### (19) S1.2.9.3 TUBE WALL THICKNESS FOR ARCH TUBES

The minimum wall thickness of replacement arch tubes shall be as determined by the following formulas:

(U.S. Customary Units)

$$t = \frac{PD}{16{,}000} + 0.125$$

(SI Units)

$$t = \frac{PD}{111} + 3.175$$

where

*D* = outside diameter of tube, in. (mm)

*P* = maximum allowable working pressure, psi (MPa)

t = thickness of tube wall, in. (mm)

### (19) S1.2.9.4 THERMIC SYPHONS

a) For repairs to syphon knuckles see *Repair of Firebox and Tubesheet Knuckles*, and NBIC Part 3, Figures S1.2.11.5-a and S1.2.11.5-b.

b) Except for the attachment weld to the throat sheet, welds on the thermic syphon unit shall be full penetration, and the unit shall be stress relieved in accordance with ASME, Section I, PW-39. Volumetric examination is not required.

**FIGURE S1.2.9.4-a**

LOCOMOTIVE FIREBOX THERMIC SYPHON INSTALLATION

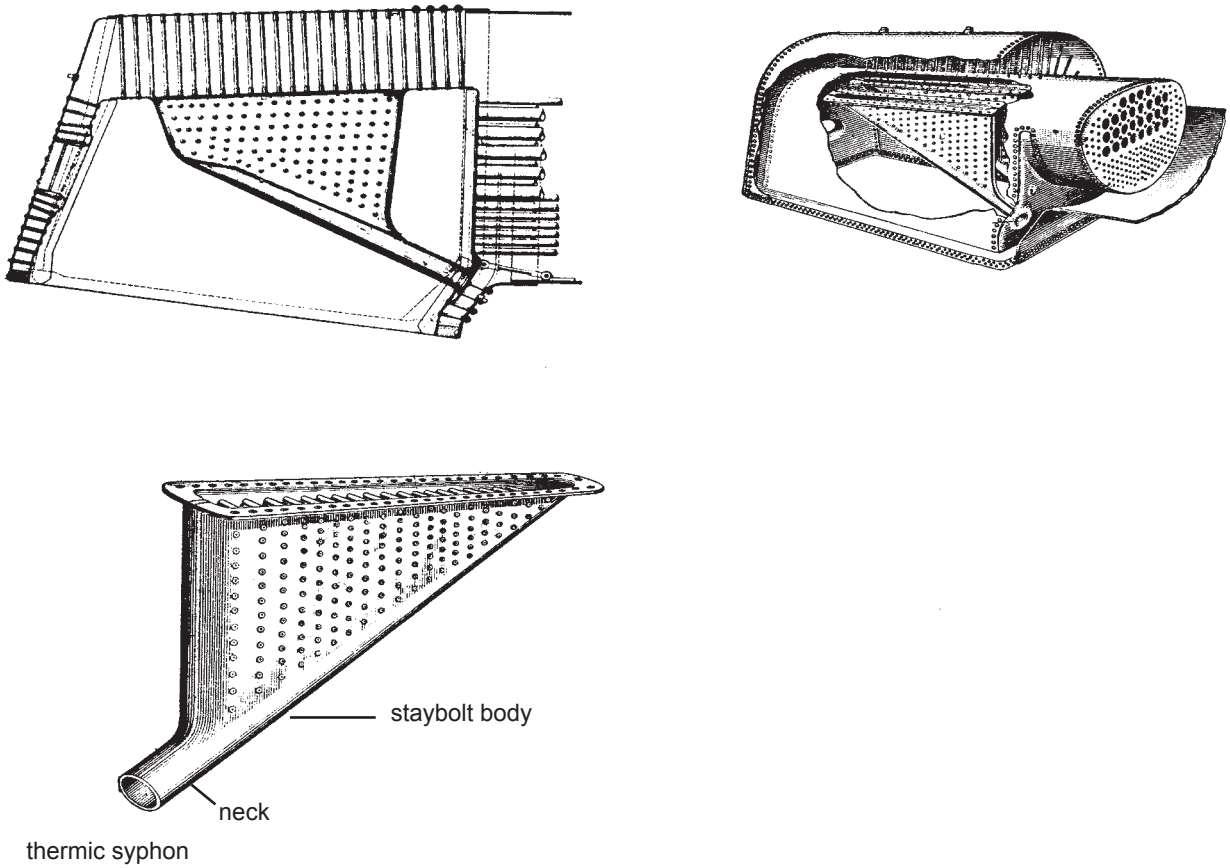
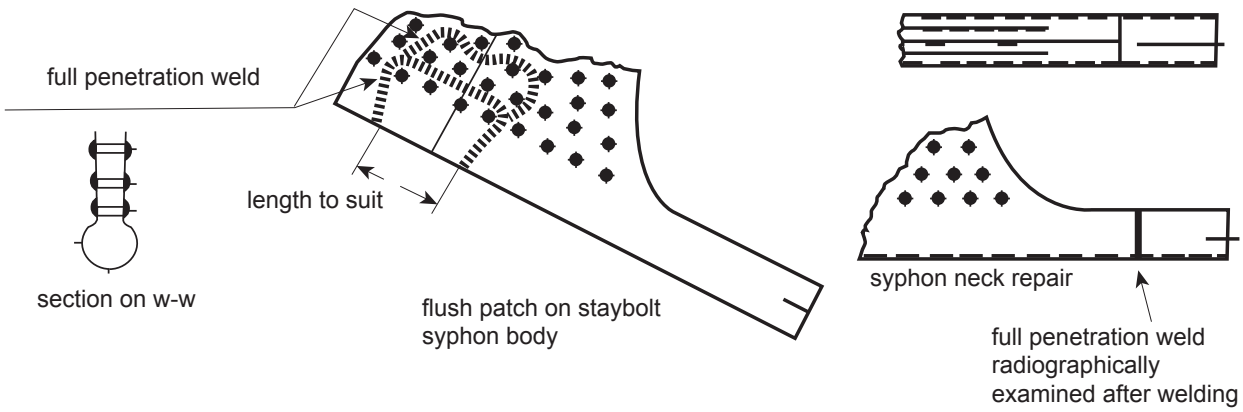



