which necessitates the higher stress basis for $^7/_8$" bolts and 1 $^3/_8$" bolts) is regarded by NAM as being far too pessimistic. If one were to stick to the original 276 MPa stress basis for the $^7/_8$" bolt and the 1 $^3/_8$" bolt then the allowable negative scatter in the achieved bolt force is in all cases 20% or more with exception of the DN 80 900# flange with RTJ-face in the 09-CS-25 class where it is 13%. This made NAM to decide not to adapt the proposed higher stress bases for the $^7/_8$" bolts and the 1 $^3/_8$" bolts with their associated higher make-up torques but instead to stick also for these two bolt sizes to the bolt tightening procedure as described in section 5 of NSS 12-D-7-00 issue 6.

4.3.1.1 Class 09-CS-11 with RTJ-Faces

Calculations have been made for 15 MPa (design pressure at 20°C) in combination with the highest permissible temperature for the gaskets of 175°C. However, for the DN 450 and DN 500 flange sizes calculations for 15 MPa at 20°C, 13.9 MPa at 100°C. 13.5 MPa at 150°C and 13.3 MPa at 175°C had to be made to show compliance. All flanges with PIKOTEK VCS gaskets in this class are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_1-force. (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

4.3.1.2 Class 09-CS-15 with RTJ-Faces.

Note that this class is identical to the 09-CS-11 class except for the bolts which are made in this class from either A-193 grade B7M or A-320 grade L7M.

The same pressure/temperature combination as for class 09-CS-11 have been used to show the suitability of these flanges.

All flanges with PIKOTEK VCS gaskets in this class are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_1-force.

4.3.1.3 Class 09-CS-21 with RTJ-Faces.

This class is identical to the 09-CS-25 class except for the bolting materials. In this class the much stronger bolting materials A-193 grade B7 and A-320 grade L7 will be used.

Hence, the flange assessments made for class 09-CS-25 are applicable for this class as well. One is referred to 4.3.1.4 of this report for the class 09-CS-25 flange assessments.

4.3.1.4 Class 09-CS-25 with RTJ-Faces

The design conditions for this class are:

temperature	-20/50°C	100°C	150°C	175°C
pressure	15 MPa	13.9 MPa	13.5 MPa	13.3 MPa

Flange assessments have been made for 15 MPa at 175°C for all flange sizes except

DN 400: 15 MPa at 20°C and 13.9 MPa at 175°C
DN 450: 15 MPa at 20°C, 13.9 MPa at 100°C and 13.5 MPa at 175°C
DN 500: 15 MPa at 20°C, 13.8 MPa at 100°C, 13.4 MPa at 150°C and 13.2 MPa at 175°C

With exception of the DN 500 flange size all flanges with PIKOTEK VCS gaskets are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_1-force.

Though the DN 500 flange with PIKOTEK VCS is suitable for the specified design conditions, in combination with external loads with $F_e + 4.M/D_g = \pi/4 * D_i^2 *$ pressure, the maximum pressure can be only 99% of the pressures as specified for this class.

n.b. The limitations on the pressure in combination with flange loadings is entirely due to the flange stresses in the operating conditions. The bolting material as such does not set these limitations.

4.3.1.5 Class 09-SS-02 with RTJ-Faces

Calculations have been made for 15.5 MPa (design pressure at 20°C) in combination with the highest permissible temperature of 175°C for the gaskets. All flanges with PIKOTEK VCS gaskets in this class are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_1-force. (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

n.b. Except for the higher design pressure of 25.8 MPa at 20°C in class 15-SS-02, the flange sizes DN 15, DN 20, DN 25 DN 40 and DN 50 in class 09-SS-02 are exactly identical to those in class 15-SS-02. For the assessments of these flanges one is referred to class 15-SS-02.

4.3.1.6 Class 09-CS-11 with Raised Faces

This class is identical to class 09-CS-15 except for the bolts which are made from the stronger bolt materials A-193 grade B7 and A-320 grade L7 respectively.

Hence, the flange assessments made for class 09-CS-15 are applicable to this class as well. One is referred to 4.3.1.6 of this report for the class 09-CS-15 flange assessments.

4.3.1.7 Class 09-CS-15 with Raised Faces

Calculations have been made for 15 MPa (design pressure at 20°C) in combination with the highest permissible temperature of 175°C for the PIKOTEK VCS gaskets. However, for the DN 450 and DN 500 flange sizes calculations for 15 MPa at 20°C, 13.9 MPa at 100°C. 13.5 MPa at 150°C and 13.3 MPa at 175°C had to be made to show compliance. All flanges with PIKOTEK VCS gaskets in this class are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_1-force.
(i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

4.3.1.8 Class 09-CS-21 with Raised Faces

This class is identical to class 09-CS-25 except for the bolts which are made here from the stronger bolt materials A-193 grade B7 and A-320 grade L7 respectively.

Hence, the flange assessments made for class 09-CS-25 are applicable to this class as well. One is referred to 4.3.1.8 of this report for the class 09-CS-25 flange assessments.

4.3.1.9 Class 09-CS-25 with Raised Faces

The design conditions for this class are:

temperature	-20/50°C	100°C	150°C	175°C
pressure	15 MPa	13.9 MPa	13.5 MPa	13.3 MPa

Flange assessments have been made for 15 MPa at 175°C for all flange sizes except

DN 400: 15 MPa at 20°C and 13.9 MPa at 175°C
DN 450: 15 MPa at 20°C, 13.9 MPa at 100°C and 13.5 MPa at 175°C
DN 500: 15 MPa at 20°C, 13.8 MPa at 100°C, 13.4 MPa at 150°C and 13.2 MPa at 175°C

With exception of the DN 500 flange size all flanges with PIKOTEK VCS gaskets are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_1-force.

Though the DN 500 flange with PIKOTEK VCS is suitable for the specified design conditions, in combination with external loads with $F_e + 4.M/D_g = \pi/4 * D_i^2 *$ pressure, the maximum pressure can be only 99% of the pressures as specified for this class.

n.b. The limitations on the pressure in combination with flange loadings is entirely due to the flange stresses in the operating conditions. The bolting material as such does not set these limitations.

4.3.1.10 Class 09-SS-02 with Raised Faces

Calculations have been made for 15.5 MPa (design pressure at 20°C) in combination with the highest permissible temperature of 175°C for the gaskets. All flanges with PIKOTEK VCS gaskets in this class are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_1-force. (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

n.b. Except for the higher design pressure of 25.8 MPa at 20°C in class 15-SS-02, the flange sizes DN 15, DN 20, DN 25 DN 40 and DN 50 in class 09-SS-02 are exactly identical to those in class 15-SS-02. For the flange assessments of these flange assessments one is referred to class 15-SS-02.

4.3.2 The 1500# Flange Rating Classes

One adaptation has to be made with respect to the bolt tightening procedure as described in section 5 of NAM's NSS 12-D-7-00.

flange size	bolt size	stress basis	make-up torque
DN 15	$^3/_4$"	184 MPa	135 N.m

n.b. This adaptation has already been mentioned under the 900# flange rating classes as flange size DN 15 with rating class 900# is really a rating class 1500# flange.

4.3.2.1 Class 15-CS-11 with RTJ-Faces

This class is identical to class 15-CS-15 except for the bolts which are made from the stronger bolt materials A-193 grade B7 and A-320 grade L7 respectively.

Hence, the flange assessments made for class 15-CS-15 are applicable to this class as well. One is referred to 4.3.2.2 of this report for the class 15-CS-15 flange assessments.

4.3.2.2 Class 15-CS-15 with RTJ-Faces

Calculations have been made for 25 MPa (design stress at 20°C) in combination with the highest permissible temperature of 175°C for the gaskets. All flanges with PIKOTEK VCS gaskets in this class are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_1-force (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

4.3.2.3 Class 15-CS-21 with RTJ-Faces

Calculations for 25 MPa (design pressure at 20°C) in combination with the highest permissible temparature of 175°C show that all flanges with PIKOTEK VCS gaskets are suitable for the specified design conditions up to 175°C wherby external loads on the flange connections are approximated by doubling the F_1-force
(i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

4.3.2.4 Class 15-SS-02 with RTJ-Faces

Calculations have been made for 25.8 MPa (design pressure at 20°C) in combination with the highest permissible temparature of 175°C for the gaskets. All flanges with PIKOTEK VCS gaskets in this class are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_1-force (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

4.3.2.5 Class 15-CS-11 with Raised Faces

This class is identical to class 15-CS-15 except for the bolts which are made from the stronger bolt materials A-193 grade B7 and A-320 grade L7 respectively.

