Issue Date: April 15, 2015

THE NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS

SINCE 1919

NATIONAL BOARD INSPECTION CODE COMMITTEE

Minutes March 24 and 25, 2015

Meeting of Sub Group Locomotives
Location1055 Crupper Ave
Columbus, OH 43229

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The National Board of Boiler & Pressure Vessel Inspectors
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Columbus, Ohio 43229-1183
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1. Adoption of Agenda
2. Announcements
    a. Minutes of March 18,19 2014,
3. Educational Presentation-None
4. Errata-None
5. NBIC Negative Votes -None
6. Items at Subcommittee Level -None

7. Letter Ballots
8. Old Business
    a. NB11-1805 Staybolts (pgs 4-6)passed unanimous
    b. NB13-1401 Boiler Tube Seal Welding (pgs 7-16)passed unanimous
    c. NB13-1403 Installation of Boiler Tubes & Arch Tubes (pgs 17,18) Motion to return to the requestor and have this revised to be incorporated into Part 3 Repair Rules. This information is not specific to Locomotives. R. Stone is PM. Passed unanimous
    d. NB13-1404 Fillet welded staybolts (pg 19)Motion to close and incorporate action and information into NB15 1701/1702, Passed unanimous
    e. NB13-1406 Superheater Units. Motion to return to the requestor and have this revised to be incorporated into Part 2 Inspection Rules. This information is not specific to Locomotives. R. Stone is PM. Passed unanimously (pgs 54-56)
    f. NB13-1407 Bolts, Nuts & Washers passed unanimously (pg 20)
    g. NB13-1408 Threaded boiler studs- passed unanimously (pgs 21-26)
    h. NB13-1409 Method for Analyzing Bulges Created by Overheating in Stayed Boiler Surfaces (pg 28-41) Motion to return to the requestor and have this revised to be incorporated into Part 2 Inspection Rules. This information is not specific to Locomotives. R. Stone is PM. Passed unanimous
    i. NB14-1101 Diagram Weld Inspection (pgs 42-44) Motion to return to the requestor and have this revised to be incorporated into Part 2 Inspection Rules. This information is not specific to Locomotives. R. Stone is PM. Passed unanimous
    j. NB14-1102 Diagram Weld Repair (pgs 45, 46) Motion to return to the requestor and have this revised to be incorporated into Part 2 Inspection Rules. This information is not specific to Locomotives. R. Stone is PM. Passed unanimous
    k. NB14-1801 Ferrules (pgs 47-49) Motion to return to the requestor and have this revised to be incorporated into Part 2 Inspection Rules. This information is not specific to Locomotives. R. Stone is PM. Passed unanimous
    l. NB14-1802 Title: Riveted Staybolt Head Dimensions & Figure S1.2.2-c Title: Threaded Staybolt Inspection (pgs 50,51) Motion to return to the requestor and have this revised to be incorporated into Part 2 Inspection Rules. This information is not specific to Locomotives. R. Stone is PM. Passed unanimous

9. New Business
    a. Motion to accept a mission statement to provide a guide for the processing of action items by the Subgroup. Passed unanimous
        i. **Mission Statement of SG Locomotive Boilers**
        The mission of the NBIC Subgroup on Locomotive Boilers is to ensure that sufficient and accurate inspection and repair information for steam locomotive boilers is contained in the appropriate Parts of the NBIC. Information included shall be limited to that which applies to procedures not otherwise covered in other Sections or Parts of the NBIC, or in other applicable construction Codes for steam locomotive boilers.

    b. NB15-1702 Fillet Welded Staybolt Repair (pg 53) Motion to move to SC R&A, passed unanimous
    c. NB15-1701 Fillet Welded Staybolt Procedure (pg 52) Motion to move to SC Inspection, passed unanimous
    d. Discussion of ASME Action Item 14-2083 Stay bolt protrusion. Closed with no further discussion or action
10. Guest Questions
11. Next Meeting to be announced on the NB Website
12. Adjournment
13. Roster Attachment

NBIC Subgroup Locomotive - Committee Members

(M) = Member (MN) = Member non-voting

(M)	**Linn Moedinger (Chairman)**	Email linnwm@supernet.com
(M)	**Matthew A. Janssen (Vice Chairman)**	Email mjanssen@vaporlocomotive.com
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Subgroup Locomotives
National Board Item No. NB11-1805
Current Level: Subgroup moved to SC Inspection

NBIC Part 2 Paragraph(s): S1.4.2.9

Title: Staybolts
Date: Opened: April 2011

Background:
1) My reason for requesting these additions and changes was to add the values for the minimum allowable staybolt head thickness and minimum allowable staybolt head diameter of driven head staybolts.

2) The reasons we need to set these minimum values are:

A) Threaded staybolts do not have sufficient threads engaged in the firebox sheets to provide the threaded section sufficient strength to resist the operating loads by the length of thread engaged.

The normal rule used in mechanical engineering for the design of threaded fastener connections in ferrous material is for the minimum thread engagement length between the fastener and the part (the depth of the tapped hole into which the fastener threads and the length of the fastener threads that engage the tapped hole threads) to equal 1 x bolt diameter.

Therefore a 1" diameter staybolt requires 1" of thread engagement in the firebox sheet in order for the connection to rely only on the threads of both parts to provide the rated design strength.

However, the normal design of staybolted firebox used on our locomotive boilers does not enable this long threaded connection to be made. The reason for this is the firebox sheets usually are in the 3/8" - 1/2" thickness range. This limits the length of the threaded connection on flat surface to the sheet thickness.

The remaining strength of the threaded connection between the staybolt and the firebox sheet therefore is dependent on the design and condition of the threaded staybolt's driven head. The staybolt's driven head acts in the same manner as a standard nut applied to a standard bolt by providing to both the staybolt and the firebox plate additional strength. The additional strength is used to resist the action of the boiler pressure from forcing the firebox plate off of the staybolt. This applies to normal operation during overheating events up to the first transition temperature range when the strength of the staybolts and firebox plate is reduced.

B) The ASME B&PVC recognized the strength value of the different designs of driven head staybolts in both Section I and in Locomotive Boilers Section III. An example of this is shown on Part L-31 in the 1952 Edition of Locomotive Boilers Section III. In the formula the value "C" is used for the strength of the different size and types of staybolt heads.

3) I've given our Loco Sub-Group members copies of strength tests conducted by the Master Boiler Makers Association for different design staybolts heads. I can provide you and the rest of our group members another copy of this if you consider it useful. The test data shows that staybolts having smaller design driven heads have less resistance to being pulled out of the plate.

S1.4.2.9 STAYBOLTS

Staybolts shall be inspected for:

a) Cracks in or breakage of the body;
b) Erosion of the driven head from corrosion or combustion gases;
c) Staybolt head flush with or below the surface of the sheet;
d) Plugging of telltale holes except as permitted by 49 CFR Part 230.41;
e) Waterside corrosion;
f) Staybolt heads that have been covered over by welding; and
g) ~~Correct application of seal welding to Staybolt heads.~~

Notes: An indicator of waterside corrosion on threaded staybolts is the lack of threads on the section of the staybolt body ~~just above~~ adjacent to the sheet.

Broken staybolts may be detected by leakage through telltale holes and by hammer testing. Both methods are most effective when the boiler is under hydrostatic pressure of at least 95% MAWP.

If a hydrostatic test cannot be applied, the hammer test may be performed alone with the boiler drained.

When a broken staybolt is found, the staybolts adjacent to it should be examined closely because these may have become overstressed by addition of the load from the broken staybolt.

A telltale hole plugged by installation of a nail or pin may indicate the staybolt is broken and requires replacement.

A telltale hole plugged by refractory to prevent buildup of foreign matter in the telltale hole is permitted for locomotives operating under FRA Jurisdiction per 49 CFR Section 230.4.1.

One indication that a threaded staybolt leaks during service is when the head of it is found to have been re-driven repeatedly.

Voted by Subgroup: Passed Date: 3/25/2015

Subgroup Locomotives

National Board Item Numbers: NB13-1401 & NB13-1403. In addition, the new text also includes and replaces our original NBIC Part 3 sections S1.2.9.6: RE-ROLLING OF FLUE-TUBES AFTER SEAL WELDING and S1.2.9.8 FLUES SMALLER THAN 3 INCHES.

Current Level: Subgroup discussion

NBIC Part 3 Paragraph(s): S1.2.9.1 Title: INSTALLATION OF BOILER FLUES (Figures S1.2.9.1-a, S1.2.9.1-b, S1.2.9.1-c, S1.2.9.1-d & S1.2.9.1-e)

Note to group: I recommend we number this new section as S1.2.9.1. Then re-number the existing section S1.2.9.1 FLUE AND TUBE RE-ENDING as S1.2.9.6 and keep its original title. We can then delete our original sections S1.2.9.6: RE-ROLLING OF FLUE-TUBES AFTER SEAL WELDING and S1.2.9.8 FLUES SMALLER THAN 3 INCHES because the new text also includes and replaces both of them.

Date: Opened: November 2007 & April 2011

Rationale & Background:
Committee generated to provide guidelines for boiler flue installation in locomotive boilers.

In addition, this subject is based on the experiences of Mike Tillger with a boiler repair firm that cut the boiler flues too short for installation into a locomotive. The boiler repair firm personnel tried to heat the boiler flues during the installation process in order to lengthen them sufficiently to engage the tube sheet. When Mike questioned them about it they replied, "we do this all the time". Mike forbid it and sent them back to their shop to obtain the correct length flues.