**FIGURE S1.2.9.4-b**

THERMIC SYPHON REPAIR



### S1.2.9.5 CIRCULATORS

a) All buttwelds on circulators shall be radiographically examined.

b) Welds applied to the circulator/firebox sheet joint shall be in accordance with the weld requirements for arch tubes. (See NBIC Part 3, Figure S1.2.9.2-a).

### (19) S1.2.9.6 INSTALLATION OF BOILER FLUES

a) Maximum allowable working pressure and nominal wall thickness for flues shall be determined using TABLE S1.2.9.1 and TABLE S1.2.9.1M.

b) Except as otherwise specified in this Part, flues shall be attached as illustrated in Figure S1.2.9.6 (a thru e). Flues shall not be attached by welding alone.

c) All flues smaller than 3 in. (75 mm) O.D. shall be expanded and beaded, with or without seal welding, or expanded and welded on the firebox end. At least 1 in 10 distributed evenly on the front flue sheet shall be expanded and beaded or expanded and welded. All flues 3 in. (75 mm) O.D. and larger shall be expanded and beaded, with or without seal welding, or expanded and welded at both ends. All adjacent flues smaller than 3 in. (75 mm) O.D. that are within the area occupied by the larger superheater flues shall be expanded and beaded or expanded and welded at both ends. At least 1 in 10 of the remaining flues smaller than 3 in.(75 mm) O.D. shall be beaded and/or welded on the front flue sheet, in addition to expanding. Where less than all flues are welded or beaded on the front flue sheet, those welded or beaded shall be distributed as evenly as practicable throughout the flue pack.

d) Flues shall be re-expanded upon completion of seal welding or beading, or both. The new reduced wall thickness of the enlarged flue end shall be reviewed to confirm that upon completion of the flue expansion process the new wall thickness will be sufficient for the MAWP.

e) When stipulated by the original design, the ends of boiler flues may be swaged to a smaller or larger diameter as required to fit the tube sheet holes. The swaging shall create smooth surfaces, smooth curves, and a uniform diameter reduction across the entire swaged length. Swaging or not swaging is considered a repair.

f) When flues are applied by expanding and seal welding, the seal weld shall protrude beyond the sheet a distance of 1/8 in. to 1/4 in. (3 mm to 6 mm) inclusive [see Figure S1.2.9.1-b] and the end of the flue shall not protrude past the weld. The end of the flue shall be ground or polished to eliminate any sharp edges.

g) Prior to welding, beading, or both, ensure that the flue is satisfactorily seated in the sheet. Seal welding may be done with water in the boiler, provided the water is heated to between 100°F and 120°F (38°C and 50°C).

h) Ferrous or nonferrous ferrules may be used on either or both ends of flues. When seal welding over ferrous ferrules used in straight-expanded and seal-welded flues, the weld shall attach to the sheet and not just to the ferrule. Care shall be taken to avoid contamination of seal welds when nonferrous ferrules are used.

