PFI Standard ES-49
(New September 2008)

Guidelines for installation of integrally reinforced branch connection outlet fittings

1. Scope

1.1. This standard provides general guidelines for the installation and welding of integrally reinforced branch connection outlet fittings attaching to the outside of the run pipe, otherwise known as a set on/stub on configuration.

2. General

2.1. A branch connection is the joining of two intersecting pieces of pipe that split a process flow. The pipe containing the hole for the branch connection, typically referred to as the run pipe, is weakened by the opening made in it. The primary function of an integrally reinforced branch outlet fitting, (branch fitting), is to reinforce this opening and restore the original strength of the run pipe, eliminating the need for an additional reinforcing element such as a reinforcing pad or saddle. The use of branch fittings can provide an economic alternative to tee fittings, reinforcing pads or saddles. Branch fittings are attached to the run pipe by welding. A branch fitting's strength and corresponding thickness is specified by the wall schedule of the run and branch pipes. Very often the designer may require the use of a branch fitting to provide reinforcement for external loads other than pressure, such as vibration, impact, and thermal cycles.

3. Dimensions

3.1. 90 degree branch fitting dimensions, finish, marking, materials, and strength requirements for butt weld, socket weld, and threaded fittings are provided by the MSS SP-97 Standard Practice.

3.2. Although standard MSS SP-97 provides standard dimensions from the outside of the run pipe to the branch connection end of the fitting, ("A" dimension, See Detail "1-B"), the outside diameter of the fitting, and the corresponding fitting wall thickness is proprietary, and must be supplied by the fitting manufacturer.

4. Welding

4.1. The full penetration attachment weld shall be a full penetration weld and must be filled out to the edge of the fitting weld bevel. The fitting weld bevel is defined as the first bevel that is adjacent to the header and having an inclusive angle of 35 to 45 degrees, as measured between the header surface and the fitting weld bevel surface.

4.2. The groove weld requires a cover fillet weld whose primary purpose is to provide a smooth transition between the run pipe and the branch weld. The transition fillet weld throat thickness is defined as dimension "tc" by the applicable code.

4.3. A cover fillet weld with a slightly concave profile that provides a smooth transition between the deposited cover fillet weld metal and run pipe surface contributes to improved fatigue life. This is of particular importance when branch connections are cyclically loaded, and should be specified by the engineer when required.

4.4. Where cyclic loading is a concern, the hole in the run pipe should be flush with the inside diameter of the branch fitting, and the inside corner of the run pipe hole should be rounded. This shall be specified by the engineer when required.

4.5. Refer to figures 1, 2, and 3 for examples of the preferred weld profiles.

5. Distortion

5.1. Full integral reinforcement is provided within the branch fitting, and the attachment weld metal, by a large volume of metal concentrated around the run pipe hole. The branch fitting's larger volume in the weld attachment area, yields a branch connection weld that is typically thicker than the branch pipe, and may also be thicker than the run pipe. Large weld volumes create internal stresses as a result of weld shrinkage during solidification, which has the potential to distort the run pipe. Run pipe distortions are created in the longitudinal direction in the form of bending or camber, (See figure 5), and in the circumferential direction affecting ovality, (See figure 4).

5.2. The use of a thin wall pipe for the run pipe exhibits a greater tendency to distort. High alloy branch connections tend to distort more than low alloys materials, due to their higher expansion and lower thermal conductivity.

5.3. Distortion may be minimized through combination of fitting selection, design, sequential welding technique, and following the fitting manufacturer's recommandations.

5.3.1. Designers should specify a fitting to meet the requirement of the service. Avoid specifying a branch fitting designed for a heavier run wall thickness than the run pipe under consideration. (Example: Specify a Schedule 10, or "light weight" branch fitting, for a schedule 10 run pipe). It should be noted that the weld volume required to attach the branch fitting to the run pipe can vary widely among the various fitting manufacturers for a given branch size/run size/wall thickness combination, and should be considered when selecting a particular brand of fitting.

5.3.2. Where possible, avoid placing numerous branch fittings in succession, in close proximity to each other, and along the same side of the run pipe. Weld shrinkage is cumulative, and may result in large cambers. Welding every other fitting in succession will reduce the amount of induced camber (Example : Fitting 1, 2, 3 & 4 in succession on same side of pipe, would be welded in the order of 1, then 3, then 2, then 4).