This same problem also occurs in the power boiler industry for fire tube and water tube boilers on boiler tubes or boiler water wall tube panels have been cut too short or been formed to the wrong shape. The heating is used to lengthen the tubes or panels so they can be installed, but ignores the consequences of future tube failures caused by the tube contracting when it cools. This contraction places both the weld and tube metal under great tension that creates high stress and causes either the material or weld to crack.

On another occasion I encountered a locomotive boiler on which the firebox flue ends were machined to the required small diameter to fit the firebox tube sheet, instead of being swedged. This reduced the flue wall thickness considerably and made all of the flues unfit for use.

Existing NBIC Part 3 Sections To Be Replaced
~~S1.2.9.6: RE-ROLLING OF FLUE-TUBES AFTER SEAL WELDING:~~
~~All flues and tubes that are installed by rolling and seal welding shall be re-rolled after seal welding is complete).~~

Note #1: New Items 'q' and 'r' duplicate and replace existing NBIC section S.1.2.9.6 RE-ROLLING OF FLUE-TUBES AFTER SEAL WELDING.

~~S1.2.9.8 FLUES SMALLER THAN 3 INCHES~~
~~All flues smaller than 3"OD shall be rolled and beaded or rolled and seal welded on the firebox end, and at least one in ten at the front flue sheet end. All flues 3" OD and larger shall be rolled and beaded or rolled and seal welded at both ends and all adjacent flues smaller than 3" OD that are within the large flue pack shall be rolled and beaded or rolled and seal welded at both ends.~~

~~At least one in ten of the remaining flues smaller than 3" OD shall be beaded or seal welded on the front flue sheet in addition to rolling. Where less than all flues are seal welded or beaded on the front flue sheet those seal welded or beaded shall be distributed as evenly as practical throughout the flue pack. This shall be considered a repair.~~

Note #2: New Items 'n' and 'o' duplicate and replace existing NBIC section S1.2.9.8 "FLUES SMALLER THAN 3 INCHES".

Revised Title & Section
S1.2.9.1 Title: INSTALLATION OF BOILER FLUES (See Figures S1.2.9.1-a, S1.2.9.1-b, S1.2.9.1-c, S1.2.9.1-d & S1.2.9.1-e)

Flues used on locomotive boilers shall be installed in accordance with the directions of the original equipment manufacturer (OEM). If this information is not available, the following procedures shall be used.

a. Locomotive boiler flues shall be installed by the expanding method by use of either a roller-type expander or prosser-type expander unless the original design requires a different installation method be used. The prosser-type expanders shall be either the combination roller/prosser-type or the sectional prosser-type. The use of a combination roller/prosser expander instead of a segmented prosser expander is a repair. The expander length shall be sized to expand the flue across the entire width of the tube sheet and into the flue body. The expander rollers or prosser segments shall have smooth surfaces with smooth rounded corners or ends to prevent cutting or damaging the flue and tube sheet surfaces.

b. The deletion of prosser expanding from the flue expansion process is a repair provided the method used to expand the flue consists of roller expanding and seal welding, with or without beading.

c. Changing the method by which flues are installed from the method of expanding and beading, with or without seal welding the bead to the tube sheet, to the method of expanding straight without beading and then seal welding the straight flue end to the tube sheet is a repair.

d. The addition of seal welding to flues that are installed by expanding and beading into either the firebox or front tube sheets is a repair.

e. 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. Flues that are cut too short shall not be used unless repaired by re-ending. Refer to NBIC Part 3, Section S1.2.9.1 FLUE AND TUBE RE-ENDING for additional information. Flues shall be cut to the final required length by a mechanical cutting method such as sawing or by use of a roller pipe cutter. Cutting the flue to the required length by use of any torch or electric cutting process is prohibited. If flues are to be cut to the rough length by either the torch or electric cutting process, the cut line from these processes shall be located at least 1 in. (25.4 mm) from the final cutting edge length and the flue shall be cut to its finished length by use of a mechanical cutting method.

f. Prior to installing the boiler flues the boiler tube sheets shall be straightened or braced in their required position to prevent flexing in the event this is necessary using removable braces or strong-backs. All cut or damaged tube holes shall be repaired as required.

g. The clearance between the flue OD and tube sheet hole ID shall not exceed 0.030 in. (0.76 mm) unless the original design requires a different value be used.

h. When required by the original design, the ends of boiler flues shall be swedged to a smaller or larger diameter as required to fit the tube sheet holes. The swedging shall create smooth surfaces, smooth curves, and a uniform diameter reduction across the entire swedged length. Swedging shall be performed using dies. Machining the flue end to a smaller diameter to obtain the required swedge diameter is prohibited. When flues are swedged to a larger diameter, 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.

i. The surfaces of the flue and tube sheet holes shall be clean, dry, and free of all grease, tube rolling lubricant and oil prior to installing the flue, prior to beading, and prior to seal welding. If a lubricant is used to lubricate the flue expander during use, the lubricant shall be a water soluble-type to aid its removal and surface clean up.

j. Sharp edges on both sides of each tube sheet hole shall be removed prior to installing the flue and/or ferrule unless the original design requires a different method be used. When the hole edges are required to have a radius to prevent it cutting into the flue surface upon expansion, the dimension range of the radius shall be between 1/32 in. -1/16 in. (0.794 mm - 1.59 mm) unless the original design requires that a different value be used.

k. If ferrules are used, each ferrule shall be secured into position in the tube sheet hole by expanding and flaring (belling) prior to insertion of the flue. Each ferrule shall remain in position in the tube sheet hole without any movement or slippage during the flue installation and expansion process. The ferrule installation work shall be performed using the required size ferrule expander. Refer to NBIC Part 3, Section S1.2.9.7 FERRULES for additional information. The deletion of ferrules from the flue installation is a repair per Part S1.2.9.7 FERRULES provided the flues are made to or swedged to the required diameter to provide the required amount of expansion and minimum wall thickness reduction permitted by the original design

l. Each flue during installation shall be placed in its required position in both tube sheets and then be temporarily locked or fixed in place to prevent it from moving as it is expanded. Each flue shall have both ends expanded into its mating tube sheet holes using the required amount of expansion or wall thickness reduction required by the design. In the event the flue is to receive only an initial and partial expansion subsequent to performing beading, prossering or seal welding, the expansion work at both flue ends shall be completed to the extent that the flue is secured firmly in position within the tube sheet prior to performing this work. Upon completion of this work the flue shall be expanded to its final setting.

m. At the firebox tube sheet all flues regardless of size shall be expanded in combination with being either beaded, beaded and seal welded, or seal welded. The installation into the firebox tube sheet of flues that are expanded only is prohibited.

n. At the front tube sheet, when the boiler is fitted with both large and small diameter flues, all flues that are 3 in. (76.2 mm) OD or larger shall be expanded and beaded. In addition, all flues smaller than 3 in. (76.2 mm) OD located within the flue pack formed by the large diameter flues shall be expanded into the front tube sheet and beaded.

   All remaining flues in the front tube sheet that are smaller than 3 in. (76.2 mm) OD and located within the flue pack formed by the remaining small diameter flues shall be expanded and also shall be beaded per the number and location arrangement of the original design. If the original design did not require all remaining small diameter flues to be beaded, the beading shall be performed on at least one in every ten of these remaining small diameter flues. These beaded flues shall be located as evenly as practical throughout the small diameter flue pack. Increasing the number of small flues over the one-in-ten ratio is a repair.

o. At the front tube sheet, when the boiler is fitted with only small diameter flues not exceeding 3 in. (76.2 mm) OD all flues shall be expanded and also shall be beaded per the number and location arrangement of the original design.

p. Beading of flues shall be performed to prevent damaging the flue and tube sheet by cutting or grooving. The flue bead edge shall contact the tube sheet surface around the entire flue circumference upon completion of the beading work. The flue shall then be lightly re-expanded to confirm the beading process has not loosened it in the tube sheet hole. If the flue bead is to also be seal welded, this light re-expansion of the flue shall be performed upon completion of seal welding. Repair of a defective or incorrectly formed flue bead by welding is prohibited. Flues shall not be heated during the beading process. If ferrules are used, no part of the ferrule shall interfere with the forming of the bead.

   If the original design did not require that all small diameter flues be beaded, the beading shall be performed on at least one in every ten of the flues. These beaded small flues shall be located as evenly as practical throughout the flue pack. Increasing the number of small diameter flues that are beaded over the one-in-ten ratio, or beading all of the small diameter flues, is a repair.

q. When beaded flues are to be seal welded to the tube sheet, the flue shall first be expanded either partially or completely into the tube sheet hole, then beaded around its entire circumference and all oil or lubricant removed prior to seal welding. The tube sheet temperature shall not be less than 70°F (21°C) during the seal welding process. The seal weld size shall range between 1/8 in. - 1/4 in. (3.2 mm - 6.3 mm) and be applied as a fillet weld of the equal leg or unequal leg type unless the original design requires a different weld size or weld type be used. Upon completion of seal welding the flue shall either be expanded to its final setting or re-expanded lightly to confirm that the seal welding has not loosened it in the tube sheet hole. If ferrules are used, no part of the ferrule shall protrude from the bead and come into contact with the seal weld.

r. When flues are installed by expanding straight and seal welding without beading, each flue shall first be expanded either partially or completely into the tube sheet hole then all accessible oil or lubricant shall be removed prior to seal welding. The tube sheet temperature shall not be less than 70°F (21°C) during the seal welding process. The seal weld size shall range between 1/8 in. - 1/4 in. (3.2 mm - 6.3 mm) based on the flue thickness unless the original design required different values be used. See Figure S1.2.9.1-b and ASME Code, Sec I, Part PFT, Figure 12.1 for additional information regarding the seal weld size for this flue installation method.