**Cautionary Note:**

Boiler flues shall be cut to or made to the correct length required for installation when the boiler and flues are at equal temperature. The use of heating or stretching the flue during installation to obtain the required length by thermal or mechanical expansion is prohibited.

### S1.2.9.7 FERRULES

a) Ferrous or non-ferrous ferrules may be used on either or both ends of flues and arch tubes.

b) If ferrules are recessed, the recess depth shall not exceed 1/16 in. (1.6 mm) measured from the flue sheet fireside edge.

c) Protrusion of the ferrule beyond the edges of either flue sheet is permitted provided the ferrule does not interfere with any further attachment procedures.

d) For steel ferrules, if the flue is installed by expanding it straight and seal welding it to the flue sheet, the seal weld shall be arranged to contact the flue sheet and the flue. Seal welding the flue to the ferrule only is prohibited.

e) The applications of ferrules where none were used before shall be considered a repair.

f) The application with ferrules, where none were used before shall be considered a repair.

### S1.2.10 REPAIRS AND ALTERATIONS TO BOILER BARREL UNSTAYED AREAS

a) Except as provided in NBIC Part 3, 3.4.4.8, a repair of a defect in a welded joint or base material shall not be made until the defect is removed. A suitable nondestructive examination (NDE) method such as magnetic particle (MT) or liquid penetrant (PT) may be necessary to ensure complete removal of the defect. If the defect penetrates the full thickness of the material, the repair shall be made with a full penetration weld such as a double buttweld or a single buttweld with or without backing. Where circumstances indicate that the defect is likely to recur, consideration should be given to removing the defective area and installing a flush patch or taking other corrective measures acceptable to the Inspector, and when required by the Jurisdiction.

b) Weld buildup shall not be used if the affected section of plate has wasted below 60% of the minimum required thickness.

c) If the cracked section of plate is retained and is to be repaired by installation of a riveted patch, the crack may be stopped by drilling stop holes at each end or removed by a method such as grinding, cutting, or machining. Results of stop drilling or crack removal shall be verified by NDE.

d) Welded repairs at or near riveted seams requiring preheating or postweld heat treatment shall be carefully made in order to prevent loosening in the riveted seams, especially when localized heating is used. Where necessary to control expansion or to gain access for welding, rivets at the defective section and to each side of it may be removed. Reuse of rivets and staybolts is prohibited.

e) All welded repairs to boiler barrel unstayed areas shall be radiographically examined in accordance with ASME Code, Section I when the size of the repaired area is greater than the maximum size of an unreinforced opening as calculated in accordance with the latest edition of ASME Code, Section I.

f) Riveted patches may be any shape or size provided the lowest patch efficiency is equal to or greater than the lowest equivalent seam efficiency of the boiler course to which it is applied. Ref: ASME Code, Section I.

g) The factor of safety of all riveted patches shall not be less than four for locomotives operating under Federal Railroad Administration regulations.

## S1.2.11 REPAIRS AND ALTERATIONS TO BOILER BARREL STAYED AREA

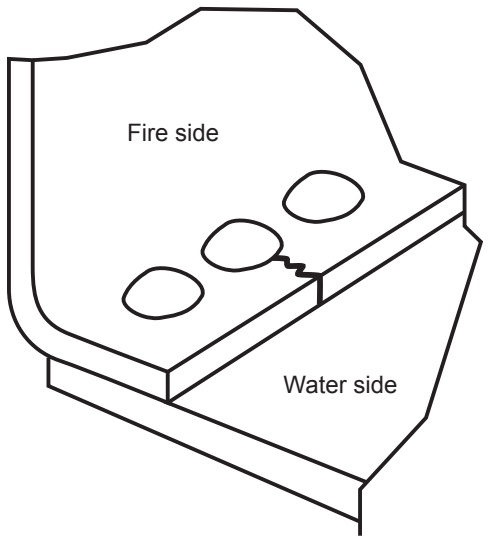
### S1.2.11.1 FIREBOX SHEET REPAIR

a) Cracks in all stayed firebox sheets may be repaired by welding or the installation of a flush patch.

b) If the crack extends into a staybolt or rivet hole, the staybolt or rivet shall be removed prior to making the repair.

c) Fire cracks or thermal fatigue cracks in riveted seams located in the firebox that run from the edge of the plate into the rivet holes may be left in place provided they do not leak and there is no indication that the seam or rivets are loose. (See NBIC Part 3, Figure S1.2.11.1).