5.3.3. The branch fitting attachment weld should stop at the edge of the first fitting bevel adjacent to the header. More weld is not better, the additional weld volume only contributes to more distortion. It should be noted that partially filling the groove joint between the run pipe and branch fitting is not an option, even when it is obvious that the branch fitting is designed far in excess of the design conditions of the run pipe (See Par 5.3.1). Partially filling the branch fitting groove will void the manufacturer's pressure rating.

5.3.4. Where possible, restrain the run pipe in the direction opposite of the anticipated distortion.

5.3.5. It is recommended that the design temperatures and pressures be supplied to the fitting manufacturer, so that they may determine the lightest fitting for the application, there by reducing weld volumes. Branch fitting manufactures will typically assume a "worst case" when no design information is supplied. The type of fitting they supply will be based on header and branch wall thickness and sizes alone. This approach results in the largest fitting attachment weld volumes.

5.4. Often run pipe distortion cannot be avoided. In these cases, some means of straightening the pipe within an acceptable tolerance is required. For carbon steels, local heat may be applied to the opposite side of the pipe to counteract the weld shrinkage on the branch fitting side. Local heat applied to pipe shall be monitored to ensure that the temperatures do not exceed that which is considered detrimental to the material. Furnace stress relief may provide an alternate method for straightening; however, it requires a careful selection of the run pipe support points within the furnace, with somewhat unpredictable results. Applying local heat to stainless and high alloy materials may degrade the material's favorable characteristics; therefore, some method of cold forming is required to return the run pipe to an acceptable tolerance.

6. Inspection

6.1. All nondestructive examination shall be performed in accordance with the applicable piping codes and specifications and meet the acceptance criteria therein.

6.2. The fitting to run pipe weld profile should meet the profiles as depicted in figures 1 through 3.

6.3. The fitting to run pipe weld size shall be considered adequate if the weld is filled out to the edge of fitting weld bevel. Some branch fittings possess transitional taper (s) between the branch fitting weld bevel and the OD of the branch fitting, and the delineation between the two surfaces will be obscured by weld deposit. In these cases, it is difficult to determine if the weld has been properly filled out. It then becomes necessary to measure the angle of the exposed "bevel". If the bevel is equal to or greater than 50 degrees the bevel shall be classified as a transition, and the weld shall be considered complete. Refer to figure 7.

6.4. The cover fillet weld shall meet the requirements of the applicable code and the manufacturer's recommendations, except that, the cover fillet thickness may transition to zero in any location around the fitting where the angle between the face of the branch fitting groove weld and the surface of the pipe, at the location, exceeds 135 degrees.

7. Post Weld Heat Treatment

7.1. The need for post weld heat treatment (PWHT) is defined by the applicable piping code and is typically determined by the run and branch pipe wall thicknesses. The branch fitting thickness, or the attachment weld, may not be exempt from PWHT as defined by the governing thicknesses of ASME B31.1 paragraph 132.4, ASME B31.3 paragraph 331.1.3, or other applicable code. PWHT may be required for the branch connection while the remainder of the pipe assembly is exempt from PWHT. Refer to Figure 6 for code PWHT requirements.

8. Ordering Information

- Material grade
- Quantity
- Fitting type description
- Material certification requirements
- Branch outlet size and schedule or class
- Run pipe size and schedule
- Design temperature and pressure (when available)
- Applicable design and fabrication code
  - Confirm fitting complies with code
- When fabrication code is ASME Section I
  - Design pressure and temperature
  - Request Branch calculations (if required)
- Dimensional information (if required)
  - Fitting height or dimension from outside of run pipe to the branch connection end preparation, ("A" dimension or "E" dimension), if not in compliance with MSS SP-97
  - Outside diameter of fitting, ("B" dimension) to determine weld thickness and volume in conjunction with "C" dimension.
  - Required header hole size ("C" dimension)
- It is recommended that, the purchaser provide a statement within purchasing documents, that design, dimensions, manufacture, and testing shall be accordance with MSS SP-97, to assure that the fitting ordered meet the requirements of the applicable codes and specifications