The seal weld shall be applied so its horizontal (longitudinal outermost) edge is even and in line with the flue end upon completion. If flue end is longer and extends past the seal weld edge, the flue end shall be trimmed back and made even with the seal weld edge by filing or grinding. Then all sharp edges of the flue and seal weld shall be smoothed and rounded by filing, sanding, or grinding. Care shall be used to prevent tearing, cracking or overheating the flue during all trimming and smoothing work. Upon completion of the seal weld and trimming work, the flue shall either be expanded to its final setting or re-expanded lightly to confirm that the seal welding has not loosened it in the tube sheet hole.

s. If steel ferrules are used, the seal weld shall be sized and positioned to contact the flue end and tube sheet. The use of copper ferrules with this flue installation method is prohibited.

t. If it is necessary to determine the workmanship of the flue installation prior to seal welding the flues, the boiler shall be tested hydrostatically to either MAWP or to a lower value. If this test is done, the boiler shall be given its required hydrostatic test to MAWP upon completion of the seal welding work.

u. Any flue that show cracks within the expanded section or the flue bead upon completion of the flue installation process shall be replaced.

v. Cracks in seal welds shall be repaired by grinding out the crack and then reapplying the seal weld. These cracks often result from oil contamination of the weld seal. The temperature of the flue sheet shall not be less than 70°F (21°C) during the seal weld crack repair process. Upon completion of seal welding the flue shall be re-expanded lightly to confirm the seal welding has not loosened it.

w. The thickness of boiler flues shall equal the original design values. Changing the boilers flue thickness from the original value is an alteration.

New Figures S1.2.9.1-a, S1.2.9.1-b, S1.2.9.1-c, S1.2.9.1-d & S1.2.9.1-e are attached and are to be included as part of this action.

Voted by Subgroup: Date:

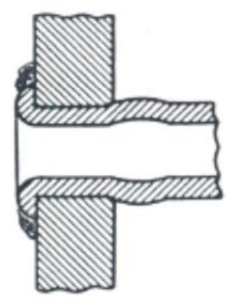
COMMON LOCOMOTIVE BOILER FLUE
INSTALLATION METHODS

Figure S1.2.9.1-a

ROLLER EXPANDED
& BEADED

PROSSER EXPANDED
& BEADED

ROLLER EXPANDED, BEADED
& SEAL WELDED

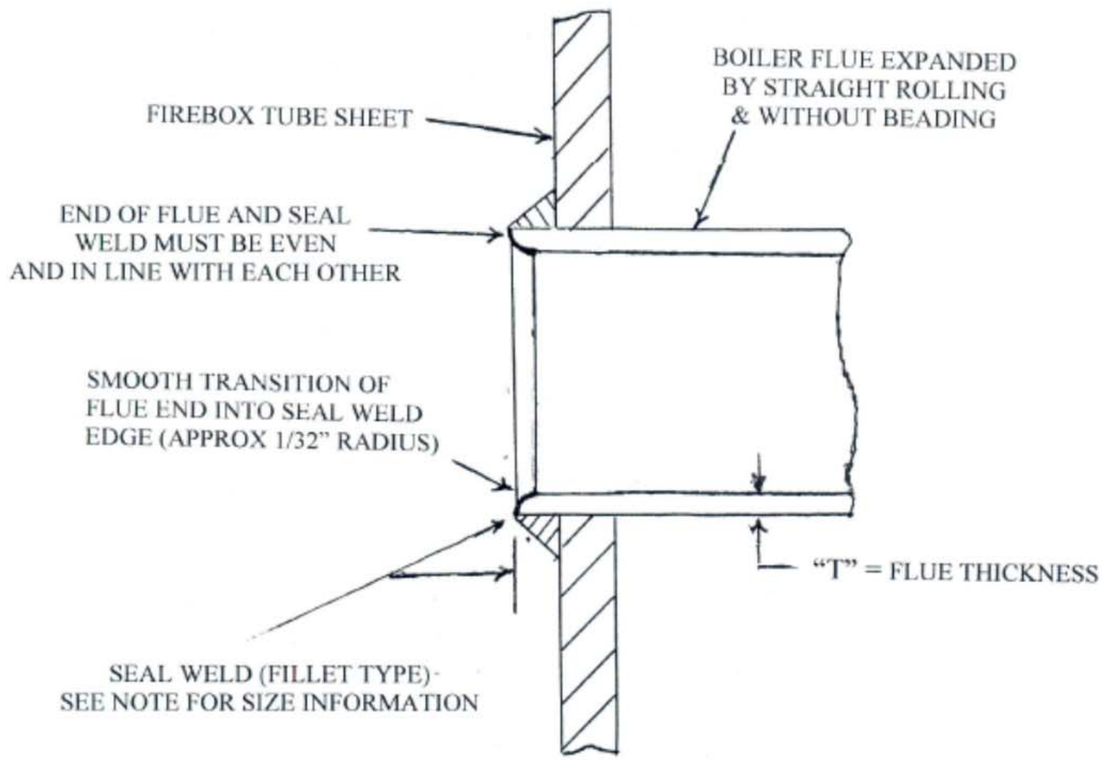


ROLLER EXPANDED, PROSSER
EXPANDED AT REAR
& SEAL WELDED

ROLLER EXPANDED USING
STRAIGHT ROLLER & SEAL WELDED -
SEE FIGURE S1.2.9.2 FOR DETAILS

METHOD OF INSTALLING LOCOMOTIVE BOILER FLUES
BY EXPANDING USING STRAIGHT ROLLER
EXPANDER & SEAL WELDING

Figure S1.2.9.1-b

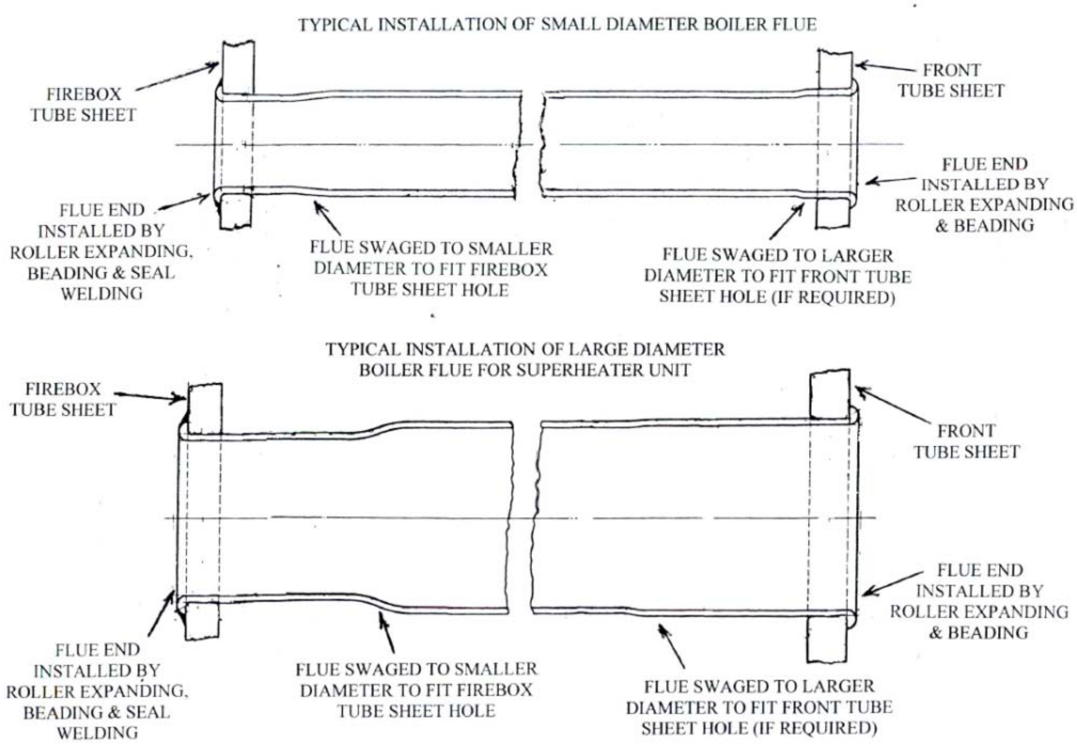


NOTE:
MINIMUM SEAL WELD SIZE TO BE NOT LESS THAN "T"
OR 1/8" (3.2 mm) WHICHEVER IS GREATER
&
MAXIMUM SEAL WELD SIZE TO BE NOT LARGER THAN
2 x "T" OR 1/4" (6 mm)