Hence, the flange assessments made for class 15-CS-15 are applicable to this class as well. One is referred to 4.3.2.5 of this report for the class 15-CS-15 flange assessments.

4.3.2.6 Class 15-CS-15 with Raised Faces

Calculations have been made for 25 MPa (design stress at 20°C) in combination with the highest permissible temperature of 175°C for the gaskets. All flanges with PIKOTEK VCS gaskets in this class are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_1-force (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

4.3.2.7 Class 15-CS-21 with Raised Faces

Calculations for 25 MPa (design pressure at 20°C) in combination with the highest permissible temparature of 175°C show that all flanges with PIKOTEK VCS gaskets are suitable for the specified design conditions up to 175°C wherby external loads on the flange connections are approximated by doubling the F_1-force
(i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

4.3.2.8 Class 15-SS-02 with Raised Faces

Calculations have been made for 25.8 MPa (design pressure at 20°C) in combination with the highest permissible temparature of 175°C for the gaskets. All flanges with PIKOTEK VCS gaskets in this class are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_1-force (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

4.3.3 The 2500# Flange Rating Classes

In order to prevent crushing of the PIKOTEK VCS gaskets in the DN 15 ($^1/_2$") Raised Face flanges in the 2500# rating classes the tightening procedure given in section 5 of NAM's NSS 12-D-7-00 is to be adapted as follows:

flange size	bolt size	stress basis	make-up torque
DN 15	$^3/_4$"	184 MPa	135 N.m

4.3.3.1 Class 25-CS-11 with RTJ-Faces

Calculations have been made with 41.7 MPa (design pressure at 20°C) for flange sizes up to and including DN 150 (=6 inch) and with 31.9 MPa (design pressure at 20°C) for flange sizes DN 200 and beyond at the highest permissible temperature of 175°C for the gaskets.

All flanges with PIKOTEK VCS gaskets in this class are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_I-force (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

4.3.3.2 Class 25-CS-15 with RTJ-Faces

Calculations for 41.7 MPa (design pressure at 20°C) in combination with the highest permissible temperature of 175°C for the gaskets show that all flanges with PIKOTEK VCS gaskets are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_I-force (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

4.3.3.3 Class 25-CS-21 with RTJ-Faces

Calculations for 41.7 MPa (design pressure at 20°C) in combination with the highest permissible temperature of 175°C for the gaskets show that all flanges with PIKOTEK VCS gaskets are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the
F_1-force (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

4.3.3.4 Class 25-FG-11 with RTJ-Faces

Calculations for 41.7 MPa (design pressure at 20°C) in combination with the highest permissible temperature of 175°C for the gaskets show that all flanges with PIKOTEK VCS gaskets are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the
F_1-force (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

4.3.3.5 Class 25-SS-02 with RTJ-Faces

Calculations for 43.1 MPa (design pressure at 20°C) in combination with the highest permissible temperature of 175°C for the gaskets show that all flanges with PIKOTEK VCS gaskets are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the
F_1-force (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

4.3.3.6 Class 25-CS-11 with Raised Faces

Calculations have been made with 41.7 MPa (design pressure at 20°C) for flange sizes up to and including DN 150 (=6 inch) and with 31.9 MPa (design pressure at 20°C) for flange sizes DN 200 and beyond at the highest permissible temperature of 175°C for the gaskets.

All flanges with PIKOTEK VCS gaskets in this class are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_l-force (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

Note that the $^3/_4$" bolts in the DN 15 ($^1/_2$") flange size have a stress basis of 184 MPa. The corresponding make-up torque is only 135 N.m.

4.3.3.7 Class 25-CS-15 with Raised Faces

Calculations for 41.7 MPa (design pressure at 20°C) in combination with the highest permissible temperature of 175°C for the gaskets show that all flanges with PIKOTEK VCS gaskets are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_l-force (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

Note that the $^3/_4$" bolts in the DN 15 ($^1/_2$") flange size have a stress basis of 184 MPa. The corresponding make-up torque is only 135 N.m.

4.3.3.8 Class 25-CS-21 with Raised Faces

Calculations for 41.7 MPa (design pressure at 20°C) in combination with the highest permissible temperature of 175°C for the gaskets show that all flanges with PIKOTEK VCS gaskets are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_l-force (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

4.3.3.9 Class 25-FG-11 with Raised Faces

Calculations for 41.7 MPa (design pressure at 20°C) in combination with the highest permissible temperature of 175°C for the gaskets show that all flanges with PIKOTEK VCS gaskets are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_1-force (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

4.3.3.10 Class 25-SS-02 with Raised Faces

Calculations for 43.1 MPa (design pressure at 20°C) in combination with the highest permissible temperature of 175°C for the gaskets show that all flanges with PIKOTEK VCS gaskets are suitable for the specified design conditions up to 175°C whereby external loads on the flange connections are approximated by doubling the F_1-force (i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 * P_d$).

n.b. The future inclusion of the 12" flange size in this class is anticipated by including already a flange assessment for this size. The wall thickness of the connecting 12" pipe is assumed to be 30 mm.

5. CONCLUSIONS

With exception of the DN 500 flange size in the 900# rating classes all flanges with PIKOTEK VCS gaskets in the relevant NAM piping classes are suitable for the specified design conditions whereby external loads on flange connections are included in the approximate method as described in par. 2.1 of sheet D 0701 from the "Rules",
i.e. $F_e + 4.M_e/D_g \leq \pi/4 * D_i^2 *$ pressure. This applies to flanges with RTJ-faces as well as to flanges with raised faces.

The DN 500 flange size in the 900# rating classes (for RTJ-faces and raised faces) are suitable for only 99% of the specified design pressure if external loads are included in the approximate method. In case there is no external load then they are suitable, of course, for the full design pressure as specified in these classes.

From a practical viewpoint it is quite possible to ignore this 1% underachievement on the rating pressure in combination with external loads as these external loads have been estimated only in a rough-and-ready way by doubling the F_1-force. If there is reason to believe that the actual external load is more than this estimate then one really should perform a pipe stress analysis to find the actual load and check the flange for that load per paragraph 2.2 of this report.

However, the following adaptations to the bolt tightening procedure given in section 5 of NAM's NSS 12-D-7-00 are to be made in order to allow in all cases a negative scatter of 30% in bolt force.

Flange rating class	Flange size	Bolt size	Basic bolt stress, in MPa	Make-up torque in N.m	Notes
900	DN 15	$^{3}/_{4}$"	184	135	1,3
900	DN 80	$^{7}/_{8}$"	340	399	4
900	DN 200	1 $^{3}/_{8}$"	305	1462	4
900	DN 250	1 $^{3}/_{8}$"	305	1462	4
900	DN 300	1 $^{3}/_{8}$"	305	1462	4
1500	DN 15	$^{3}/_{4}$"	184	135	3
2500	DN 15	$^{3}/_{4}$"	184	135	2,3

Notes

1 - The DN 15 class 900 flange is identical to the DN 15 class 1500 flange, see ASME/ANSI B16.5.

2 - Only mandatory for the raised face flange. The bolts in the RTJ-faced flange may also be tightened with a basic stress of 276 MPa and the corresponding make-up torque of 203 N.m.

3 - Basic bolt stress lowered to stated value to prevent crushing of the GRE laminates of the gaskets.

4 - Basic bolts stress increased to stated values to achieve sealing at the GRE laminated gasket surfaces too, even at the maximum underachievement of 30% of the bolt force due to tightening with torque wrenches.

Attention is drawn to the remark in paragraph 4.3.1 concerning these adaptations, NAM has decided not to follow the recommended adaptations for the $^{7}/_{8}$" bolt size and the 1 $^{3}/_{8}$" bolt size.

APPENDIX A - PIKOTEK VCS Gaskets

This appendix contains:

- fax from ERIKS B.V. - Alkmaar, the dutch representative of PIKOTEK, with dimensions of these gaskets.
  Note that the mentioned inside gasket diameters are for information only and that these diameter will be adapted to customer's requirements. The gaskets can be and will be flush with the insides of the flanges for all NAM applications.