**FIGURE S1.2.11.1**
EXAMPLE OF THERMAL FIRE CRACK




### S1.2.11.2 FIREBOXES AND OTHER STAYED AREA PATCHES

a) Patches may be any shape provided they are adequately supported by staybolts, rivets, tubes, or other forms of construction. Patches on stayed surfaces should be designed so weld seams pass between staybolt rows. (See NBIC Part 3, Figure S1.2.11.2).

b) Patches are to be flush type, using full penetration welds. If the load on the patch is carried by other forms of construction, such as staybolts, rivets, or tubes, radiographic examination and postweld heat treatment of the welds are not required.

c) If the patch includes an existing riveted seam, the patch shall be riveted at that seam. Changing a riveted seam to a welded seam is considered an alteration.

d) All rectangular or angled patches shall have adequate radius at all corners. Minimum radius to be not less than three times plate thickness.

e) Patches shall fit flush on the waterside of the sheet. Misalignment shall not exceed one-quarter plate thickness on edge alignment with the sheet water side.

f) Staybolts and rivets should be installed after welding of patch is completed. Reuse of staybolts and rivets is prohibited.

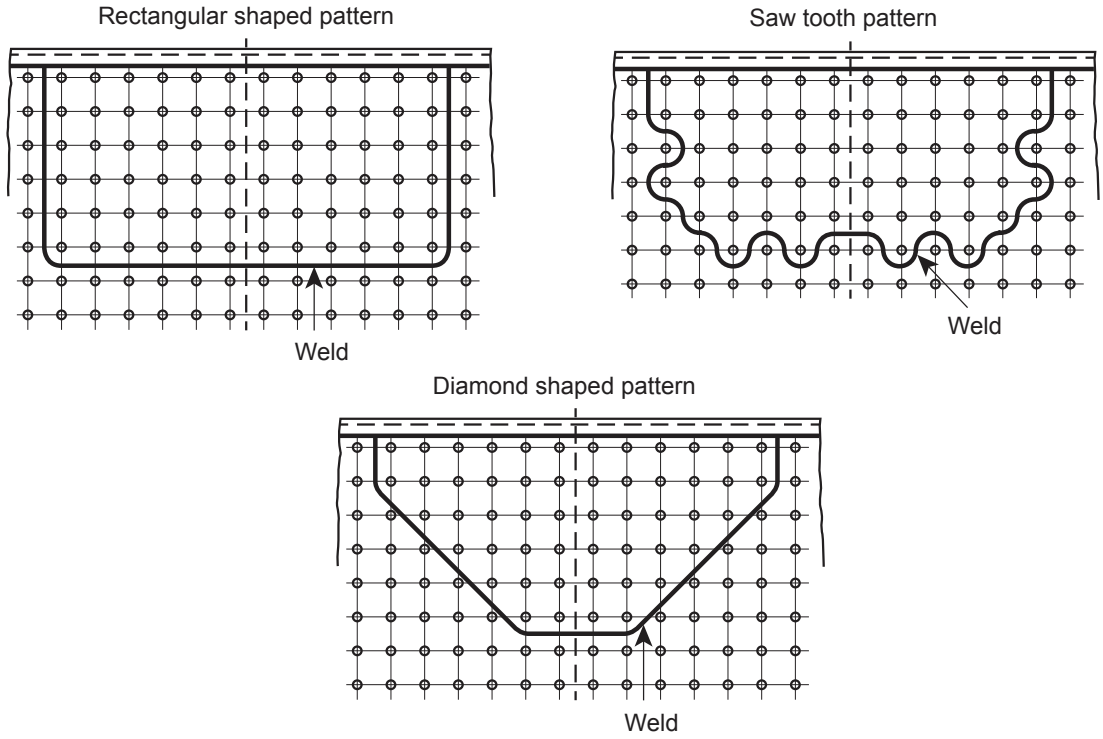
g) Weld seams parallel to a knuckle shall be located no closer to the knuckle than the point of tangency of the knuckle unless the weld is radiographically examined. Weld seams not located in the knuckle are preferred. (See NBIC Part 3, Figure S1.2.11.5-b).

h) Patches shall be made from material that is at least equal in quality and thickness to the original material.

**FIGURE S1.2.11.2**

TYPICAL FIREBOX PATCHES

This figure illustrates what would be considered a saw-tooth patch. Its advantage is that a maximum amount of welding is obtained for securing a given patch and by zig-zagging the weld, the weld is supported by three rows of staybolts instead of two. Its disadvantage is its irregular shape which causes greater difficulty in fitting and applying. Rectangular and diamond shaped patches are illustrated for comparison.




