

COMMITTEE CORRESPONDENCE
ASME B16-F, FITTINGS

6/14/2016

TO: NOTE FOR RECORD

FROM: GUY A. JOLLY

SUBJECT: ASME B16.11 HISTORY SPECIFIC TO SW FITTINGS

ASA B16.11-1946, 1ST EDITION, STEEL SOCKET-WELDING FITTINGS

1. This edition did not have coverage for threaded fittings.
2. Coverage included SW Ells (45° & 90°), Tees, Crosses, Full Couplings and Half Couplings.
3. Fitting dimensions are identified to fitting designs that will mate with Schedule 40, 80 and 160 pipe of equivalent material as the fitting. The fitting was projected to have a burst pressure greater than the specified mating pipe.
4. Pressure rating would be based on Schedule pipe. The fitting was to be made of a material have properties close to that of the mating pipe.
5. Fitting Material specified-ASTM A234.
6. Wall thickness of the fitting shall be \geq the pipe wall thickness that the fitting is specified to be mated with.
7. The Socket-Weld Wall thickness shall be $1.25 \times T$ nominal for the specified schedule pipe wall thickness that the fitting is designed to be mated to.
8. Burst Strength is calculated as follows:

$$P = 2ST/D$$

Where

P = calculated burst pressure, psi

S = minimum specified tensile strength of the pipe material, psi

T = $0.875 \times T$ nominal, in.

D = OD of pipe, in.

9. Production Test is not required but the fitting shall be capable of meeting the following:

$$P = 2ST/D$$

Where

P = calculated production test pressure, psi

S = $0.5 \times$ minimum specified yield strength of the designated material, psi

T = T nominal of specified schedule pipe specified for use with fitting, in.

D = OD of pipe, in.

10. The fitting bore shall comply with the pipe ID for Schedule pipe specified for use with fitting.
11. Key Dimension: Center Line to Bottom of Socket.
12. Concentricity of SW and Fitting Bore = ± 0.30 in.
13. Material specified—ASTM A234. No date reference.
14. Wall thickness reference – ASA B36.10-1939.
15. Coincidence of Axis-Maximum variation off fitting bore and socket bore axis shall be $1/16''$ per foot.

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NOTE: The wall thickness of the fitting has not changed requiring T nominal to be equal to the projected schedule of pipe specified for the fitting. This requirement of the fitting has never changed.

ASA B16.11-1966, 2nd EDITION, FORGED STEEL FITTINGS, SOCKET-WELD AND THREADED

1. This edition has coverage for both SW and Threaded fittings. Threaded fitting coverage included Ells (45° and 90°), tees, crosses, full couplings, half couplings, caps, plugs and bushings. Dimensions for threaded fittings were adopted from MSS SP-49 and MSS SP-50.
2. This edition deleted “Pipe Schedule Specific” to a “Designated Pressure Class” mapped to pipe schedule for SW and Threaded fittings as follows:

SOCKET-WELD FITTINGS

Class 3000 –Sch. 80

Class 6000- Sch. 160

THREADED FITTINGS

Class 2000-Sch. 40

Class 3000-Sch. 80

Class 6000-XXS

3. The wall thickness of the Designated Pressure Class fitting shall be equal to the T nominal of the specified schedule pipe that the fitting is mapped to per above.
4. The Socket-Weld wall thickness was changed to $1.09 \times T$ nominal for the specified schedule pipe wall thickness that the fitting is designed to be mated to.
5. The Class 2000 SW fittings were deleted. Class 3000 SW (Sch. 80) and Class 6000 SW (Sch. 160) were retained.
6. This edition contained P/T tables for Class 2000, 3000, & 6000 threaded fittings of several materials including Carbon, Low-alloy steel, and Stainless steel.
7. Size range for SW fittings increased to cover NPS 4 fitting dimensions for Class 3000.
8. Material specified—ASTM A181-61T Grade 1 except with minimum yield not less than 35000 psi. Also ASTM A182-62T of the appropriate grade.

ANSI B16.11-1973, 3rd Edition, FORGED STEEL FITTINGS, SOCKET-WELDING AND THREADED

1. The P/T tables for threaded Designated Class 2000, 3000, and 6000 removed.
2. A Designated Class 9000 fitting details was added.
3. There was no change in correlation of pipe schedule to Class but Class 9000 correlation was added as follows:

SOCKET-WELDING FITTINGS

3000—Sch. 80

6000—Sch. 160

9000—XXS

4. There was a change in correlation of pipe schedule to Class for threaded fittings as follows:

THREADED FITTINGS

	This Edition	1964 Edition
Class 2000	Sch. 80	Sch. 40
Class 3000	Sch. 160	Sch. 80
Class 6000	Sch. XXS	Sch. 160

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5. Material specified-A105 and A182

6. All dimension presented in Metric units as well as U.S. Customary.

7. A major change to Socket-Weld wall thickness was made as follows:

Two (2) values are given in tables-Average wall and Minimum wall. The Avg. wall is determined by $1.25 \times T$ nominal for specified schedule pipe for fitting. The minimum wall is based on $1.09 \times T$ nominal for specified schedule pipe for fitting.