9. References

ASME B31.1 -	Power Piping Code
ASME B31.3 -	Process Piping Code
ASME B31.9 -	Building Services Piping Code
ASME B16.9 -	Factory made wrought butt weld fittings
ASME B16.11 -	Forged Fittings, socket weld and threaded
ASME B16.25 -	Butt welding ends
MSS SP-97 -	Integrally Reinforced Forged Branch Outlet Fittings

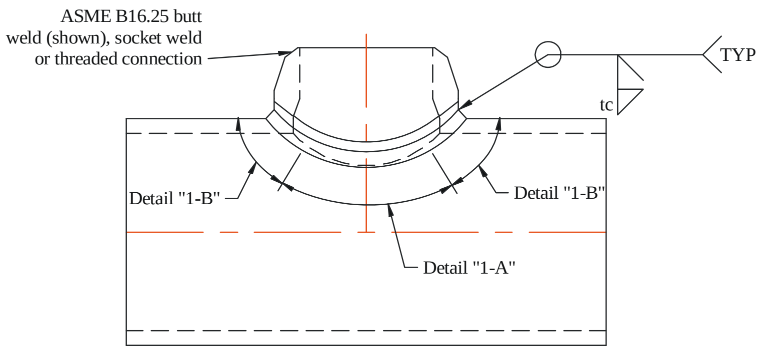
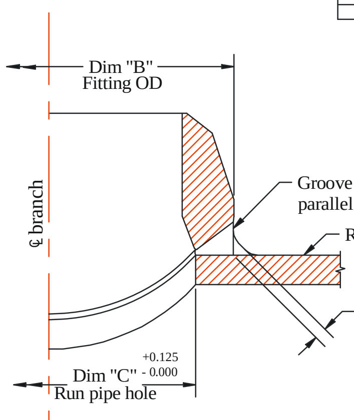
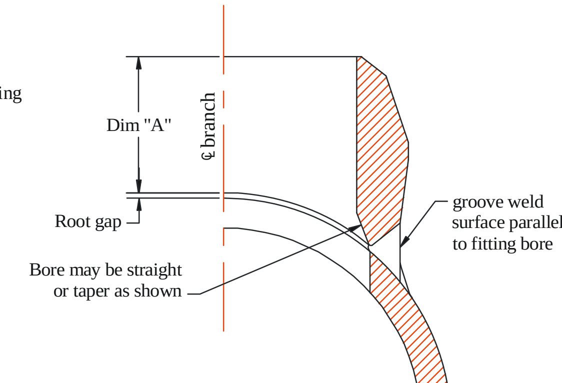


Figure 1

Weld profile for 90 degree branch fitting



Detail 1-A



Detail 1-B

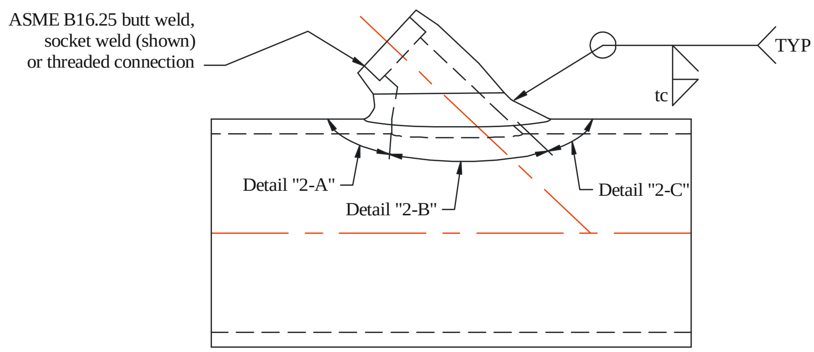
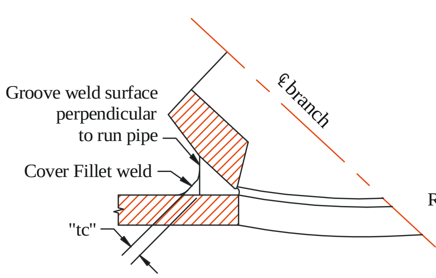
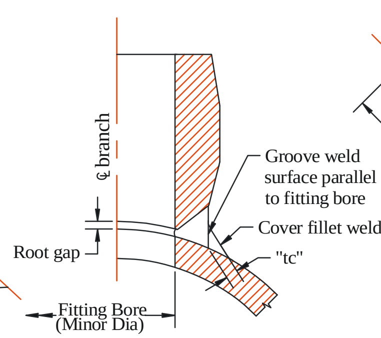