## S1.2.11.3 REPAIR OF STAYED FIREBOX SHEETS GROOVED OR WASTED AT THE MUDRING

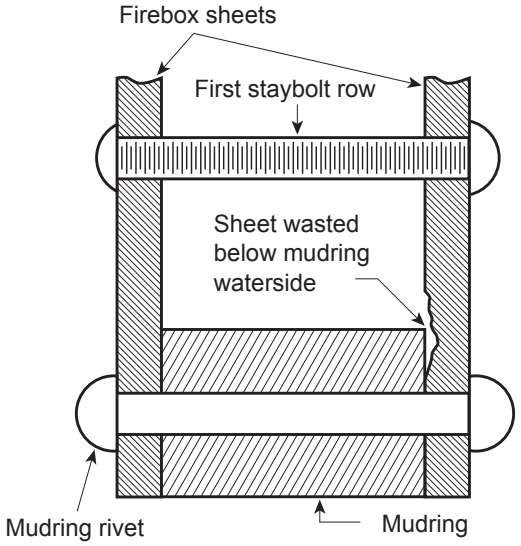
a) Grooved or wasted firebox sheets having greater than 60% of the minimum required thickness remaining may be repaired by weld buildup provided the wastage does not extend below the waterside surface of the mudring and the strength of the structure will not be impaired. If extensive welding is required, the affected area shall be removed and replaced with a flush patch.

b) If the sheet thickness has been reduced to less than 60% of the minimum required thickness, the affected section shall be removed and replaced with a flush patch.

c) If wastage and grooving extends below the mudring waterside surface and if the plate thickness remaining has been reduced to less than the minimum required thickness, the affected section shall be removed and replaced with a flush patch.

d) Flush patches shall be arranged to include the mudring rivets and at least the first row of staybolts above the mudring.

**FIGURE S1.2.11.3**
STAYED FIREBOX SHEET GROOVED OR WASTED AT MUDRING

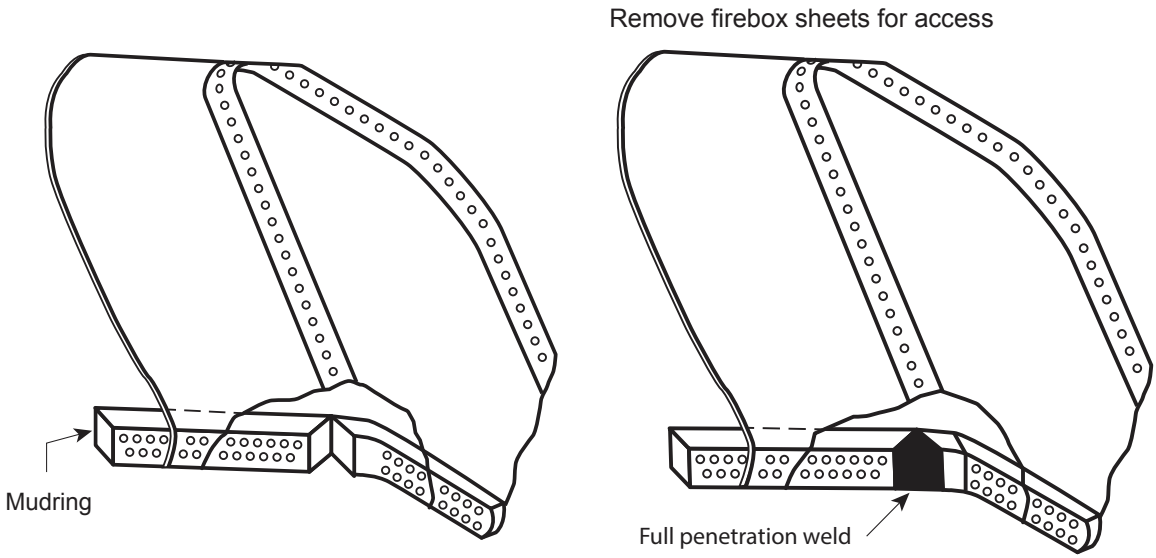



## S1.2.11.4 MUDRING REPAIRS

a) Pitted and wasted sections of mudrings may be built up by welding provided the strength of the mudring will not be impaired. Where extensive weld buildup is employed, the Inspector may require an appropriate method of NDE for the repair.

b) Cracked or broken mudrings may be repaired by welding or installation of flush patches using full penetration welds. Patches shall be made from material that is at least equal in quality and thickness to the original material. Patches shall fit flush on waterside surfaces. Where necessary, firebox sheets on both sides of the defect may be removed to provide access for inspection and welding.