REF: ASME B&PVC SEC I, PART PFT, FIGURE PFT-12.1

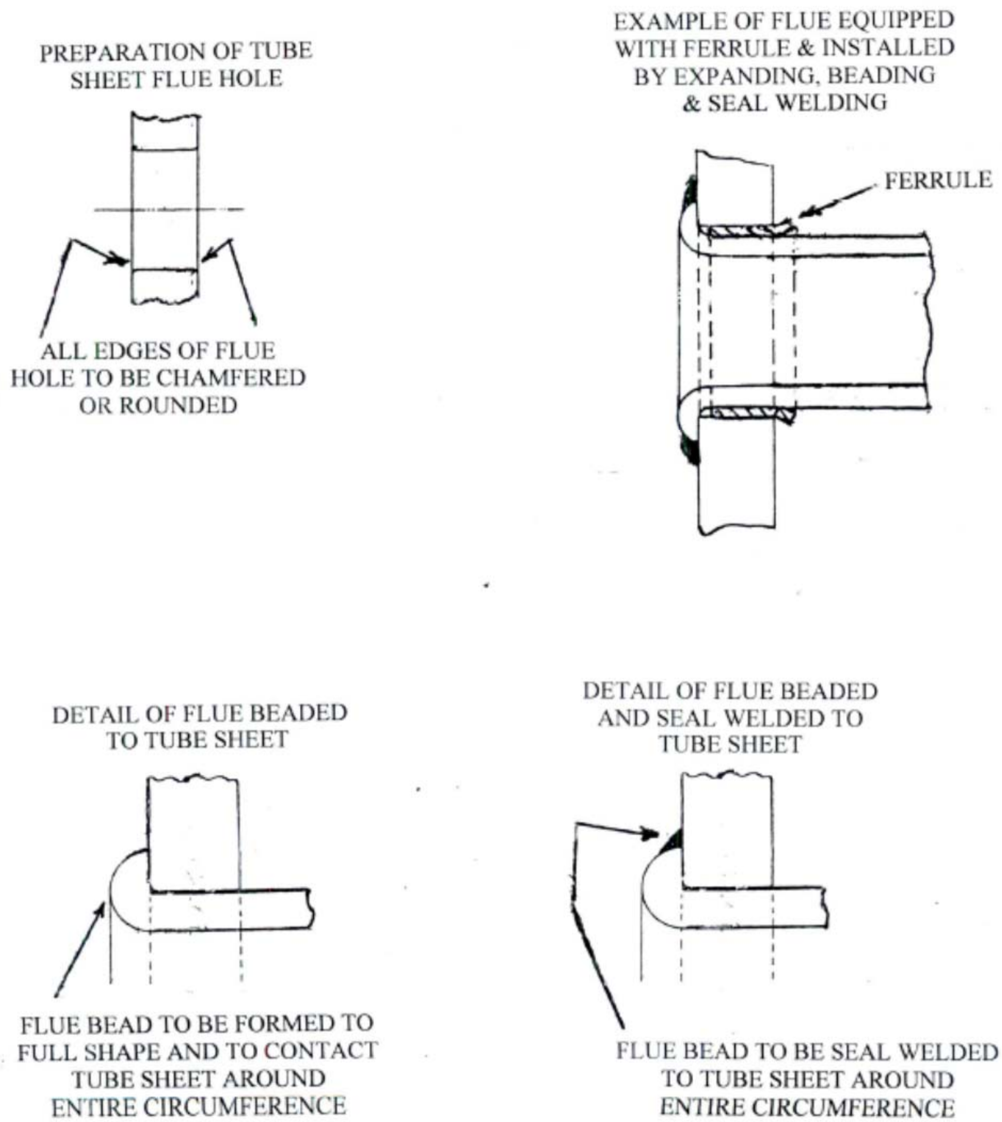
EXAMPLES OF LOCOMOTIVE BOILER FLUE INSTALLATION

Figure S1.2.9.1-c



DETAILS OF LOCOMOTIVE
BOILER FLUE INSTALLATION

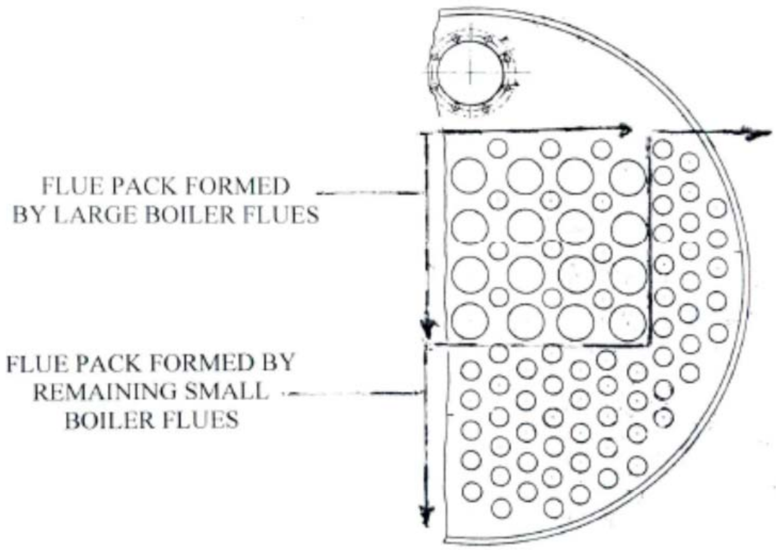
Figure S1.2.9.1-d



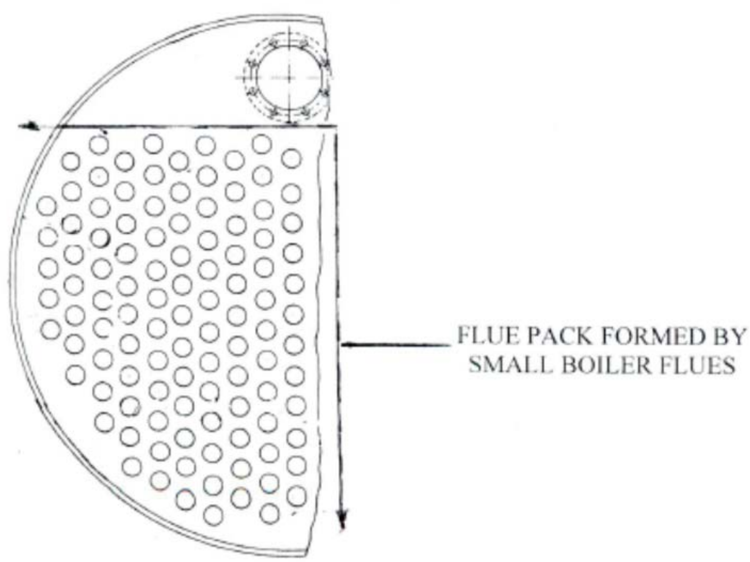
EXAMPLES OF FLUE PACK
ARRANGEMENT AT FRONT TUBE SHEET

Figure S1.2.9.1-e

FRONT TUBE SHEET WITH
LARGE AND SMALL BOILER FLUES



FRONT TUBE SHEET WITH
SMALL BOILER FLUES



Subgroup Locomotives National Board Item No. NB13-1403

Current Level: Subgroup

NBIC Part 3 Paragraph(s): At or near S1.2.9.2

Title: **Installation of Boiler Tubes & Arch Tubes**
Date Opened: April 2011

Background:
1. This subject is based on the experiences of Mike Tillger with a boiler repair firm that cut the boiler tubes too short for installation into a locomotive. The boiler repair firm personnel tried to heat the boiler tubes during the installation process in order to lengthen them sufficiently to engage the tube sheet. When Mike questioned them about it they replied, "we do this all the time". Mike forbid it and sent them back to their shop to obtain the correct length tubes.

This same problem also occurs in the power boiler industry for firetube and water tube boilers on which the boiler tubes and/or tube panels have been formed incorrectly (wrong the shape) or are cut too short.

2. I encountered a locomotive boiler on which the firebox tube ends were machined to a smaller diameter in order to obtain the required swedge size. The wall thickness reduction of the boiler tube this created was considerable and made the tubes unfit for use.

Proposed Action:

1. Boiler tubes and arch tubes shall be cut to or made to the correct length required for installation with all parts at ambient temperature. The use of heating or stretching the tube at installation to obtain the required length is prohibited. Tubes that are cut too short shall be rejected.

2. The ends of boiler tubes and arch tubes may be swedged to the diameter required to fit the tube sheet holes. The swedging shall create smooth surfaces, smooth curves, and a uniform diameter reduction across the entire swedged length. The creation of sharp corners, sharp edges or a partial collapse of tube interior within the swedged section is prohibited. Tubes that are swedged incorrectly shall be rejected.

Swedging shall be performed using dies whenever possible.
Machining the tube end to obtain the required swedge diameter is prohibited.

3. Bends in boiler tubes and arch tubes shall be formed to correct shape and curvature required for installation with all parts at ambient temperature. The bending work shall be performed to create smooth surfaces over the entire bend. The creation of sharp corners,

sharp edges, or a partial collapse of tube interior within the bend is prohibited.

The use of heating or stretching the tube at installation to obtain the correct bend shape is prohibited. Tubes that are formed to the wrong shape or curvature shall be rejected.

Subgroup voted Date:

Subgroup Locomotives National Board Item No. NB13-1404

Current Level: Subgroup

NBIC Part 2 & 3 Paragraph(s): To Be Determined

Title: Fillet welded staybolts
Date Opened: April 2011

Background:

Fillet welded staybolts
A Task group consisting of Griner, Moedinger, Janssen, and Rimmasch
Committee thoughts
Part 2 – leakage, look at heads, welds
Part 3 – Method + NDE, do not allow threaded to be changed to fillet welded.