- fax from ERIKS B.V. - Alkmaar concerning the gasket seating pressures, i.e. minimum value to obtain sealing at the GRE laminates and the maximum value to prevent crushing of these GRE laminates.

- partly in black-and-white reproduced PIKOTEK brochure with, among other things, information on the maximum allowable continuous temperature for the G-10 glass/epoxy lining laminates and the G-11 sleeve materials

FOR TEFLON SEALS - STANDARD ANSI B16.5 FLANGES

Size	A OD of Gasket	C OD of Seal Groove	E Width of Seal Groove	B Gasket ID
		2500# CATEGORY		
1/2"	2.675	1.090	.120	.50
3/4"	2.925	1.235	.120	.70
1"	3.300	1.443	.120	1.00
1-1/4"	4.050	1.630	.120	1.25
1-1/2"	4.550	2.005	.120	1.50
2"	5.625	2.506	.120	2.00
2-1/2"	6.500	3.068	.120	2.50
3"	7.625	3.693	.120	3.00
4"	9.125	4.943	.120	4.00
5"	10.875	5.693	.120	5.00
6"	12.375	7.004	.150	6.00
8"	15.125	9.012	.150	8.00
10"	18.625	11.262	.150	10.00
12"	21.500	13.262	.150	12.00

Sheet 1 of 3

ERIKS telefax */telex

ERIKS BV
P.O.B. 280, 1800 BK ALKMAAR, Holland
Telefax (+31)72-155645 Telex 57151

Date: 23-1-96

Contact: Frans Nelissen

Direct extension : (+31)72-141 304 (invullen)

To: Continental eng. BV
A'dam

Attn: tav h. I. C.J. Dekker

Geachte h. Dekker.

Zoals afgesproken vind u bijgesloten de informatie van Pikotek.

Deze gegevens bevestigen uw gedachten.

Mocht u nog vragen hebben over dit onderwerp dan kunt u kontakt opnemen met mijn collega de h. D. Pronk, aangezien ik over twee dagen naar Duitsland ben.

met vr. groet. Frans. Nelissen.

* doorhalen indien telex van toepassing is ** invullen

datumstempel

pikotek
engineering solutions today for tomorrow's problems

Fax Transmission

12980 West Cedar Drive • Lakewood, CO 80228 • USA

To: Franz Nielson ? Nelissen.
Company: Eriks b.v.
Phone:
Fax: 011-31-72-155645

From: Thomas C. Wallace
Company: Pikotek U.S.A.
Phone: 1-303-988-1242
Fax: 1-303-988-1922

Date: 01/22/96
Page(s): 2 + 1

Franz:

I am responding to a telephone conversation that you had earlier today with Mike Gauthe.

First of all, I must apologize for the confusion. Some of the technical information in our composite catalogue is relatively outdated and needs to be updated. However, with respect to the special note in section D, item 2 in the TECHNICAL SPECIFICATIONS section of the catalogue, the stated maximum compressive stress not to exceed 25,000 PSI is realistically too low. The bolt stress calculations that we currently use (see VCS Gasket User's Manual) assumes a "gasket failure load" of 40,000 PSI. Never, should the gasket ever see either of these two figures under normal operating parameters. But for official purposes (i.e. Continental Engineering), the maximum compressive stress to be applied to the Pikotek VCS and PGE gaskets is the 40,000 PSI figure. This is not to be confused with the maximum compressive strength of the G-10/11 material which the manufacturer states as 60,000 PSI (G-11) and 75,000 PSI (G-10) because this figure does not take into account the fact that the composite retainer material is bonded to a metal core material. The total compressive strength of the VCS gasket is therefore limited to the shear strength of the bond between the composite and the metal core material. Obviously, the stated compressive strength of G-10/11 by itself depends on which manufacturer you are talking/referring to.

Furthermore, the design stress is actually 7,500 PSI but for the ASME code calculations, we use 12,500 PSI to be conservative. That is where this figure comes from in section D, item 2 in the composite catalogue.

Therefore in summary, what the NAM/Shell should be using is a total maximum compressive strength of 40,000 PSI for the VCS and PGE gaskets (the gasket failure load which in all cases exceeds 50% of the stud bolt yield strength) and a gasket design stress of 7,500 PSI minimum for successful flange makeup. This is consistent with all of our current literature and testing. The ASME code calculations should use an M factor of 0 and a Y factor of 12,500 PSI. I believe that this is consistent with everything that I have told Dik Pronk.

If you need further clarification, please contact me directly.

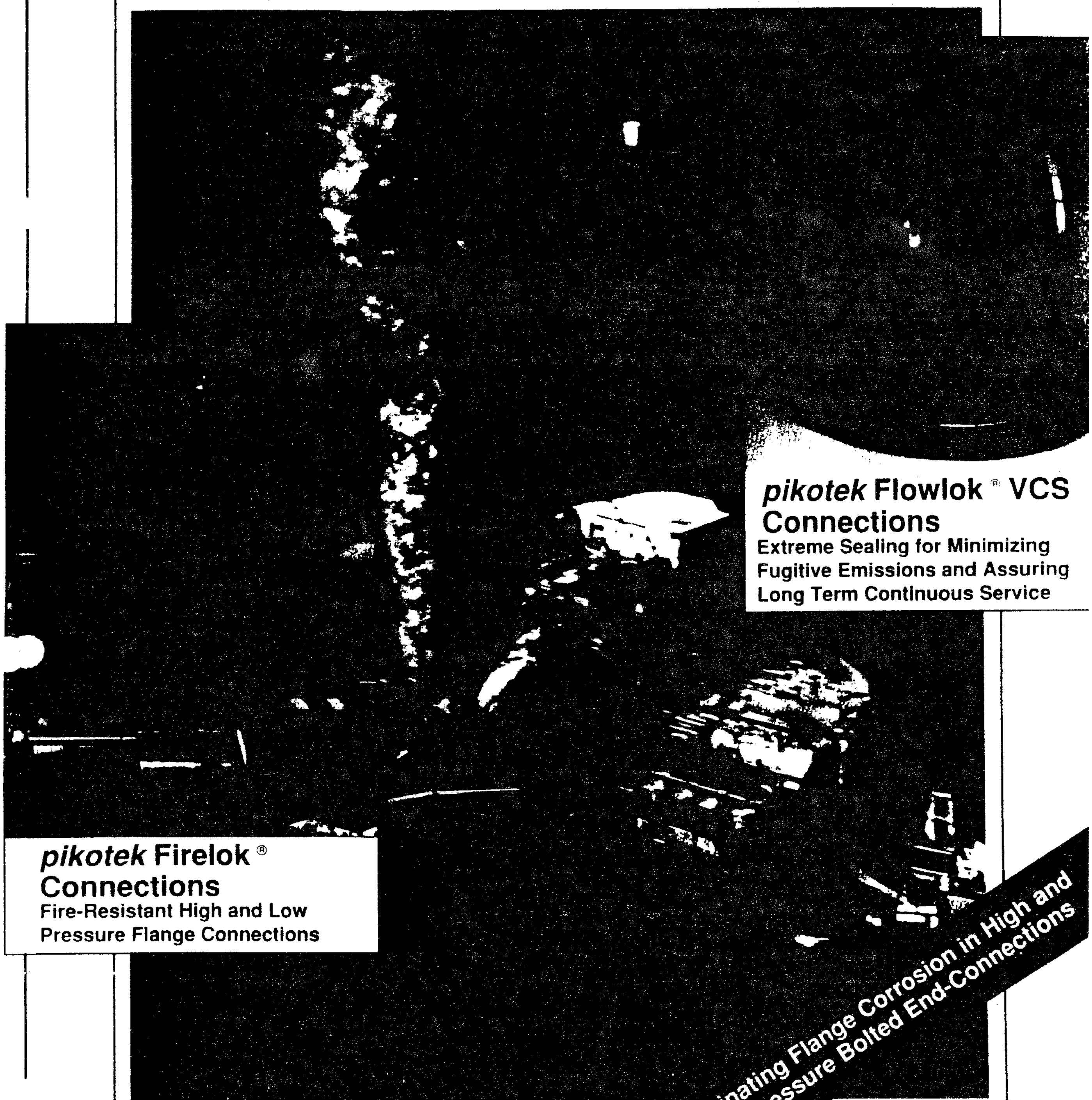
Sincerely,

Thomas C. Wallace

cc: Sam Dornan

pikotek® Flowlok®/Firelok® Flange Connections

Inoculation Against Downtime and the Proven Alternative to Conventional Flange Gaskets in Critical Service Applications