**FIGURE S1.2.11.4**
MUDRING REPAIRS




## S1.2.11.5 REPAIR OF FIREBOX, WRAPPER, AND TUBESHEET KNUCKLES (19)

a) Welds within the points of tangency of a knuckle are permitted. Welds with angles of less than 45 degrees to the longitudinal axis of the knuckle shall be radiographically examined. (See NBIC Part 3, Figures S1.2.11.5-a through S1.2.11.5-g).

b) Any patch not supported by means other than the weld, such as rivets, staybolts, tubes, or other forms of construction, shall have all weld seams radiographically examined.

c) Patches shall be formed to proper shape and curvature.

d) Wasted sections of knuckles that have not wasted below 60% of the minimum required thickness may be repaired by weld buildup provided the strength of the structure will not be impaired. Where weld buildup is employed, the Inspector may require an appropriate method of NDE for the repair.

e) Wasted sections of knuckles that have wasted below 60% of the minimum required thickness shall be replaced.

f) Flanges shall be made so as to avoid stress intensifiers such as abrupt ridges and grooves.

g) Flanges shall be made smooth and free of ridges, valleys and grooves.

h) Flanges may be welded in accordance with this section and all applicable sections of this code.

i) For one-piece flange knuckle joint patches in portions of a riveted lap joint or in mud ring corners with a lap joint in the firebox, the knuckle patch shall be supported on at least one of the two planes adjacent to the flange, by means other than the weld. See Figure S1.2.11.5-c1. The weld shall be at least the full thickness of the new plate being installed. Volumetric examination is not required. This type of repair shall be considered a repair.

**Cautionary note**: Where a double-riveted lap joint is replaced with a seamless plate, stay pitch and stress must be considered since the doubling effect of the lap seam is being eliminated.