Proposed Action:

Subgroup voted Date:

Subgroup Locomotives National Board Item No. NB13-1407

Current Level: Subgroup discussion

NBIC Part 3 Paragraph(s): S1.2.7.1 Title: **Bolts, Nuts & Washers**

Date Opened: April 2013

Background:
To provide guidance for the repair and replacement of the bolts, nuts and washers used on locomotive boilers for assembly of pressure retaining components.

Proposed Action:

Bolts, nuts and washers used on locomotive boilers for assembly of pressure retaining components, shall be maintained, repaired or replaced in accordance with the directions of the original equipment manufacturer. If this information is not available, the following procedures shall be used.

a. Bolts, nuts and washers that have wastage, corrosion or mechanical damage, sufficient to impair the holding power or function of the fastener shall be replaced.

b. Bolts and nuts that have damaged threads may be repaired by re-threading.

c. Replacement bolts, nuts and washers shall have the same fit-up, alignment and thread engagement length as the original.

d. The use of replacement bolts, nuts and washers of a different strength, grade specification or size than the original shall be suitable for the service intended.

Note 1: For material requirements for bolts and nuts can be found in Table S1.1.3.1

Note 2: If a bolt or nut is heated to a metal temperature that exceeds 1100°F (593°C), it will be damaged or suffer a reduction of hardness and should be replaced.

Subgroup voted Date:
Subgroup Locomotives

Subgroup Locomotives

National Board Item No. NB13-1408. This new section includes and replaces the existing NBIC section S.1.2.7 THREADED STUDS

Current Level: Subgroup

NBIC Part 3 Paragraph(s): Locate at S1.2.7.2 (Note: This is the location of existing section THREADED STUDS) Patch Bolts S1.2.7.3 from S1.2.8

Date Opened: April 2013

Background: To provide guidance for the repair and replacement of taper thread boiler studs. These are studs that thread directly into the boiler by use of a boiler-type taper thread. The mating taper thread tapped hole in the boiler shell and the taper threaded stud body end usually extend directly through the boiler shell. The opposite end of the stud is machined with standard straight machine-type threads to permit attachment of a nut and washer. These are used to secure a boiler or related locomotive component such as a pipe bracket for boiler piping, dome cover.

Existing title and section:

~~S1.2.7 THREADED STUDS Threaded Fasteners~~

~~Studs threaded into the boiler or firebox sheets shall not be seal welded.~~

Revised title and section: S1.2.7.2 TAPER THREAD BOILER STUDS (SEE NBIC PART 3, FIGURES S1.2.7.2-a, S1.2.7.2-b & S1.2.7.2-c)

Taper thread boiler studs are designed to thread directly into the boiler shell and are used to secure locomotive boiler components or related locomotive components such as pipe brackets for boiler piping, dome cover and feed water check valves. The stud end that threads into the boiler shell is machined with a boiler-type taper thread and the mating hole in the boiler shell is tapped with the same boiler-type taper thread. The opposite end of the stud is machined with standard straight machine screw-type threads to permit attachment of the components along with a nut and washer.

Taper thread boiler studs used on locomotive boilers shall be maintained, repaired or replaced in accordance with the directions of the original equipment manufacturer. If this information is not available, the following procedures shall be used.

a) Taper thread boiler studs and the mating tapped holes shall be made to the required size and taper to create a tight and leak free joint upon final tightening. The stud taper threads shall have a good uniform fit along the entire length of the tapped hole threads and not just at the top or bottom edges of either the stud or hole. When the hole threads are to be tapped in new material or re-tapped for repair or cleaning the taper tap shall be run through the entire hole depth in order to form all threads correctly. The length of the taper thread section shall be sized so that upon the stud being tightened at final assembly at least one full thread shall be above the boiler shell exterior surface and at least one full thread shall extend beyond the interior surface. (See Fig.S1.2.7.2-c)

b) When taper thread boiler studs are installed into blind holes on the boiler shell or sheet the taper section length shall be confirmed to be shorter than the hole depth in order to prevent the stud from contacting the hole bottom upon being tightened at final assembly.

c) Studs and boiler shell surfaces that are cracked or damaged shall be either repaired or replaced per items “f” and “g” of this section.

b) Changes to the taper, thread pitch or thread form of the taper thread boiler stud or its mating tapped hole in the boiler shall be suitable for the service intended.

c) Replacement taper thread boiler studs of a different strength, grade specification or size than the original shall be suitable for the service intended.

f) A worn or damaged taper thread stud hole may be repaired by re-tapping it to a larger diameter and installing a taper thread boiler stud that has a corresponding larger diameter boiler thread end than the original stud. The largest portion of the tapered section of the stud shall not exceed the original stud straight section (shank) diameter by 33%. The larger diameter boiler stud shall be made with a 1/8 inch (3mm) radius from the stud body into the larger diameter boiler thread end.

g) Oversize cracked or damaged boiler studs holes in the boiler shell may be repaired by weld build-up or by replacing the damaged plate section using a flush patch. If weld build-up is performed, the existing boiler stud threads shall be removed from the hole by reaming, grinding or machining prior to welding. All welding and welded repairs shall be performed per NBIC Part 3.

a) Taper thread boiler studs, nuts and washers that have wastage, corrosion or mechanical damage, sufficient to impair the holding power or function of the fastener shall be replaced.

b) Taper thread boiler studs and nuts that have damaged threads may be repaired by re-threading.

c) Replacement taper thread boiler studs, nuts and washers shall have the same fit-up, alignment and thread engagement length as the original.

d) The use of replacement taper thread boiler studs, nuts and washers of a different strength, grade specification or size than the original shall be suitable for the service intended.

Note 1: For material requirements for bolts and nuts can be found in Table S1.1.3.1

Note 2: If a taper thread boiler stud or nut is heated to a metal temperature that exceeds 1100°F (593°C), it will be damaged or suffer a reduction of hardness and should be replaced.

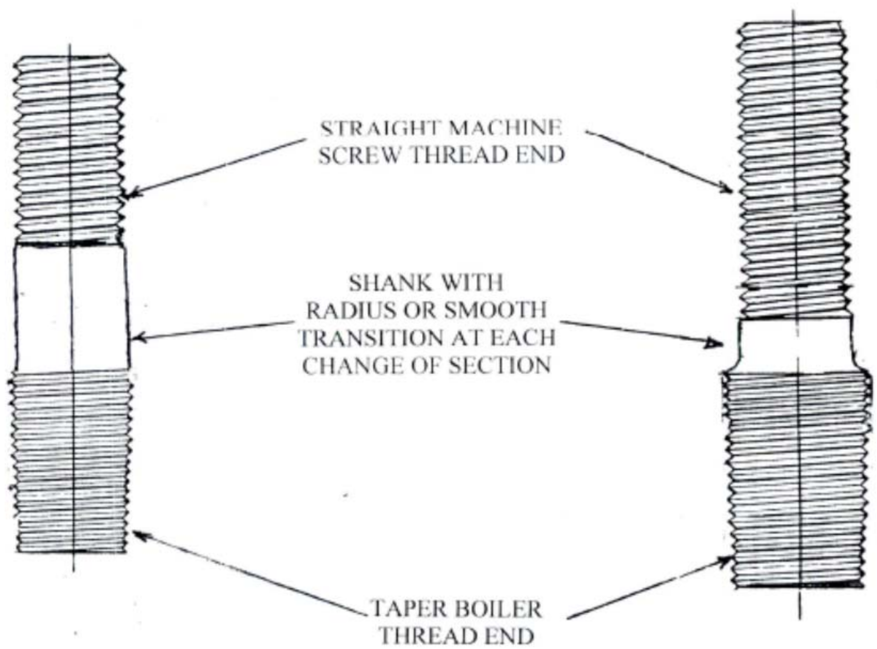
New Figures S1.2.7.2 –a, S1.2.7.2-b and S1.2.7.2-c are attached are to be included as part of this action.