NOTE: The B16.11-1973 SW wall thicknesses have not been changed in B16.11-1980/1991/1996/2001/2005/2009/2011 Editions.

8. The minimum wall thickness of the SW fitting shall be in accordance with the nominal wall thickness of the specified wall of the specified schedule pipe used for the Class fitting.

ANSI B16.11-1980, FORGED STEEL FITTINGS, SOCKET-WELDING AND THREADED

1. This Edition has a Figure 2 included for the 1st time that illustrates the minimum fillet weld dimensions acceptable to install a B16.11 fitting in the piping system. The leg length of this fillet weld is dimensioned as Cx.

2. Figure 2 indicates that Cx (min.) shall be $1.09 \times T$ nominal, where T nominal is nominal wall thickness of the connecting pipe.

3. Figure 2 also specifies that a Minimum Flat = $0.75 \times Cx$. This implies that the fillet weld may have to be made on a portion of the radius of the fitting end to meet the $Cx \geq 1.09 T$ nominal.

4. An Annex was added for the "Burst Testing of Fittings". This Annex provided a method for burst testing of B16.11 fittings but was not a requirement of the standard.

5. Material specified-Forging, bar, seamless pipe or tube meeting the requirements including melting practice of ASTM A105, A182, or A350.

ANSI B16.11-1991, FORGED FITTINGS, SOCKET-WELDING AND THREADED—(Jolly, Start Chair)

1. Materials-All forgings listed in B16.34 Table 1 are acceptable under this edition. Since B16.34-88 was listed in Reference Annex C the materials included carbon, low alloy steel, stainless steel, and nickel alloy materials.

2. Title changed from "Forged Steel Fittings" to "Forged Fittings" to indicate nonferrous material fittings (nickel alloys) now has coverage under B16.11.

2. The fillet weld Cx requirements was removed from Figure 2.

3. The minimum flat of the fillet weld leg on fitting was changed to $0.81 \times$ minimum wall thickness of socket weld thickness (C). NOTE: The flat should have been presented as $0.81 \times T$ nominal.

4. Socket-weld caps was added to this edition.

ANSI B16.11-1996, FORGED FITTINGS, SOCKET-WELDING AND THREADED

1. An annex was added for Quality System Program.

2. The minimum flat of the fillet weld leg on fitting was changed to $0.75 \times$ minimum wall thickness of socket weld thickness (C). This was the value used in the 1980 Edition and a correction from B16.11-1991.

3. Materials specified-Continued from 1991 Edition all forgings listed in B16.34 Table 1 are acceptable under this edition. Since B16.34-88 was listed in Reference Annex D the materials included carbon, low alloy steel, stainless steel, and nickel alloy materials.

4. Metric dimensions added as equal to U.S. customary dimensions.

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ASME B16.11-2001, FORGED FITTINGS, SOCKET-WELDING AND THREADED

1. Partial compliance and non-standard materials removed from standard.
2. Materials specified-Continued from 1996 Edition all forgings listed in B16.34 Table 1 are acceptable under this edition. Since B16.34-96 was listed in Reference Appendix II the materials included an expanded list of carbon, low alloy steel, stainless steel, and nickel alloy materials.
3. The nonmandatory Annex “Method for Burst Testing Fittings” was removed from this edition.

ASME B16.11-2005, FORGED FITTINGS, SOCKET-WELDING AND THREADED

1. Threaded street elbows added.
2. Materials specified-Continued from 2001 Edition all forgings listed in B16.34 Table 1 are acceptable under this edition. Since B16.34-98a was listed in Reference Appendix II the materials included a list of carbon, low alloy steel, stainless steel, and nickel alloy materials.
3. Added new sentence to 5.1 Materials that reads, “Tees, elbows, and crosses shall not be made from bar stock”.

ASME B16.11-2009, FORGED FITTINGS, SOCKET-WELDING AND THREADED—(Cuccio, Start Chair)

1. Major change in material requirements. Standard materials were linked to ASTM Fitting Specifications A234, A403, A420, A815, or B366 and ASTM Forging Specifications A105, A182, A350, B462, or B564. This normalized the B16.11 dimensional data with the ASTM fitting material specifications while maintaining the forging material specification as standard materials.
2. The change to materials led to considerable changes in the marking requirements.

ASME B16.11-2011, FORGED FITTINGS, SOCKET-WELDING AND THREADED

1. No change in scope.
2. No change in Standard Materials.
3. Updated Appendix II, Reference dates.
4. Across flats in Table 5 accuracy tighten to accommodate metric tooling. Note 2 added to Table 5 and I-5. Note 2 requires manufacturer to apply tolerances to across flat dimensions to accommodate U.S. Customary tooling.
5. Para. 6.5, Reducing Fittings, revised to clarified applicable dimensions for reducing fittings.
6. The reference point for external thread gaging changed and clarified in para. 6.3.3.