Figure 2

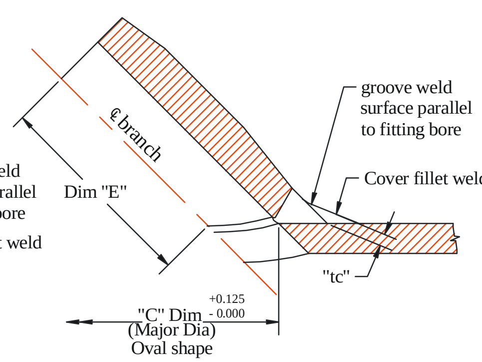
Weld profile for lateral branch fitting



Detail 2-A



Detail 2-B



Detail 2-C

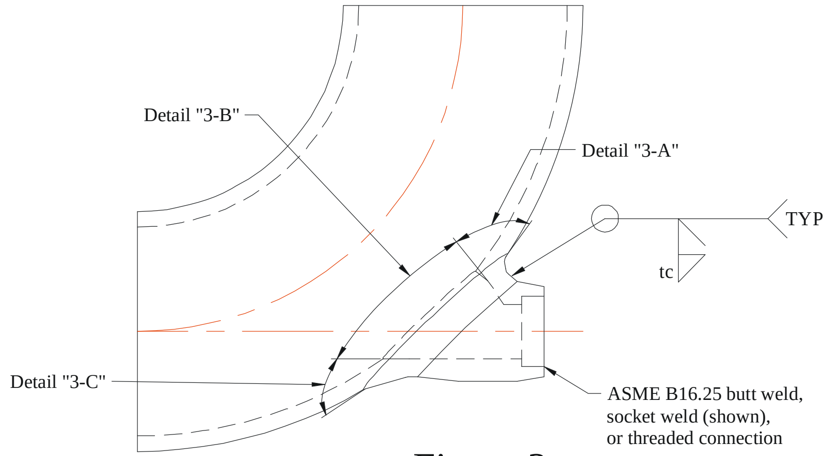
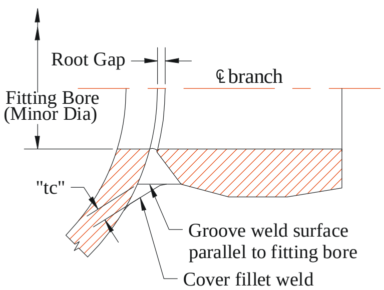
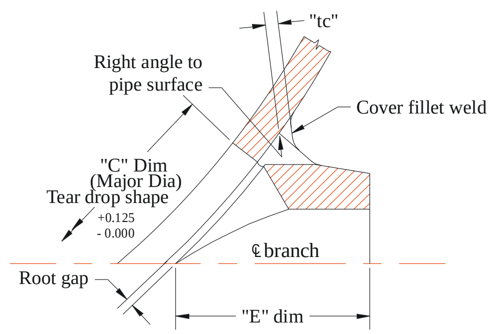