Subgroup voted Date:

EXAMPLES OF TAPER
THREAD BOILER STUDS

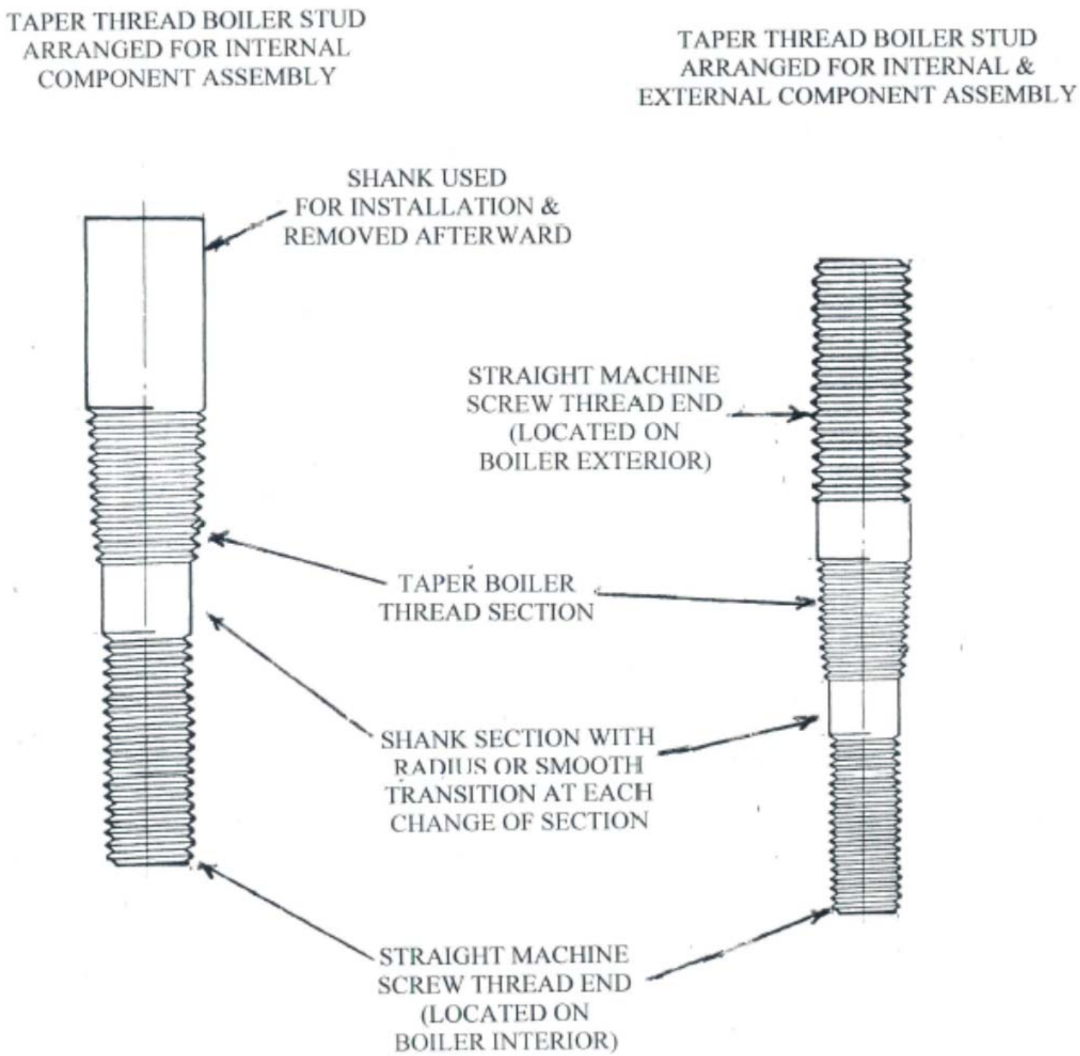
Figure S1.2.7-a

TAPER THREAD BOILER STUDS
ARRANGED FOR EXTERNAL
COMPONENT ASSEMBLY



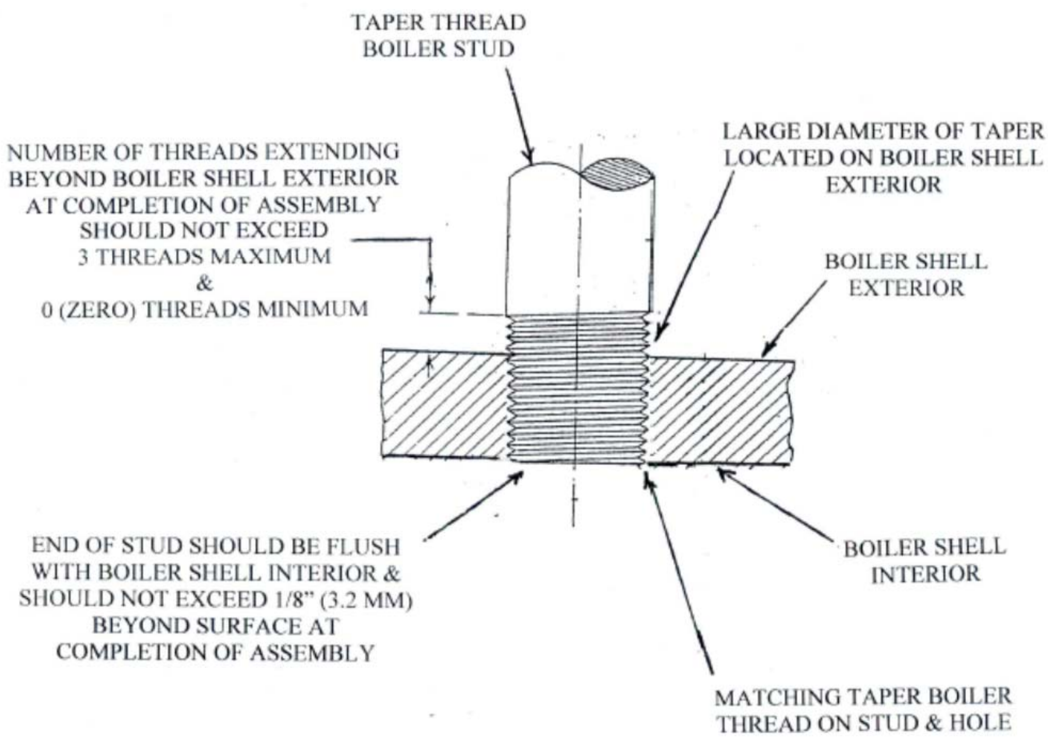
ADDITIONAL EXAMPLES OF TAPER
THREAD BOILER STUDS

Figure S1.2.7-b



TYPICAL INSTALLATION OF
TAPER THREAD BOILER STUD
IN A THROUGH HOLE

Figure S1.2.7-c



Subgroup Locomotives National Board Item No. NB13-1409

Current Level: Subgroup New Business

NBIC Part 2 Paragraph(s): To be determined

Title: Method for Analyzing Bulges Created by Overheating In Stayed Boiler Surfaces

Date Opened: April 16,2013

This item is submitted by Richard Stone

As you know, my "Calculation Method For Analyzing Bulges In Stayed Firebox Sheets" has been used by the historic boiler and locomotive boiler groups to set limits for the allowable bulge depth on the stayed firebox sheets of their particular boiler types. I suggest the National Board incorporate my method's principle calculations into the "Inspection Section" of the NBIC as a way to assist National board inspectors and repair firms with the evaluation of bulges caused by the overheating of the stayed boiler surfaces of other boiler types. My method would be useful for analyzing bulges caused by overheating on the stayed surfaces of boilers made by manufacturers that are now out of business since the engineering resources of these firms would not be available for consultation. The benefits of my method and calculations for analyzing bulges caused by overheating on the stayed surfaces are :

1) It provides a simple way to determine the normal deflection (bulge depth) of the stayed surface during normal operation in order to compare it to the as-found bulged condition.

2) It provides a simple and fast way to determine the extent of the weakening that occurred to produce the as -found bulged condition.

3) It provides a simple and fast method to determine the temperature that the overheated stayed surface was heated to as the bulge formed.

This in turn will serve to aid boiler owners and operators to understand the seriousness of the bulging event. I've included additional information about how a National Board inspector would perform their inspection and use my calculations within my report. It is listed in the Section "Recommended Use Of This Inspection Method By The NBIC Inspector**.** I've attached a copy of my report, the illustrations and the reference documents at the bottom of this e-mail.

Background:
Bulging of the firebox sheet between the staybolt rows while the staybolts and staybolt heads remain in satisfactory condition is a serious condition. If the bulging action continues, it can result either in the firebox sheet rupturing or pulling completely off of numerous staybolts.

Bulging usually is caused by the firebox sheet becoming overheated as result of the inability of the sheet to transfer the combustion heat rapidly into the water.

The common causes for the loss of heat transfer and overheating are:

- Scale buildup on sheet waterside.

- Poor heat transfer caused by problems with water chemistry.

- Excessive heat on the sheet fireside caused by over-firing.

- Loss of water circulation on sheet waterside. This can result from conditions such as foaming of the boiler water or an obstruction on the waterside that reduces the rate of water circulation over the sheet.

- Operation with insufficient water to cover the waterside surface of the sheet.

The bulging stops when the firebox sheet becomes cool after water circulation resumes over it. The resumption of the water circulation and cooling likely are the result of the following:

- The obstruction or scale breaks off the firebox sheet waterside.

- The foam bubbles become dissipated by the change in the water circulation pattern that the firebox sheet bulge creates.

- The firing rate is reduced.

Proposed Action: Submit to Part 2 SC Pages 50-
RECOMMENDED USE OF THIS INSPECTION METHOD BY THE NBIC INSPECTOR

1. National Board inspectors can use my two formulas when inspecting and evaluating bulges on stayed firebox sheets of historic and locomotive boilers.

   The formulas and terms are explained in detail in the section "Analysis Method. The calculations for results listed in Table #1 are in the section "Calculations for Table #1". In addition, see Figures #1 & #2.

2. The primary formula is:

   def = maximum bulging (deflection) of firebox sheet = $\frac{5 \text{ x } W \text{ x } p^3}{384 \text{ x } E \text{ x } I}$

   (Ref: Machinery's Handbook, 20th edition, 1978, Industrial Press, Page 412)

   This is the formula for calculating the deflection of a simply supported beam under uniform load. The deflection is calculated at the center of the beam and is the maximum value.

   The beam formula equates the bulge (the deflection of the firebox sheet) to the reduction to the modulus of elasticity of the firebox sheet material that the overheating causes.