pikotek Flowlok® VCS Connections

Extreme Sealing for Minimizing Fugitive Emissions and Assuring Long Term Continuous Service

pikotek Firelok® Connections

Fire-Resistant High and Low Pressure Flange Connections

Eliminating Flange Corrosion in High and Low Pressure Bolted End-Connections

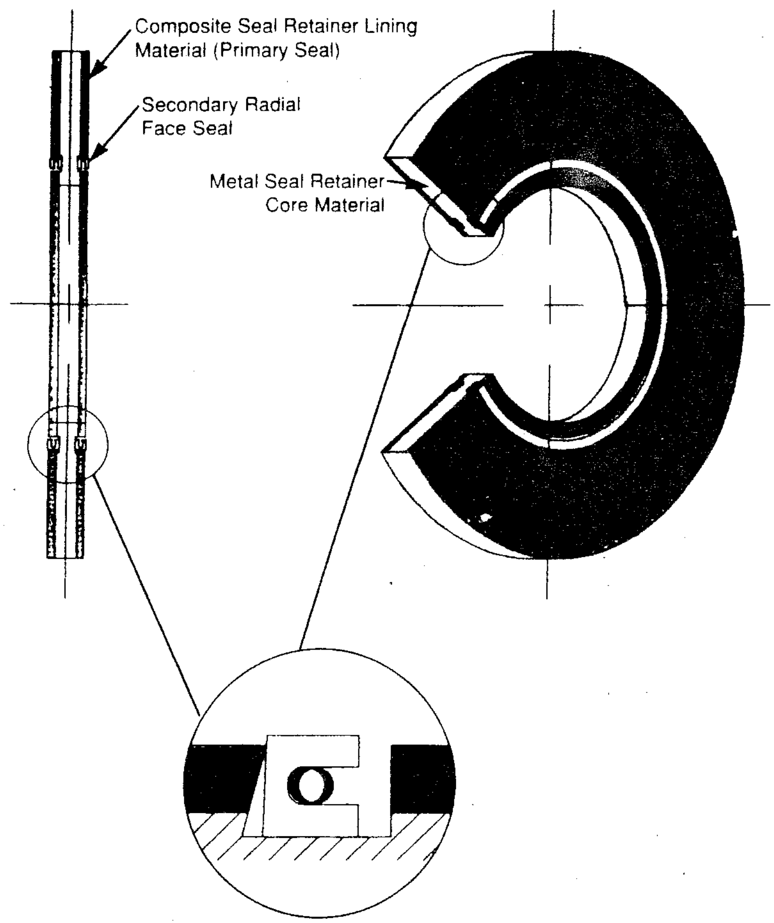
Photograph compliments of BOOTS & COOTS

Flowlok /Firelok CONNECTIONS

Pikotek is the industry leader in corrosion resistant critical service flange connections. For over ten years, the ***pikotek*** VCS has become synonymous with long term critical service flange sealing because of its ability to eliminate the forces of corrosion in high pressure, high temperature fluid/gas sealing applications. With over 80,000 VCS flange gaskets now in service, both on and offshore, there has never been a known failure of any kind. **NOT ONE!**

Now ***pikotek*** introduces a revolutionary new gasket design that greatly reduces sustained media loss (fugitive emissions) through bolted flange connections while also minimizing the risk of substantial gas or fluid loss in the event of fire/flame impingement. Both the ***pikotek*** Flowlok and Firelok flange connections exhibit excellent flange sealing characteristics that are derived from the same technological innovation found in the ***pikotek*** VCS (Very Critical Service) flange gasket. This gives the Flowlok and Firelok excellent sealing capabilities in all normal and abnormal operating conditions.

pikotek Flowlok® VCS



Spring Energized Teflon® Seal

U.S. Patent Number 4,776,600
Other Patents pending

Pikotek Flowlok flange connections are designed to minimize fugitive emissions in bolted end-connections through the use of a patented dual seal design that "locks" in the media and improves flange sealability when compared to conventional flange gasket technology even in connections with imperfect flange faces.

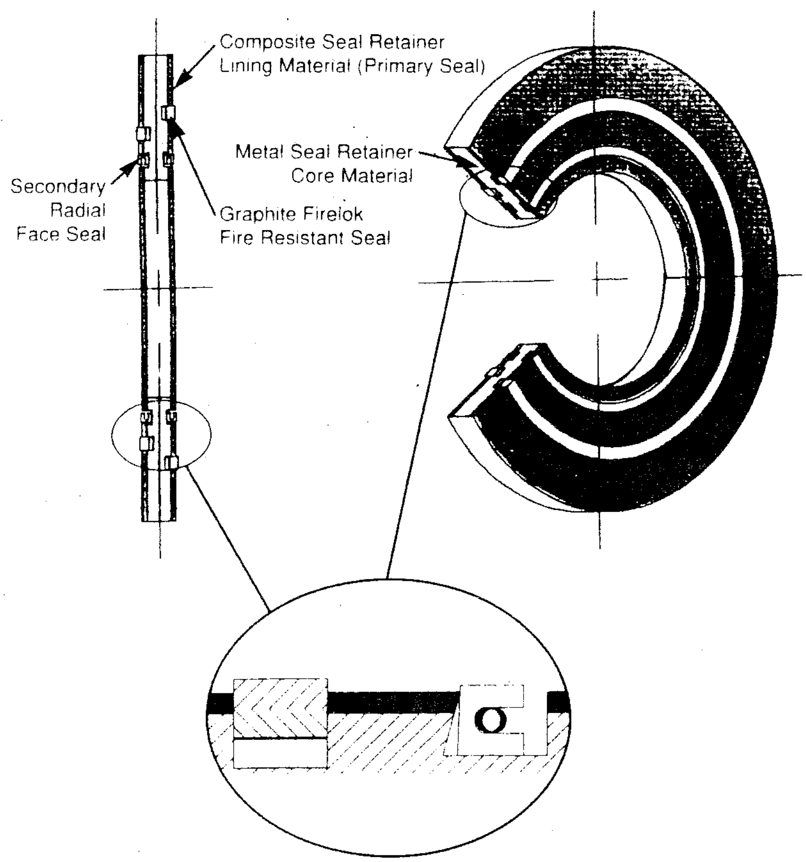
The Flowlok is composed of essentially two independent sealing components, a high modulus composite-lined structural seal retainer and a secondary pressure-energized radial face seal. The primary sealing element is the composite seal retainer lining material located outside of the secondary radial face seal.

Flowlok /Firelok CONNECTIONS

The gasket lining material is composed of a structurally rigid, yet superficially compressible material such as a glass-reinforced polymer (glass-reinforced epoxy, silicon, melamine or polyimid) or other non-asbestos, high-temperature polymer material which can then be coated with either Buna N rubber or chemical resistant neoprene. This material possesses good compressive strength while also providing a positive seal. The result is sealability without material deformation. The secondary face seal material is the key to fugitive emission minimization. The standard seal is a helical wound spring-energized Teflon lip seal. For nonstandard applications, Teflon can be substituted with a wide range of other superior elastomeric and non-elastomeric face seal materials (see section on Seal Materials).