**FIGURE S1.2.11.5-a**
FIREBOX TUBESHEET KNUCKLE REPAIR

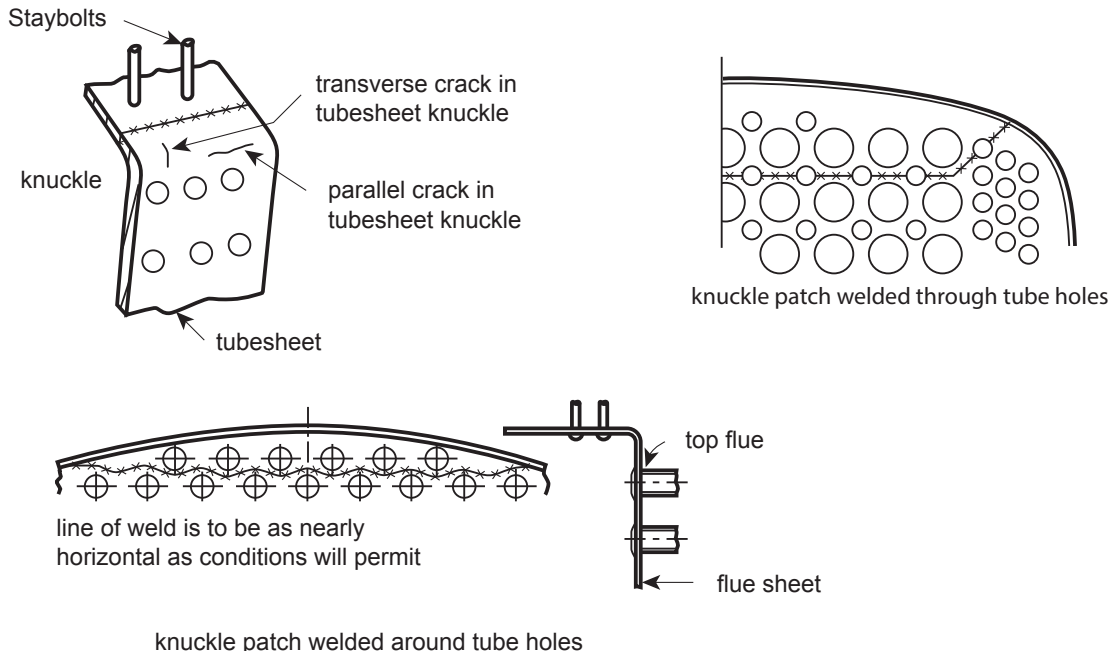



**FIGURE S1.2.11.5-b**
REPAIR OF FIREBOX AND TUBESHEET KNUCKLES

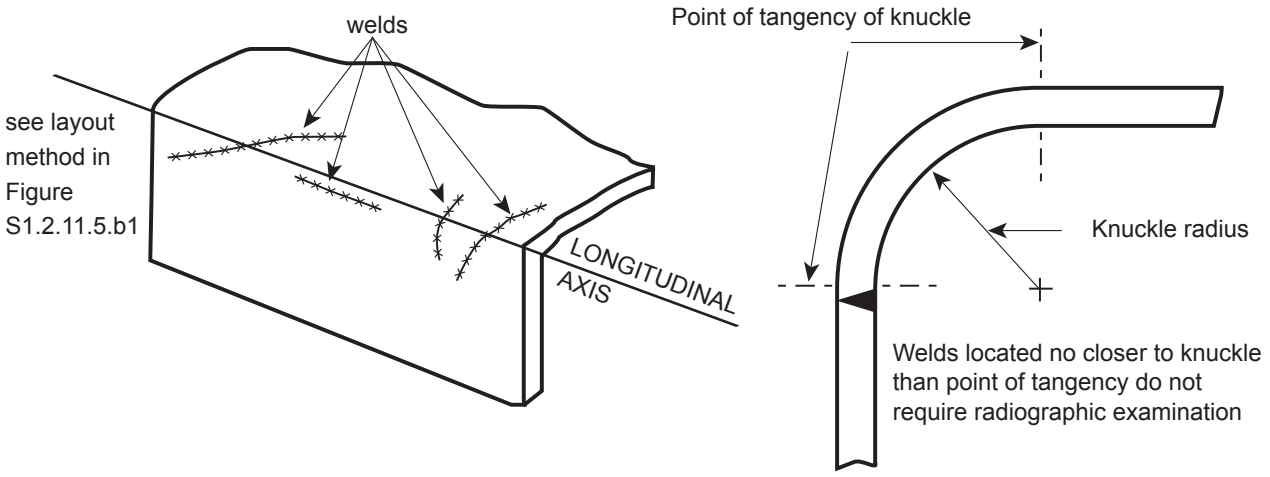
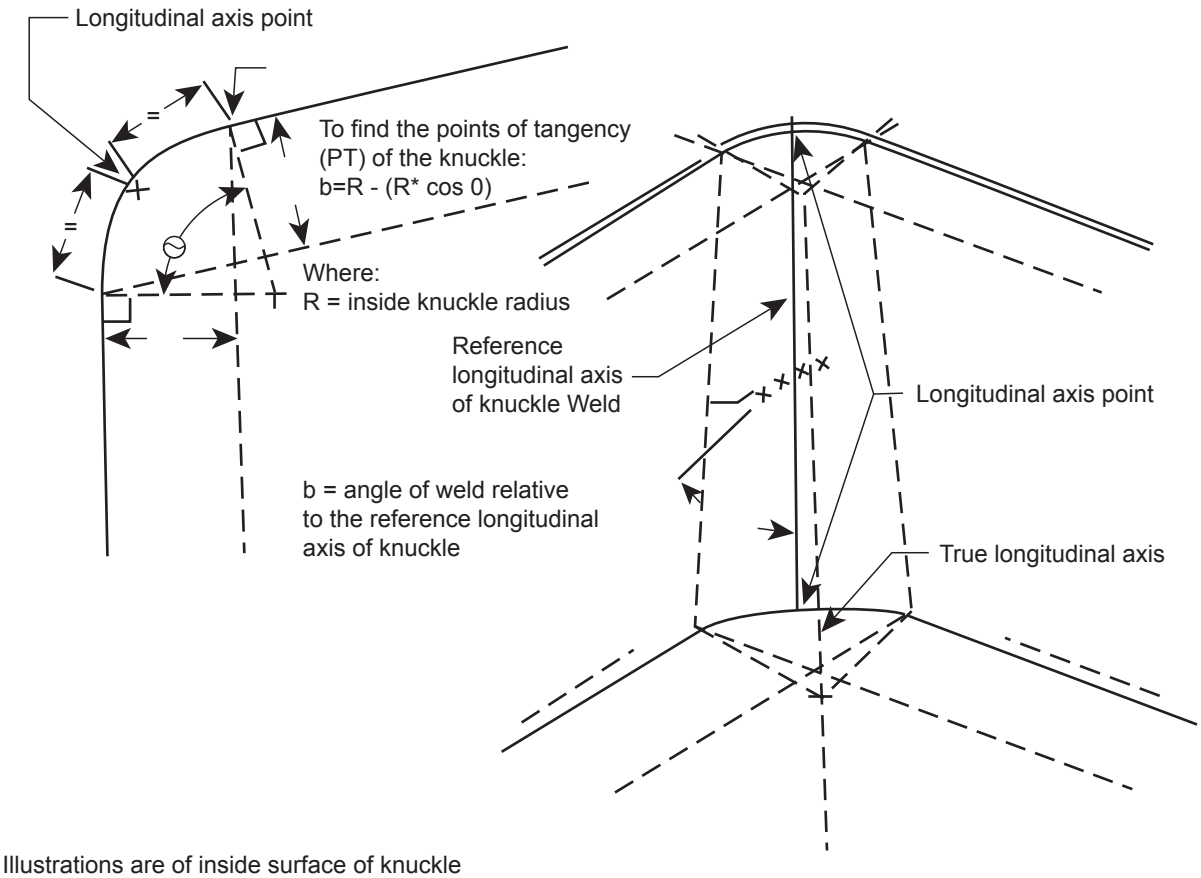