Figure 3

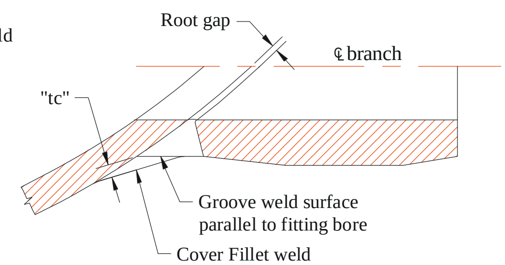
Weld profile for elbow branch fitting



Detail 3-A



Detail 3-B



Detail 3-C

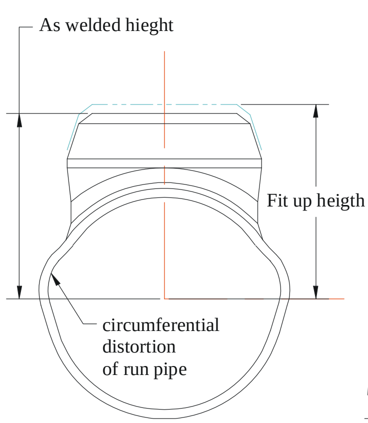


Figure 4

Circumfertial distortion

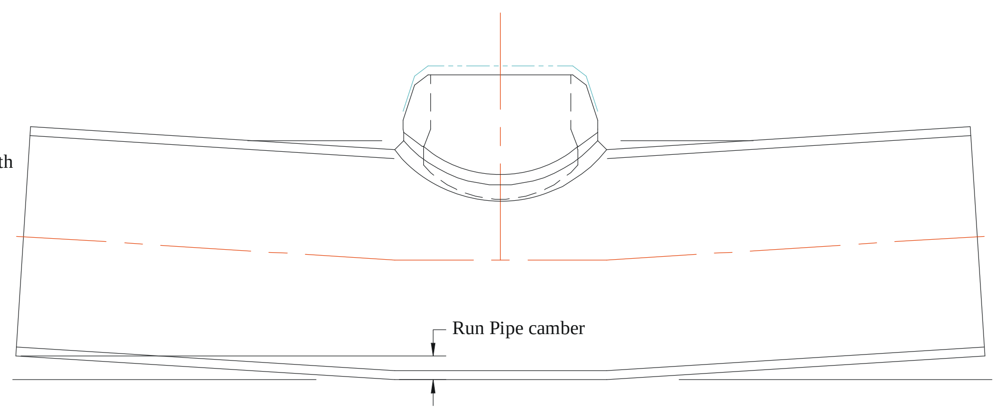


Figure 5

Longitudinal distortion

PWHT REQUIREMENTS FOR INTEGRALLY REINFORCED BRANCH FITTINGS

ASME B31.3
Process Piping
PWHT Required

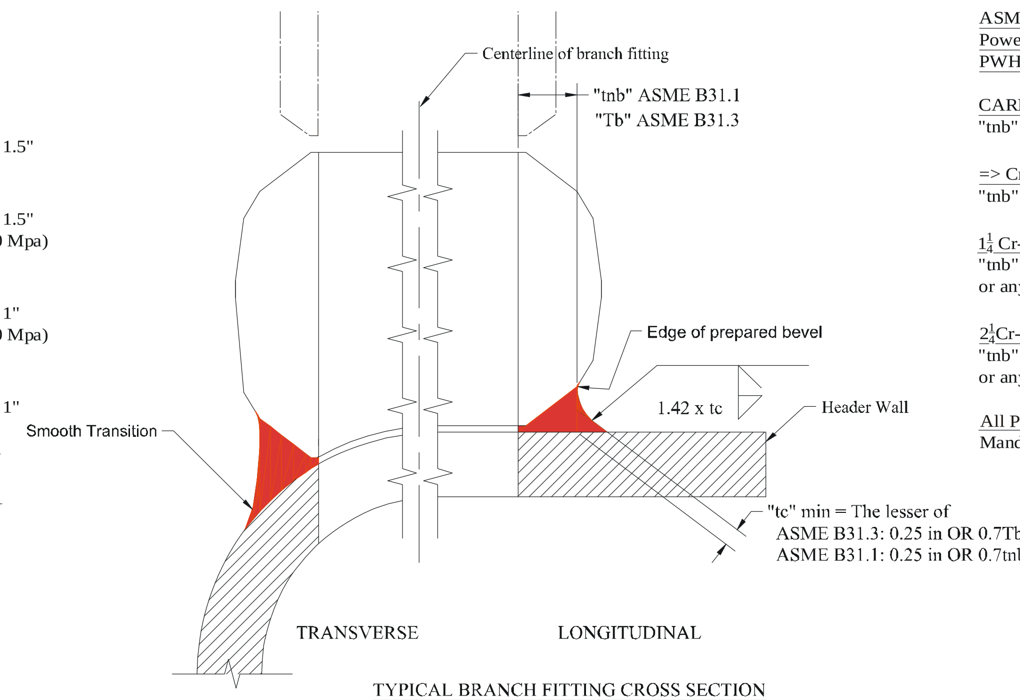
CARBON STEEL (P-no 1)
Through weld thickness (Tb + tc) > 1.5"