The ***pikotek*** Flowlok is designed for use in all ANSI and API class flanges including ring-joint (RTJ), raised-face, and flatface (or combination) flanges. This means that the Flowlok can be used to mate dissimilar flange types as well.

pikotek Firelok® VCS



Spring Energized Teflon® Seal with Graphite Firelok Fire Resistant Seal

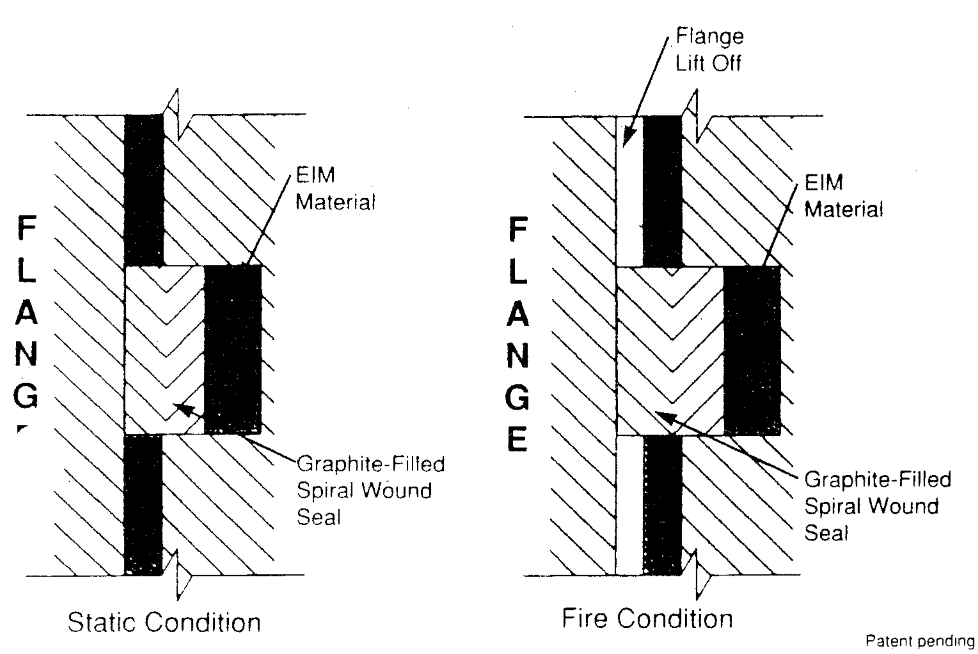
Patent pending

The ***pikotek*** Firelok flange connection offers all of the features and benefits of the Flowlok with the added feature of a patented fire-resistant "piston" seal which is designed to capture the media in the event of ultra-high temperature (hydrocarbon) flame impingement such as would be present in a runaway hydrocarbon fire.

The ***pikotek*** Firelok connection has passed the API 6 FB destructive fire test for bolted end-connections (2,000 degrees F for 30 minute duration). What makes the ***pikotek*** Firelok connection able to withstand the destructive forces of 2,000 degree hydrocarbon flame impingement? The key to its revolutionary fire resistance is in the design of its secondary high temperature seals.

In an actual hydrocarbon fire, any gasket or seal's ability to withstand flame/ temperature is only part of the problem. The bigger problem is metal fatigue which leads to stud bolt elongation which directly translates into connection relaxation and sealing failure. In other words, the presence of extreme temperature and the metal stud bolt's relatively high coefficient of thermal expansion leads to bolt elongation and a resulting and substantial loss in bolt tension (as much as 1/32 inch measurable elongation with B7 carbon steel stud bolts). This also applies to tempered alloy metal stud bolts, however, to a lesser extent depending on the relative coefficient of thermal expansion and the metal's ability to retain tensile strength. The result with conventional gaskets and seals (no matter how fire-resistant the material) is connection failure **WHICH CAN ACTUALLY FEED AND PERPETUATE THE SPREAD OF A RUNAWAY HYDROCARBON FIRE!**

Flowlok®/Firelok® CONNECTIONS



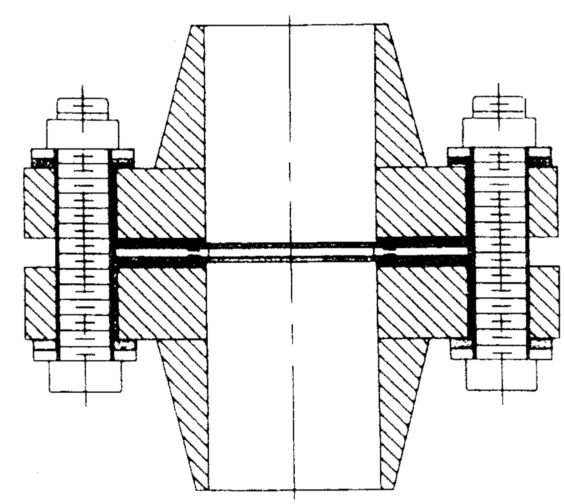
Designed to combat leakage due to metal fatigue and stud bolt elongation, the patented Firelok piston seal actually activates and "energizes" at temperature (approximately 700 degrees F) and thereby releasing a tremendous amount of deflective energy (approximately 1,200 PSI) which serves to increase unit loading on the sealing element or "live load" the seal and actually offset the effects of stud bolt relaxation.

The media sealing material is comprised of a reinforced and encapsulated high density (compressed) flexible graphite core which, when loaded, provides excellent sealing characteristics and can withstand extreme temperature environments including the heat encountered in a hydrocarbon fire.

The ***pikotek*** Firelok connection incorporates a patented new secondary seal design that actually becomes a temperature activated hydraulic piston seal when subjected to fire/flame impingement.

The ***pikotek*** piston seal uses a temperature catalyzed base material called EIM which actually "live loads" the seal by releasing hydraulic energy and forcing the graphite seals to maintain high-pressure intimate surface contact (unit loading) with the flange face- **EVEN IN THE PRESENCE OF BOLT RELAXATION AND FLANGE SEPARATION!** The result is a significantly enhanced ability to contain system pressure and system media during a runaway hydrocarbon fire.

The ***pikotek*** Flowlok and Firelok connections can also be made to electrically insulate (with insulating sleeves and washers) when intended for use in conjunction with cathodic protection. Insulating sleeves and washers are constructed of the same advanced polymer materials used to make up the seal retainer (see Materials section).



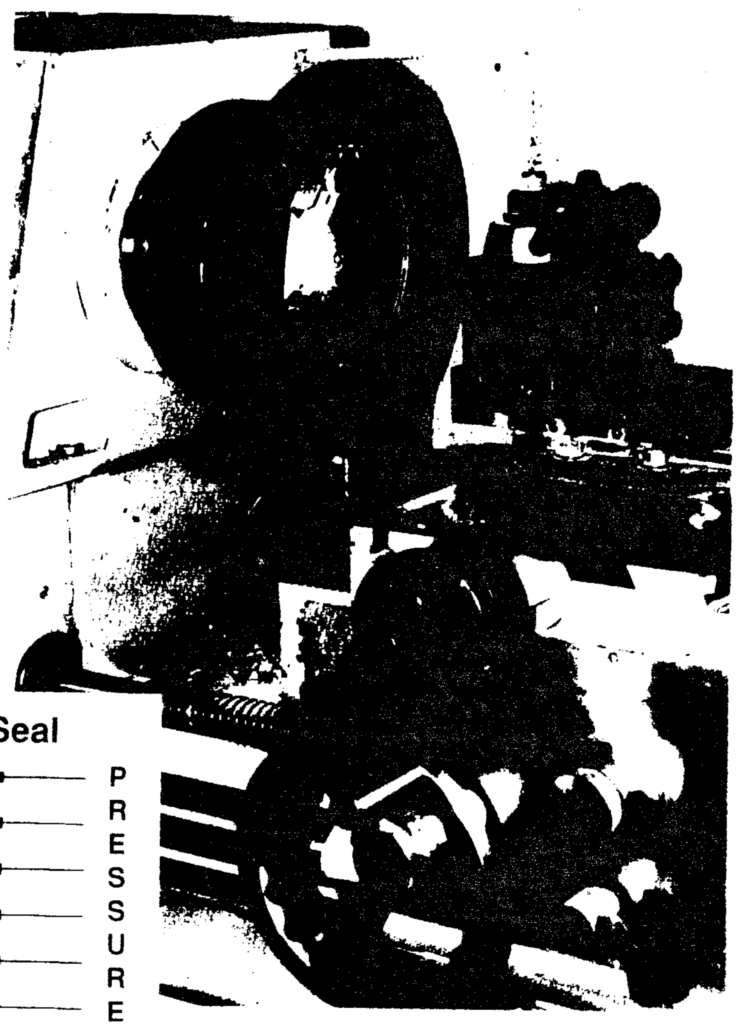
pikotek Flowlok VCS used as an electrical insulating flange gasket (with insulating sleeves and washers)

Flowlok /Firelok CONNECTIONS

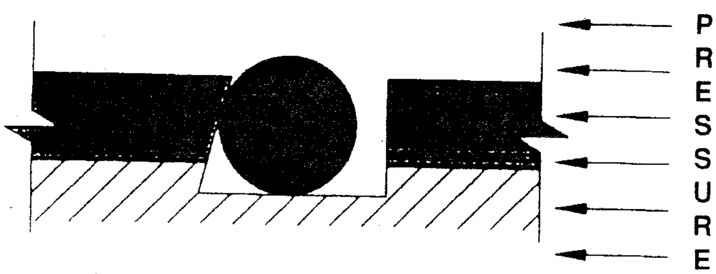
The ***pikotek*** Flowlok/Firelok seal retainer is comprised of two component materials which are then permanently bonded together using a patented method that produces a very high strength bond that allows the two dissimilar materials to thermally expand and contract relative to one another. The core material is designed to be a highly structural metal alloy cross-member that is both corrosion and temperature resistant and provides the "backbone" for the rigid seal retainer. A high density matrix glass or Kevlar reinforced composite liner material is then permanently bonded using the Pykote laminating process. This patented process uses state-of-the-art resin compounds that exhibit excellent substrate bonding properties as measured by shear strength and peel strength in addition to a relatively high modulus of elasticity. This means that not only is the bonding permanently strong, but it also allows for differentials in coefficients of thermal expansion between the core material and lining material (substrates). Consequently, the sustainable operating temperature range for the various retainers using an endless combination of materials is greatly enhanced.