   The modulus of elasticity, which is the ratio between unit stress to unit strain within the proportional limit of the firebox steel, is dependent on the firebox sheet temperature and becomes lower as the firebox sheet temperature increases. Therefore, by using the reduction of the modulus of elasticity as the primary variable for the calculation, the temperature that the firebox sheet was overheated to during the bulging event can be estimated.

   In addition, this method does not require the staybolt diameter be included in the calculations. Although for some configuration including the staybolt diameter would shorten the beam length and strengthen the beam, the staybolts are ignored to be both conservative and to simplify the work.

   The terms and symbols used in the formula are:

   I = calculated moment of inertia of the beam for deflection at its outermost face. For the bulged firebox plate the beam width (b) represents a 1 in. (25 mm) wide section of the bulged firebox section. The beam thickness (d) equals the firebox plate thickness (t). The beam length (b) equals the staybolt pitch (p).

   For reference the beam cross sectional area equals the 1 in. (25 mm) beam width (b) times the firebox plate thickness (t).

The beam moment of inertia "I" is calculated by the following formula:

$$I = \frac{b \times d^3}{3} = \frac{b \times t^3}{3}$$

(Ref: Machinery's Handbook, 20th edition, 1978, Industrial Press, Page 379)

b = 1 in. (25 mm) width of the firebox sheet at the bulged section. This represents the beam width.

t = thickness of bulged firebox sheet. This represents the beam depth "d".

p = longitudinal or vertical pitch of staybolts at the bulged firebox section

MAWP = maximum allowable boiler pressure

W = total load on the 1 in. (25 mm) wide pitch length of the firebox sheet = MAWP x p x 1 in.

E = modulus of elasticity of the firebox steel at ambient temperature and normal operating temperature = 29,000,000 psi (199950 MPa). (Ref: Machinery's Handbook, 20th edition, 1978, Industrial Press, Page 452 – see the value for common structural carbon steel)

$E_{x/x"}$ = the reduced value of the modulus of elasticity of the firebox steel needed to obtain the bulge depth found on the firebox sheet.

Bulge Depth = the bulge depth found on the firebox sheet.

3. The inspection method I recommend the NBIC inspector use when evaluating a bulged condition on a stay bolted firebox sheet is:

A. First determine the normal bulge depth (deflection) of the firebox sheet during its normal operating condition at MAWP and normal operating temperature. For this method the normal (standard) value of the modulus of elasticity of the firebox steel is used.

B. Then determine the reduction of the modulus of elasticity of the standard firebox steel that would be required to obtain the as-found bulged condition on the firebox sheet.

For this second calculation the following terms are used:

$E_{x/x"}$ = the reduced value of the modulus of elasticity of the firebox steel needed to obtain the bulge depth found on the firebox sheet.

Bulge Depth = the bulge depth found on the firebox sheet.

The first formula then is re-written to solve for the $E_{x/x”}$:

$$E_{x/x”} = \frac{5 \times W \times p^3}{384 \times \text{Bulge Depth} \times I}$$

NOTE:

Should it be necessary to determine bulge depth (deflection) of the firebox sheet at the first transition temperature of the firebox steel [approximately 1100° F (593°C)], a lower value of the modulus of elasticity of the standard firebox steel (E1) must be used in the first formula.

The strength reduction to the modulus of elasticity of the firebox steel at the first transition temperature is 28% of the standard E value. (Ref: Machinery’s Handbook, 20th edition, 1978, Industrial Press, Page 454 “Table For Influence Of Temperature On The Strength Of Metals”).

Therefore E1 = 28% x 29,000,000 = 8,120,000 psi (55985 MPa)

ANALYSIS METHOD

Reference: Machinery’s Handbook, 20th edition, 1978, Industrial Press, Pages 358, 379, 412, 452 & 454

1. The bulged section of the firebox sheet is analyzed as a simply supported beam that is uniformly loaded by the boiler pressure. Each end of the beam is assumed to be supported by the staybolt located at each end of it.

2. The beam width (b) is taken as a 1 in. (25 mm) wide section of the firebox sheet. The beam length (p) is the horizontal or vertical pitch distance of the staybolt pattern (the centerline distance of the two staybolts at the bulge location on the firebox sheet). The choice between the use of the horizontal or vertical pitch distance is dependent on the orientation of the bulge.

   For reference the beam cross sectional area is a rectangle and equals the 1” beam width (b) times the firebox plate thickness (t).

3. The bending load on the beam (the bulged plate section) equals the staybolt pitch length (p) times the boiler pressure (MWAP). To obtain the maximum bending stress

for this analysis the concentrated bending load is assumed to be positioned at the beam centerline. This places it in the center (middle) of the staybolt pitch length.

4. The deflection of the beam (the bulged plate section) is calculated at its fireside surface. Therefore the reference location for the extreme fiber section of the beam is taken at the firebox plate's fireside surface.

5. The staybolt diameter is not needed for this analysis method. Although including the staybolts would shorten the beam length and strengthen the beam, to be conservative the staybolts are ignored.

6. The variable for the beam calculation is the modulus of elasticity of the firebox steel. The modulus of elasticity, which is the ratio between unit stress to unit strain within the proportional limit of the firebox steel, is dependent on the firebox sheet temperature and becomes lower as the sheet temperature increases. This enables the bulging and weakening of the firebox steel by the overheating to be calculated by using the reduction of the modulus of elasticity as the primary variable for the calculation.

7. The primary formula is:

   def = maximum bulging (deflection) of firebox sheet = $\frac{5 \times W \times p^3}{384 \times E \times I}$

   This is the formula for calculating the deflection of a simply supported beam under uniform load. The deflection is calculated at the center of the beam and is the maximum value.

   The beam moment of inertia "I" for deflection at its outer face is calculated by the following formula:

   $$I = \frac{b \times d^3}{3} = \frac{b \times t^3}{3}$$

   b = 1 in. (25 mm) width of the firebox sheet at the bulged section. This represents the beam width.

   t = thickness of bulged firebox sheet. This represents the beam depth "d"

   p = longitudinal or vertical pitch of staybolts at the bulged firebox section

   MAWP = maximum allowable boiler pressure

   W = total load on the pitch length of the firebox sheet = MAWP x p x 1 in. (25 mm) width

E = modulus of elasticity of the firebox steel at ambient temperature and normal operating temperature = 29,000,000 psi (199950 MPa). (Ref: Machinery's Handbook, 20th edition, 1978, Industrial Press, Page 452 -see the value for common structural carbon steel)

E1 = modulus of elasticity of the firebox steel at the first transition temperature [approximately 1100° F (593°C)] and is 28% of the standard E value. (Ref: Machinery's Handbook, 20th edition, 1978, Industrial Press, Page 454 "Table For Influence Of Temperature On The Strength Of Metals").

Therefore E1 = 28% x 29,000,000 = 8,120,000 psi (55985 MPa)

$E_{x/x"}$ = the reduced value of the modulus of elasticity of the firebox steel needed to obtain the deflection (bulge depth) listed in the example.

EXAMPLE:
CALCULATIONS FOR TABLE #1
Analysis of a 3/8 in. (10 mm) thick steel firebox sheet with a 4 in. (100 mm) staybolt pitch operating at 200 psi (1.5 MPa).

b = 1 in. (25 mm) width of the firebox sheet at the bulged section. This represents the beam width.

t = thickness of bulged firebox sheet. This represents the beam depth "d" = 3/8 = .375 in. (10 mm)

p = longitudinal pitch of staybolts at the bulged firebox section = 4 in. (100 mm)

MAWP = maximum allowable boiler pressure = 200 psi (1.5 MPa)

W = total load on the pitch length of the firebox sheet = MAWP x p x 1
= 200 x 4 x 1" = 800 lb (362 kg)

E = modulus of elasticity of the firebox steel at ambient temperature and normal operating temperature = 29,000,000 psi (199950 MPa)

E1 = modulus of elasticity of the firebox steel at the first transition temperature (approximately 1100° F) = 28% x 29,000,000 = 8,120,000 psi. (55985 MPa)

E2 = modulus of elasticity of the firebox steel at the second transition temperature (approximately 1500° F) = 10% x 29,000,000 = 2,900,000 psi. (19995 MPa)

$E_{x/x''}$ = the reduced value of the modulus of elasticity needed to obtain the bulge deflection value listed in the example.