=< $\frac{1}{2}$ Cr (P-no 3)
Through weld thickness (Tb + tc) > 1.5"
or a Tensil Strength => 71 KSI (490 Mpa)

$1\frac{1}{4}$ Cr-$\frac{1}{2}$Mo (P-no 4)
Through weld thickness (Tb + tc) > 1"
or a Tensil Strength => 71 KSI (490 Mpa)

$2\frac{1}{4}$Cr-1Mo (P-no 5A)
Through weld thickness (Tb + tc) > 1"
and 350 deg. F. Preheat
and Carbon content is 0.15% or less

All P-no 5B, 6, 10, & 10I materials
Mandatory. No exemptions



ASME B31.1
Power Piping
PWHT Required

CARBON STEEL (P-no 1)
"tnb" > 0.75"

=> Cr-$\frac{1}{2}$ (P-no 3)
"tnb" > 0.5"

$1\frac{1}{4}$ Cr-$\frac{1}{2}$Mo (P-no 4)
"tnb" > 0.5"
or any thickness with carbon content > 0.15%

$2\frac{1}{4}$Cr-1Mo (P-no 5A)
"tnb" > 0.5"
or any thickness with carbon content > 0.15%

All P-no 5B materials
Mandnatory. No exemptions

Figure 6
Branch fitting PWHT requirments

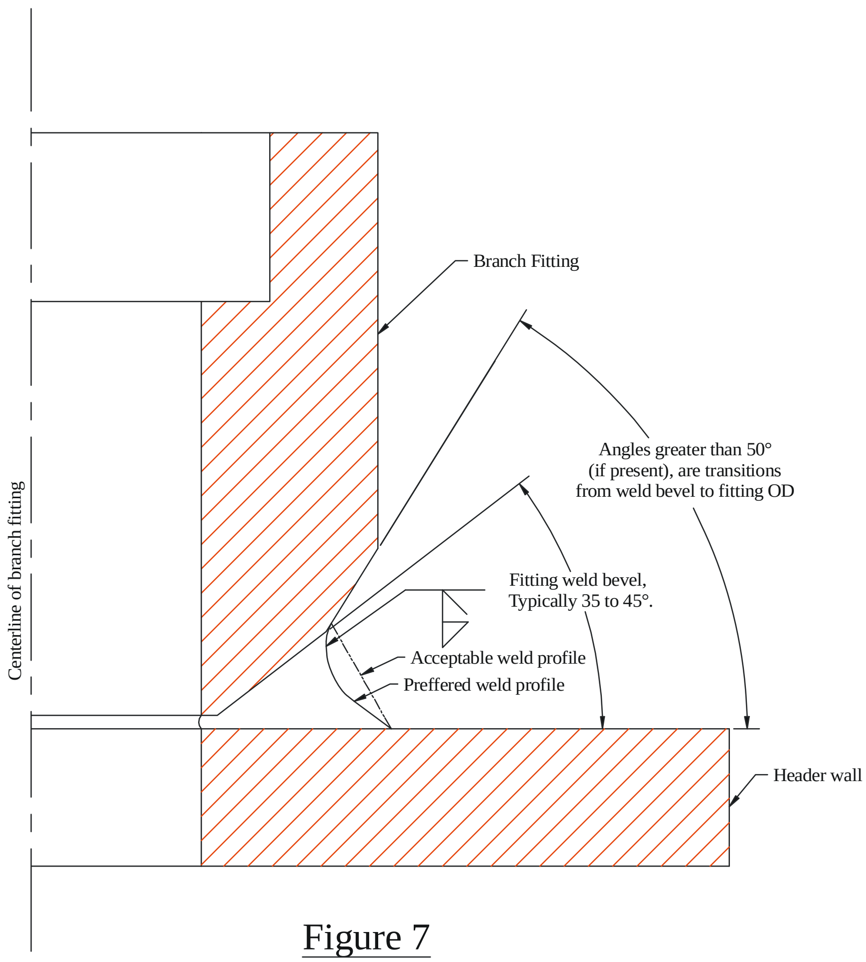


Figure 7

Branch Fitting transition