The key to the Flowlok and Firelok's ability to seal at ultra high system pressures is inherent in the secondary seal design. This seal is totally encapsulated in a patented dove tail shaped seal groove design that eliminates the risk of extrusion or seal "roll out" while firmly "anchoring" the seal into the metal retainer core. By anchoring the seal into the core material, all layered composite material outside of the seal is completely sealed off from system pressure and media which can otherwise "wick" or "migrate" through the laminated material. The result is that the retainer lining material which serves as the primary seal is forever protected from contained (system) media contamination.

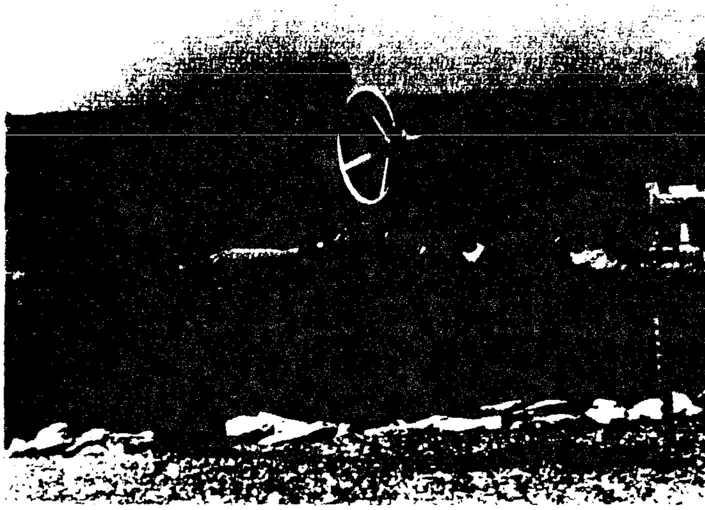
For applications involving relatively high concentrations of extremely aggressive media (i.e. H_2S, high temperature CO_2 or caustic chemicals), it is recommended to either use a suitably corrosion resistant alloy seal retainer core material (see Materials section) or to fully encapsulate the fluid surface I.D. with a suitably corrosion resistant coating material. This latter process entails machining out the exposed metal on the retainer I.D. and backfilling with the coating material (typically a chemical resistant polymer epoxy coating material).

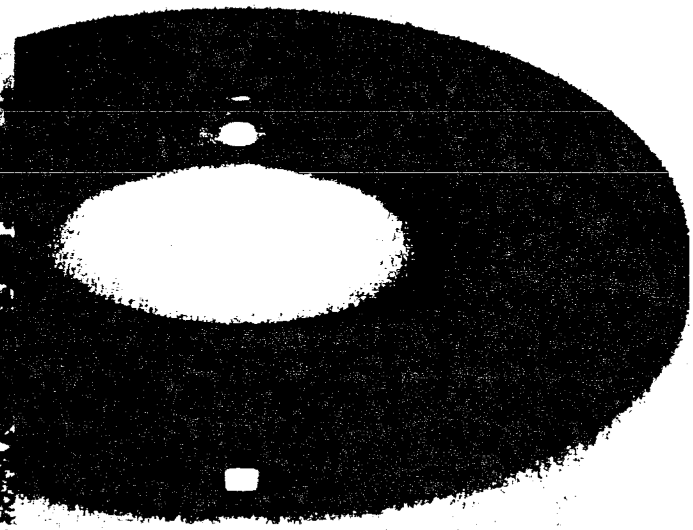


Pressure Energized Secondary Seal



Flowlok VCS with O-ring Seal





316 SS and G - 11 Retainer/Viton GLT O-ring Seal

FLOWLOK/FIRELOK SEAL RETAINER CORE MATERIALS

	Chromium%	Nickel%	Hardness (Brinell)
304 Stainless Steel	18 - 20	8 - 10	180
316 Stainless Steel	16 - 18	10 - 14	200
2205 Duplex	21 - 23	4.5 - 6.5	225
Inconel 625	21	61	145 - 240

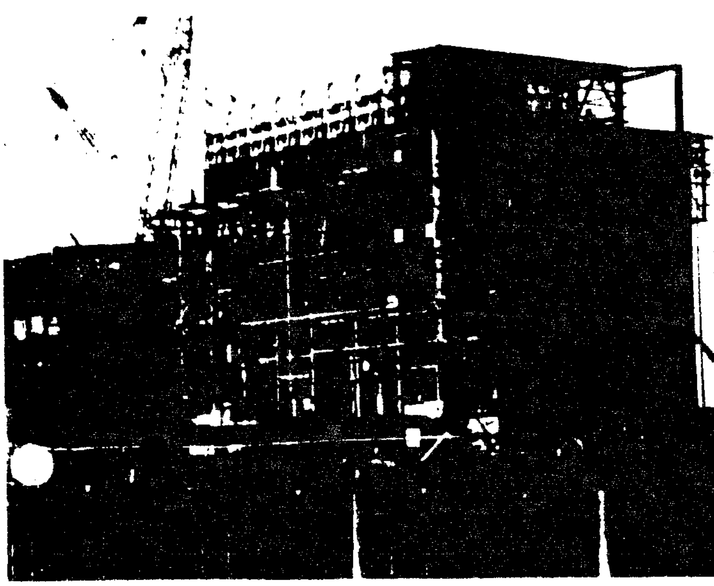
Characteristics:

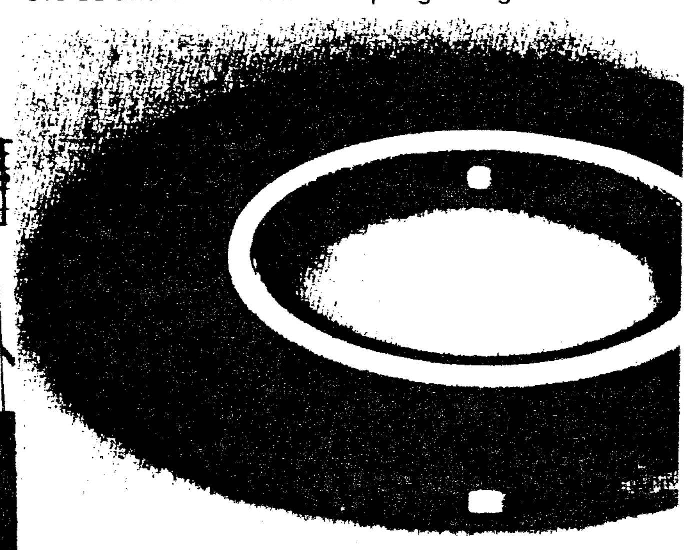
304 Stainless Steel- Good general purpose stainless steel, good overall corrosion resistance.
316 Stainless Steel- Excellent corrosion resistance, good machinability, excellent standard material.
2205 Duplex- Good stress corrosion resistance in chloride and hydrogen sulfide.
Inconel 625- Excellent chemical corrosion resistance, however very expensive.

