



$S_f = \text{product } SE$  (of the stress value  $S$  and the appropriate quality factor  $E$  from Table A-1A or A-1B) for flange or pipe material. See para. 302.3.2(e).

This method is the method we used on the high pressure VCS flanges, except that we used the ASME BPV allowable stresses which are lower than the ASME B31.3 allowables. See Table 1 below.

Paragraph 302.3.2(e) states:

*(e) Application Limits. Application of stress values determined in accordance with (d)(3) above is not recommended for flanged joints and other components in which slight deformation can cause leakage or malfunction...*

The referenced paragraph (d)(3) refers to austenitic stainless steels and nickel alloys where the allowable stress is sometimes determined by 90% of the yield strength since these alloys have a very gradual yield starting far below their tensile strength. This is not applicable to our flanges.

Therefore we can determine the limiting temperature by comparing the ASME B31.3 allowable stresses to the 17,500 psi value we used in our analysis for the flange. The bolt allowable stresses in the BPV and B31.3 are identical.

Temperature limits for the following forged carbon steels were determined based on ASME B31.3 Table A-1, and assuming a quality factor of 1.0:

**Table 1 - B31.3 Temperature Limits**

| Flange Material          | Temperature Limit, F |
|--------------------------|----------------------|
| A350 LF-1 or A181 Cl. 60 | 340                  |
| A420 WPL-6 or A234-WPB   | 585                  |
| A350 LF-2                | 635                  |
| A105 or A181 Cl. 70      | 635                  |
| A234-WPC                 | 715                  |

2. **High Pressure Equipment, B31.3 Chapter IX:** Paragraph K304.5.1(b) is the controlling paragraph. This paragraph states:

*A flange may be designed in accordance with rules, allowable stresses, and temperature limits of the BPV Code, Section VIII, Division 2, Appendix 3 (or Appendices 4, 5 and 6).*

Our analyses were done in accordance with that Appendix, which has design equations and allowable stresses identical to Section VIII Division 1 Appendix 2. Therefore our temperature limits for common forged materials in this case would be as shown below. Temperature limits for the following forged carbon steels were determined based on ASME BPV Section II Part D, Table 1A:

**Table 2 - B31.3 Chapter IX, B31.4, and B31.8 Temperature Limits**

| Flange Material          | Temperature Limit, F |
|--------------------------|----------------------|
| A350 LF-1 or A181 Cl. 60 | Not permitted        |
| A420 WPL-6 or A234-WPB   | Not permitted        |
| A350 LF2                 | 650                  |
| A105 or A181 Cl. 70      | 650                  |
| A234-WPC                 | 650                  |

**B. Conformance with ASME B31.4**

The key paragraph in this specification is Paragraph 408.1

**408.1 Flanges**

**408.1.1 General**

- (a) Flanged connections shall conform to the requirements of paras. 408.1, 408.3, 408.4, and 408.5.
- (b) (Permits the use of B16.5 or SP-44 flanges)
- (c) (Prohibits the use of cast iron flanges except those integral with proprietary products)
- (d) Flanges Exceeding Scope of Standard Sizes. Flanges exceeding the scope of standard sizes or otherwise departing from the dimensions listed in ANSI B16.5 or MSS SP-44 may be used provided they are designed in accordance with para. 404.5.1.

Paragraphs 408.3, 408.4, and 408.5 relate to flange facings, gaskets, and bolting respectively. The Pikotek design meets these requirements. The applicable section of 404.5.1 is:

*404.5.1(c) Where conditions require the use of flanges other than those covered in para. 408.1, the flanges shall be designed in accordance with Appendix 2 of Section VIII, Division 1, of the ASME Boiler and Pressure Vessel Code.*

This requirement differs from that of standard B31.3 designs in that the lower ASME BPV Section VIII design stresses are required. The allowable temperatures for B31.4 would be the same as for Chapter IX of B31.3 (Table 2 above).

**C. Conformance with ASME B31.8**

The key paragraph in B31.8 is paragraph 831.2.

**831.2 Flanges**

**831.21 Flange Types and Facings**

- (a) The dimensions and drilling for all line or end flanges shall conform to one of the following standards:

- ANSI B16 Series listed in Appendix A (for Iron and Steel)
- MSS SP-44 Steel Pipe Line Flanges
- Appendix I Light Weight Steel Flanges
- ANSI B16.24 Brass or Bronze Flanges and Flanged Fittings

The Pikotek Flanges meet the above requirements since their drilling and dimensions are in accordance with ASME B16.5.