SUMMARY

As a summary to the SW fitting dimensions the following is offered:

1. The correlation of SW Fitting Class to the mating pipe has not changed as follows:
 - Class 3000—Sch. 80
 - Class 6000—Sch. 160
 - Class 9000--XXS
2. The minimum wall thickness for SW fittings is equal to and based on the nominal wall thickness of the pipe that the fitting is mapped to be mated with. This started with the 1st Edition of ASA B16.11-1946 and continues up to the 2011 Edition.
3. The minimum SW bore thickness from the earliest B16.11-1946 required it to be 1.25 x the nominal wall thickness of the pipe it was to be mated with. Even though there was a 12-1/2% tolerance on pipe wall thickness this had no stated impact on SW bore thickness.

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4. The minimum SW bore thickness was changed to $1.09 \times T$ nominal in the B16.11-1966 Edition. The tolerance was applied to get this requirement since $.875 \times 1.25 T$ nominal = $1.09 T$ nominal.
5. ASA B16.11-1973 changed the SW bore thickness to a double value –average and minimum. The average value was based $1.25 T$ nominal and the minimum value was based on $1.09 \times T$ nominal. A note was added that the minimum value only was acceptable in localized areas and the average values for SW thickness about the periphery shall not be less than the listed values. These values and the note has not changed since the 1973 edition.
6. ANSI B16.11-1980 included an illustrative figure 2 that had some minimum dimension for the fillet weld (Cx) to install the B16.11 fitting. This minimum dimension was Cx and the minimum required for Cx was $1.09 \times T$ nominal. A minimum flat on the fillet weld location was $0.75 \times Cx$ ($0.82 T$ nominal). This implied that the actual fillet weld may have to made on the radius of the fitting to meet the Cx = $1.09 T$ nominal requirement.
7. The Cx requirement was removed from B16.11-1991, Figure 2 in the B16.11-1996 edition since installation welding was deemed a B31.x issue. The minimum flat = $0.75 \times$ minimum C from Table 4, B16.11-96 was retained. The Figure 2 and minimum flat requirements have not changed since the B16.11-1996 edition.

ASME B31 ISSUE

The B31 MDC (Mechanical Design Technical Committee) is in the process of writing a “Proof Testing Standard” for fitting and components. An issue keeps coming up that the B16.11 SW fittings may not support an adequate fillet weld. Their analysis indicate that for an equal leg fillet weld the leg length should be $1.41 \times T$ minimum pipe wall thickness. This would yield a fillet throat weld thickness = minimum wall of pipe. Since most B36.10 pipe has a wall thickness tolerance of 12-1/2 % and based on this they accept a fillet leg length of $1.25 \times T$ nominal for B16.11 fittings. They are not in full agreement with the $1.09 T$ nominal we allow for localized areas for SW thickness. The 0.75 partial flat at the welding location may be a concern as well. This B31.x issue may be brought to the B16 SC-F Committee in the future.

The history suggest that the B16.11-1946 document indicated that the SW bore wall thickness shall be $1.25 \times T$ nominal. There is no rationale for this requirement but the B16.11-1946 document did recognize the 12-1/2 % wall thickness tolerance in their presented Equations. Suspect the B31 group would suggest that the 0.875 factor was applied at the B16.11-1946 stage. That is $0.875 \times 1.41 T$ nominal = $1.25 T$ nominal. Possibly this rationale does not apply and the $1.25 T$ nominal is conservative because the B16.11 group applied the $0.875 \times 1.25 T$ nominal at a later date. This lead to the $1.09 T$ nominal that was the requirement in the B16.11-1966 edition. Later editions adopted dimensions for SW bore thickness as two (2) values-- Average based on $1.25 T$ nominal and Minimum at localized areas as $1.09 T$ nominal starting with the B16.11-1973 edition. These values have not changed since B16.11-1973 and continues in the current B16.11-2011. In summary the B31 Group seem to indicate that the fillet weld for B16.11 fittings should have a “throat dimension” that equals the minimum wall of the connecting pipe not including weld penetration or convex surface of weld and have a leg length not less than $Cx = 1.25 T$ nominal. They suggest that the 2nd application of the 0.875 that yielded a minimum wall of $1.09 T$ nominal should not have been allowed.

The following should be considered when doing analysis of fillet welds:

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Since the failure mode for fillet weld stress shall be considered as shear stress on the throat area of weld for any direction of applied load.

Possibly this led to the $1.25 \times T$ nominal for SW Bore thickness and not the requirement that the "throat thickness" shall equal the minimum wall thickness of the mating pipe. Possibly some of the B16SC-F Committee can help on responding to this emerging issue. The following issues should be reviewed:

1. Does the throat dimension have to meet T minimum pipe wall thickness to sustain pressure?
2. Does the stress analysis of the leg length of a fillet weld with a length = $1.09 \times T$ nominal pipe wall indicate the fitting/piping joint can sustain the fitting pressure?
3. Does the $0.75 Cx$ (minimum C now) flat confuse welders making the fillet welds that a $1.09 \times T$ nominal weld is required?

This should be an Agenda item for discussion at the B16SC-F meeting.