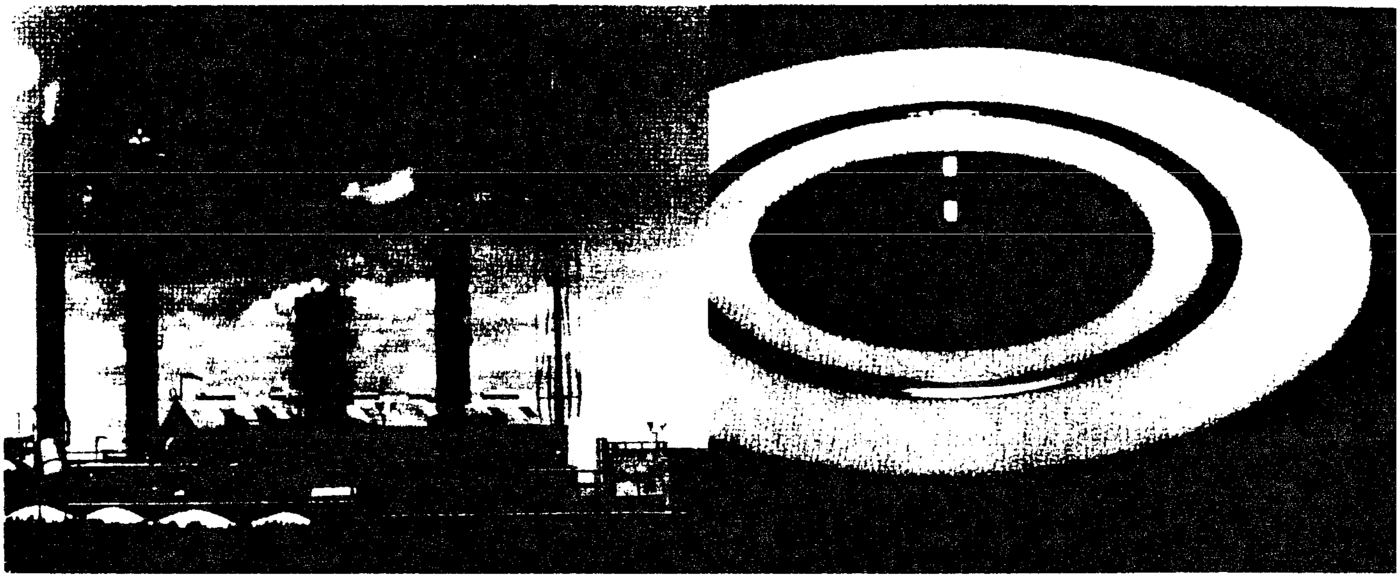
SLEEVE MATERIALS

	Dielectric Strength VPM	Water Absorbtion %	Max. Cont. Temperature F	Resistance to Thread Pinch
Mylar (Standard)	400	.01%	300 F	Good
Polyethylene	400	.05%	150 F	Fair
Phenolic	300	.07%	225 F	Good
G-10	500	.05%	300 F	Excellent
G-11	500	.03%	350 F	Excellent
Nomex	500	.10%	450 F	Good
G-7	500	.10%	600 F	Good

316 SS and G - 11 Retainer/Spring Energized Teflon Se







316 SS and Pk-91 Retainer/Graphite-Filled Spiral Wound Sea

FLOWLOK/FIRELOK SEAL RETAINER LINING MATERIALS

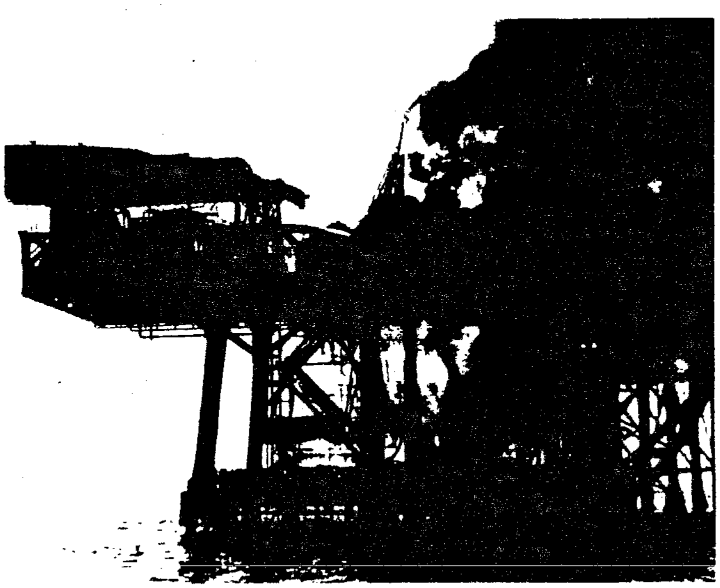
	Dielectric Strength VPM	Compressive Strength PSI	Flexural Strength PSI	Max Cont. Oper. Temp F	Water Absorp. %
Phenolic	360	39.000	22.000	250 F	1.0%
G-10*	525	80.000	79.000	400 F	.07%
G-11*	530	75 000	70 000	400 F	05%
PK-91*	350	45.000	26.000	500 F	.05%
PK-99*	500	70.000	65.000	600 F	.10%
PK-FR	400	50 000	25.000	700 F	.15%

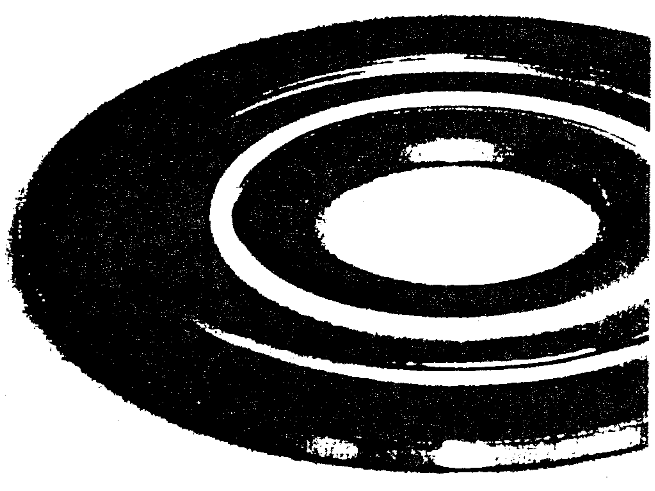
* G-10 and G-11 are glass reinforced epoxy materials. PK-91, PK-99, and PK-FR are proprietary glass reinforced polymers with enhanced temperature capabilities. PK-FR is a patented ablative polymer with extreme temperature capabilities.

HIGH/ TEMP MATERIALS

The ***pikotek*** VCS-FR is the only fire resistant, high temperature insulating gasket (operating working temperatures to 800 F). ***pikotek*** VCS-FR sealing elements are flexible graphite spiral wound seals and the retainer material is a patented ablative polymer with extremely stable temperature characteristics.

316 SS and G - 11 Retainer/Spring Energized Teflon Primary Seal/Firelok Secondary Seal





SEAL MATERIALS

The sealing elements are intended to provide an impervious barrier through which no contained media or other substance can penetrate. Consequently, the composite retainer backing material behind the seal remains uncontaminated and thus permanently holds the seal in place in a static, fully encapsulated manner.

TEFLON® (SPRING ENERGIZED)

Recommended for all environments. Helical wound spring provides radial load. Encapsulation in the seal groove eliminates creep or cold flow. This sealing system truly distinguishes the ***pikotek*** VCS from all other flange sealing systems.

Temperature range: -250° F to +550° F

NITRILE

General purpose oilfield elastomer. Excellent resistance to aliphatic hydrocarbons, silicone base fluids and glycol based systems.

Not recommended for: Systems containing H_2S, aromatic hydrocarbons, phosphate esters or halogenated hydrocarbons. Piping systems subjected to radical pressure drops (2000 PSI to 0 PSI), or piping systems containing significant partial pressures of polar gasses (i.e. CO_2).

Temperature range:

-30° F to + 250° F

VITON/VITON GLT®

General purpose oilfield elastomer. Excellent resistance to aliphatic hydrocarbons, glycols and H_2S. Good resistance to aromatic hydrocarbons.

Not recommended for: Systems with amine inhibitors and in piping systems containing significant partial pressures of polar gasses (i.e. CO_2) where radical pressure drops (2000 PSI to 0 PSI) commonly occur.

VITON: -15° F to + 350° F
VITON GLT: -65° F to + 350° F

EPDM

Excellent resistance to high pressure steam, synthetic fluids and glycol systems.