Paragraph 831.22(b) specifically permits ASTM A193 bolting.

Paragraph 831.23 requires gaskets to withstand the pressure and to maintain their physical and chemical properties at temperatures to which they will be exposed.

Paragraph A842.28 requires flanges in offshore service to “be such that smooth transfer of loads is made without high localized stresses or excessive deformation of the attached pipe. Connectors and flanges shall have a level of safety against failure by yielding and failure by fatigue which is comparable to that of the attached pipeline or riser.” No quantitative guidance is given for these requirements, so one would have to assume that ASME Code design requirements are sufficiently conservative.

ASME B31.8 does not require any particular method for the design or stress limits on flanges. Therefore the limits of the ASME Code should be used, which again limits the temperature to the values of Table 2.

**D. Applicable Pressure Ratings**

1. ASME Flanges

The following pressure ratings were verified for the Pikotek HP VCS flanges, with calculations based on ASTM A105 flange material and ASTM A193 grade B7 or B7M studs (ASTM A194 nuts are acceptable for this situation). These ratings are applicable for ASME B31.3, B31.4, and B31.8 services.

**Table 3. Rated Working Pressures**

| ASME B16.5 RF Flange Class | Rated pressure with VCS Gasket, psig |
|----------------------------|--------------------------------------|
| 300                        | 1,000                                |
| 600                        | 2,000                                |
| 900                        | 3,000                                |
| 1500                       | 5,000                                |
| 2500                       | 10,000                               |

2. API Type 6B Flanges

These same working pressures are applicable for API 6A service for the following flanges, providing the flange is constructed of materials meeting API 6A requirements (45,000 psi yield strength for weld neck and 60,000 psi yield strength for integral flanges).

The following table shows the nominal sizes on which the ASME flanges correspond to API 6A Type 6B flanges. The term “Type 6B” refers to a now obsolete API Standard 6B that previously defined these flanges. API Type 6B flanges are dimensionally interchangeable with ASME B16.5 flanges, but have a different system of nominal sizes which relate to standard wellhead equipment bores.

API 6A equipment can be purchased to eight different temperature ratings and combinations of these ratings. These are shown in API Specification 6A Table 4.2. The three low-temperature ratings K, L, and P are -75 to 180, -50 to 180, and -20 to 180 F. Ratings S, T, and U are 0 to 150, 0 to 180, and 0 to 250 F respectively. There is a special R rating (“Room Temperature”), and a V rating from 35 to 250 F. Temperature ratings of API 6A flanges are stamped on the outside diameter of the flange.

The VCS Gasket can be used up to 350 degrees F.

**Table 4 - API vs. ASME Nominal Sizes**

| ASME Class<br>600 Flange | API 6A 2000<br>psi Flange | ASME Class<br>900 Flange | API 6A 3000<br>psi Flange | ASME Class<br>1500 Flange | API 6A 5000<br>psi Flange |
|--------------------------|---------------------------|--------------------------|---------------------------|---------------------------|---------------------------|
| 2                        | 2-1/16                    | 2                        | 2-1/16                    | 2                         | 2-1/16                    |
| 2-1/2                    | 2-9/16                    | 2-1/2                    | 2-9/16                    | 2-1/2                     | 2-9/16                    |
| 3                        | 3-1/8                     | 3                        | 3-1/8                     | 3                         | 3-1/8                     |
| 4                        | 4-1/16                    | 4                        | 4-1/16                    | 4                         | 4-1/16                    |
| 5                        | 5-1/8                     | 5                        | 5-1/8                     | 5                         | 5-1/8                     |
| 6                        | 7-1/16                    | 6                        | 7-1/16                    | 6                         | 7-1/16                    |
| 8                        | 9                         | 8                        | 9                         | 8                         | 9                         |
| 10                       | 11                        | 10                       | 11                        | 10                        | 11                        |
| 12                       | 13-5/8                    | 12                       | 13-5/8                    |                           |                           |
| 16                       | 16-3/4                    | 16                       | 16-3/4                    |                           |                           |
| 20                       | 21-1/4                    | 20                       | 20-3/4                    |                           |                           |

The ASME flanges in the above sizes have the same bolt pattern as the corresponding API 6A Type 6B flanges, and can be bolted directly to them. All API Type 6B flanges are RTJ, or ring gasket, type. The VCS gaskets for these sizes are designed to be compatible with flanges having ring grooves, and should be used with no ring gasket and using the VCS gasket instead. Note that the API flanges may not have a raised face, and it is preferable but not mandatory that at least one of the two flanges be a raised face flange.