**FIGURE S1.2.11.5-b1**

LAYOUT METHOD OF DETERMINING KNUCKLE WELD ANGLE

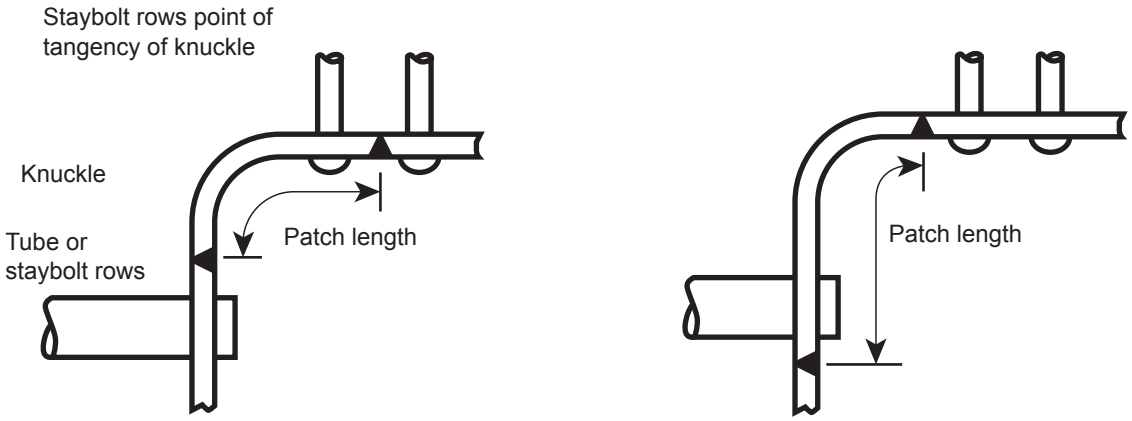



Illustrations are of inside surface of knuckle

SUPPL. 1

**FIGURE S1.2.11.5-c**
REPAIR OF FIREBOX AND TUBESHEET KNUCKLES

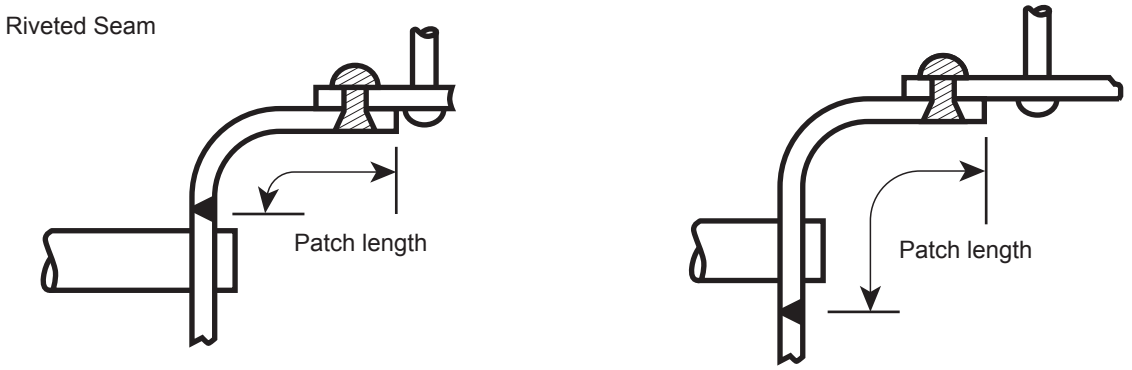
**Stayed Patch Applied to Buttwelded Seam**




Weld seams located between staybolt rows and above first tube row or staybolt row

Weld seams located between tube rows below staybolt rows or tube rows

**Stayed Patch Applied to Riveted Seam**




Weld seam located above first tube row or staybolt row

Weld seam located between tube rows or staybolt rows

**Repairs Requiring Radiographic Examination of Weld Seams**