Temperature range:

-65° F to +550° F

KALREZ®

This rubber material is the ultimate in chemical resistance. It belongs to a class of elastomers called "perfluoro-elastomers" meaning that all bond sites on the elastomer backbone and sidechains have a Fluorine atom bonded to it. This lends the chemical resistance of a Teflon to a rubbery-like material. Kalrez performs excellently in all types of hydrocarbons (aliphatic and aromatic), amine inhibitors, glycols, methanols, H_2S and acids.

Not recommended for: Cost effective applications. This material is very expensive. Spring Energized Teflon is most often a better alternative material.

Temperature range:

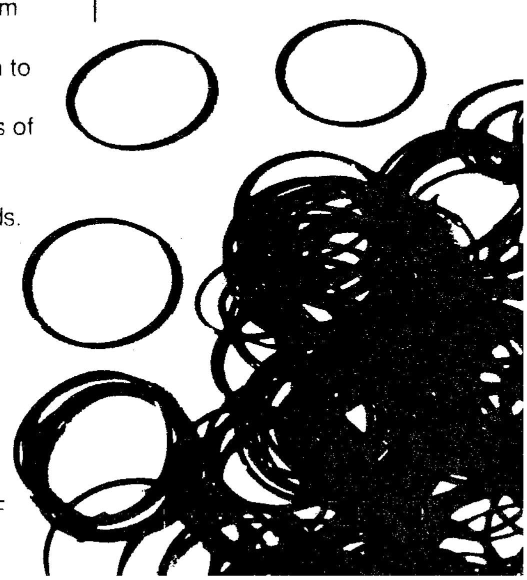
-65° F to +550° F

FLEXIBLE GRAPHITE

Excellent ultra-high temperature characteristics combined with exceptional sealing capabilities. Can be used in conjunction with electrically insulating retainer material to provide a high temperature insulating gasket.

Temperature range:

-400° F to +850° F oxidizin
-400° F to +6000° F non-oxidizin



Flowlok®/Firelok® ADVANTAGES

Originally designed for use in high pressure cathodic protection systems (flange isolation), the ***pikotek*** VCS has, for over ten years, provided trouble free service by eliminating problems associated with corrosion in metal piping systems. Conventional wisdom has always regarded high pressure oil field connections as demanding metal-to-metal sealing integrity. The VCS revolutionized the concept of integrating non-metallic, non-corrosive sealing components with a structurally rigid metallic "backbone" in order to achieve an engineered solution to corrosion resistant high pressure sealing requirements (ANSI 600 class and higher).

Now, the advanced ***pikotek*** Flowlok/Firelok flange connection builds upon the legendary service record of the ***pikotek*** VCS by offering even more features and benefits. Specific product advantages include:

- **Elimination of fluid trap in conventional RTJ flange connections which helps eliminate localized fluid induced corrosion**
- **Total flange face coverage which seals off all metal flange surfaces from potentially corrosive media**
- **Complete electrical isolation/separation for use in cathodic protection**
- **Elimination of turbulent flow (pressure drop) and flow induced erosion in conventional flange connections by sealing flush with the through conduit bore of the flanges**
- **Complete cathodic protection of dissimilar metal flange connections (ie. carbon steel mated to stainless steel)**
- **Able to mate with any flange type (ie. ring type joint--RTJ, raised face, flat face or any combination of flanges thereof)**
- **Completely reusable--thus eliminating the costly need to replace conventional flange gaskets**
- **Significant design improvement for the minimization of fugitive emissions (increased sealability)**
- **Increased structural integrity (compressive and flexural strength) which yields better resistance to gasket damage due to applied bending moment**
- **High compressive strength of the retainer reduces the potential for gasket damage due to over-compression**
- **Increased fire resistance over all conventional gasket designs (refer to Firelok specifications)**

Flowlok®/Firelok® APPLICATIONS

The ***pikotek*** Flowlok insulating connection is designed to be an engineered improvement over conventional flange sealing gaskets. When we say insulating connection, we really mean insulation from all corrosive forces that can lead to flange corrosion and/or other sealing problems. This can include corrosive media, electrolysis, dissimilar/incompatible metals, etc. The Flowlok is designed to combat these problems, **THUS PROVIDING A LONG TERM INOCULATION AGAINST PRODUCTION DOWN TIME!**

Specific applications include:

- **Electrical flange isolation used in conjunction with cathodic protection**
- **Separation of Dissimilar/Incompatible metals for the purpose of eliminating galvanic corrosion**
- **Elimination of fluid trap corrosion, turbulence and flow induced erosion in RTJ connections**
- **High concentrations of H_2S, CO_2 and other aggressive media applications**
- **CO_2 and sea/salt water injection systems**
- **Coated flange surfaces where coating impingement is a potential problem with conventional sealing devices**
- **Applications where on-going routine maintenance to valves or piping system requires gasket reusability**
- **Flanges exposed to thermal cycling and/or pressure cycling**
- **Flanges subjected to vibration/cavitation (ie. compressor stations)**
- **Mating mismatched ring-joint to non ring-joint flanges**

The *pikotek* Firelok is designed to provide all of the benefits of the Flowlok with the added security of certified fire resistance that is unmatched by conventional flange gaskets. This makes the Firelok ideal for:

- **All hydrocarbon service including offshore facilities where either corrosion or the risk of a hydrocarbon fire are significant concerns to the integrity of the production facility and welfare of personnel**
- **Refineries, gas plants, chemical and other processing facilities where corrosion is a potential problem and/or fire is a persistent threat**

APPENDIX B - A-320 GRADE L7M BOLTS IN EXCESS OF 2 $^1/_2$"

The telex received from OME Metallurgica Erbese S.p.A., Italy, concerning an enquiry of NAM Assen into the mechanical properties of A-320 grade L7M bolts in excess of 2 $^1/_2$ inch,is included here for information only.

NNNN

ZCZC PNG236 231054 RCR163 231048 XNB729
RR HPNB HNAM

FROM OME SPA TLX 380130 I
TO NAM ASSEN ECD/121/12 ++ MR POOT

REF TOX4941 23/11/87

REF.: OUR TLX 4938

PHONE CONVERSATION OF TODAY WITH OUR MR. C.FARINA

SUBJECT : SUPPLIES ACCORDING TO ASTM A 320 L7 FOR BOLTING WITH
DIA. GREATER THAN 2.1/2,,

FOLLOWING TO YOUR PRECISE REQUEST, WE CAN SUPPLY BOLTING MATERIAL A 320 L7M WITH DIA. GREATER THAN 2.1/2'' HAVING THE SAME MECHANICAL CHARACTERISTICS SHOWN IN TABLE 2 OF ASTM A 320FOR DIA 2.1/2'' MAX.
WHAT ABOVE SAID IS TO BE CONSIDERED APPLICABLE FOR DIA. FROM 2./1/2'' TO 4'' MAX.

BEST RGDS

~~CONTINUED~~

PNG236/02

OME SPA/C.FARINA
+

APPENDIX C - FLANGE ASSESSMENTS, OUTPUTS OF

This appendix contains all flange assessments as performed by means of Continental Engineering's program E104, version 5.02. Each output shows all input, intermediate results and calculated stresses together with their limits as required for an assessment in accordance with sheet D 0701 of the "Rules".

Part 1 - Class 09-CS-11 with RTJ-flanges
- Class 09-CS-15 with RTJ-flanges
- Class 09-CS-25 with RTJ-flanges

Part 2 - Class 15-CS-15 with RTJ-flanges
- Class 15-CS-21 with RTJ-flanges
- Class 25-CS-11 with RTJ-flanges
- Class 25-CS-15 with RTJ-flanges
- Class 25-CS-21 with RTJ-flanges
- Class 25-FG-14 with RTJ-flanges

Part 3 - Class 09-SS-02 with RTJ-flanges
- Class 15-SS-02 with RTJ-flanges
- Class 25-SS-02 with RTJ-flanges

Part 4 - Class 09-CS-15 with RF-flanges
- Class 09-CS-25 with RF-flanges

Part 5 - Class 15-CS-15 with RF-flanges
- Class 15-CS-21 with RF-flanges
- Class 25-CS-11 with RF-flanges
- Class 25-CS-15 with RF-flanges
- Class 25-CS-21 with RF-flanges
- Class 25-FG-14 with RF-flanges

Part 6 - Class 09-SS-02 with RF-flanges
- Class 15-SS-02 with RF-flanges
- Class 25-SS-02 with RF-flanges

n.b. flanges are in size-consecutive order in each class.