I = moment of inertia of the 1 in. (25 mm) **wide firebox plate section that represents the beam**

$$= \frac{b \times d^3}{3} = \frac{b \times t^3}{3} = \frac{1 \times (.375)^3}{3} = .0176 \text{ in}^4 \text{ (7316 mm^4)}$$

def = maximum deflection at center of bulge = $\frac{5 \times W \times p^3}{384 \times E \times I}$

<u>Deflection At MAWP & Normal Operating Temperature</u>

E = 29,000,000 psi (199950 MPa)

$$= \frac{5 \times W \times p^3}{384 \times E \times I}$$

$$\frac{5 \times 800 \text{ lb} \times (4)^3}{384 \times 29{,}000{,}000 \times .0176} = .001306 \text{ in. (1.30 mm)}$$

Deflection At 1st Transition Temperature

E1 = .28 x E = .28 x 29,000,000 = 8,120,000 psi (55985 MPa)

$$\frac{5 \times W \times p^3}{384 \times E1 \times I}$$

$$\frac{5 \times 800 \times (4)^3}{384 \times 8{,}120{,}000 \times .0176} = .00466 \text{ in. (0.118 mm)}$$

Deflection At 2nd Transition Temperature

E2 = .10 x E = .10 x 29,000,000 = 2,900,000 psi (19995 MPa)

$$\frac{5 \times W \times p^3}{384 \times E2 \times I}$$

$$\frac{5 \times 800 \times (4)^3}{384 \times 2{,}900{,}000 \times .0176} = .013 \text{ in. } (0.33 \text{ mm})$$

Modulus of Elasticity Required To Obtain 1/16 in. (1.5 mm) Deflection

def = 1/16 = .0625 in. (1.5 mm)

$$E_{1/16''} = \frac{5 \times W \times p^3}{384 \times def \times I}$$

$$\frac{5 \times 800 \times (4)^3}{384 \times .0625 \times .0176} = 606{,}060 \text{ psi } (164718 \text{ MPa})$$

Modulus of Elasticity Required To Obtain 1/8 in. (3 mm) Deflection

def = 1/8 = .125 in. (3 mm)

$$E_{1/8''} = \frac{5 \times W \times p^3}{384 \times def \times I}$$

$$\frac{5 \times 800 \times (4)^3}{384 \times .125 \times .0176} = 303{,}030 \text{ psi } (82360 \text{ MPa})$$

Modulus of Elasticity Required To Obtain ¼ in. (6 mm) Deflection

def = 1/4 = .250 in. (6 mm)

$$E_{1/4''} = \frac{5 \times W \times p^3}{384 \times def \times I}$$

$$\frac{5 \times 800 \times (4)^3}{384 \times .250 \times .0176} = 151{,}515 \text{ psi } (1046 \text{ MPa})$$

Modulus of Elasticity Required To Obtain 3/8 in. (10 mm) Deflection

def = 3/8 = .375 in. (10 mm)

$$E_{3/8''} = \frac{5 \times W \times p^3}{384 \times def \times I}$$

$$\frac{5 \times 800 \times (4)^3}{384 \times .375 \times .0176} = 101{,}010 \text{ psi } (697 \text{ MPa})$$

Percentage Reduction of Modulus of Elasticity Required To Obtain .00466 in. (0.113 mm) Deflection of Firebox Sheet At 1st Transition Temperature

$$\frac{29{,}000{,}000 - 8{,}120{,}000}{29{,}000{,}000} \times 100 = 72\%$$

Percentage Reduction of Modulus of Elasticity Required To Obtain .013 in. 0.33 mm) (Deflection of Firebox Sheet At 2nd Transition Temperature

$$\frac{29{,}000{,}000 - 2{,}900{,}000}{29{,}000{,}000} \times 100 = 90\%$$

Percentage Reduction of Modulus of Elasticity Required To Obtain 1/16 in. (1.5 mm) Deflection of Firebox Sheet

$$\frac{29{,}000{,}000 - 606{,}}{29{,}000{,}000} \times 100 = 97.9\%$$

Percentage Reduction of Modulus of Elasticity Required To Obtain 1/8 in. (3 mm) Deflection of Firebox Sheet

$$\frac{29{,}000{,}000 - 303{,}030}{29{,}000{,}000} \times 100 = 98.95\%$$

Percentage Reduction of Modulus of Elasticity Required To Obtain ¼ in. (6 mm) Deflection of Firebox Sheet

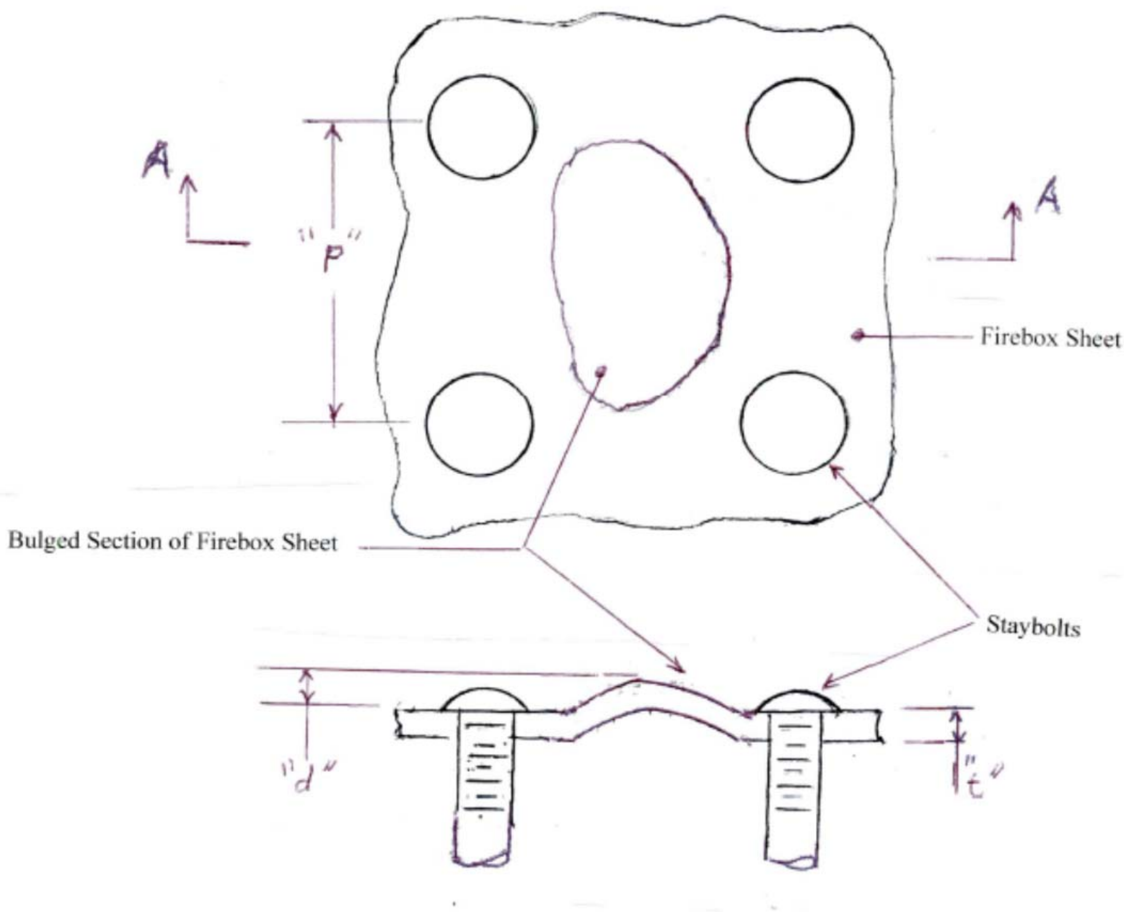
$$\frac{29{,}000{,}000 - 151{,}515}{29{,}000{,}000} \times 100 = 99.47\%$$

Percentage Reduction of Modulus of Elasticity Required To Obtain 3/8 in. (10 mm) Deflection of Firebox Sheet

$$\frac{29{,}000{,}000 - 101{,}010}{29{,}000{,}000} \times 100 = 99.7\%$$

Bulged Firebox Sheet
Analysis Method

Figure #1



Sec A - A

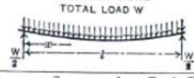
p = staybolt pitch

t = firebox sheet thickness

d = depth of bulge

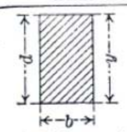
b = width of beam section = 1"

Stresses and Deflections in Beams

Type of Beam	Stresses: General Formula for Stress at any Point	Stresses: Stresses at Critical Points	Deflections (*See footnote*): General Formula for Deflection at any Point	Deflections (*See footnote*): Deflections at Critical Points
Case 1. — Supported at Both Ends, Uniform Load TOTAL LOAD W 	$s = -\frac{W}{2Zl}x(l-x)$	Stress at center, $-\frac{Wl}{8Z}$ If cross-section is constant, this is the maximum stress.	$y = \frac{Wx(l-x)}{24EIl}[l^2 + x(l-x)]$	Maximum deflection, at center, $\frac{5}{384}\frac{Wl^3}{EI}$

STRENGTH OF MATERIALS 379

Moments of Inertia, Section Moduli, etc., of Sections

A = area y = distance from axis to extreme fiber	Moment of Inertia I	Section Modulus $Z = \frac{I}{y}$	Radius of Gyration $k = \sqrt{\frac{I}{A}}$
 $A = bd;\ y = d$	$\frac{bd^3}{3}$	$\frac{bd^2}{3}$	$\frac{d}{\sqrt{3}} = 0.577\,d$

454 STRENGTH OF MATERIALS

Influence of Temperature on the Strength of Metals

Material	Degrees Fahrenheit 210	400	570	750	930	1100	1300	1475
	Strength in Per Cent of Strength at 70 Degrees F.							
Wrought iron	104	112	116	96	76	42	25	15
Cast iron	....	100	99	92	76	42	....	....
Steel castings	109	125	121	97	57	....	....	....
Structural steel	103	132	122	86	49	28	....	....
Copper	95	85	73	59	42	....	....	....
Bronze	101	94	57	26	18	....	....	....

Subgroup voted **Date:**

Note: Use ASME Section II Part D Table TM-1 to determine Moduli of Elasticity at temperature. Tables follow:

(10)

TABLE TM-1
MODULI OF ELASTICITY *E* OF FERROUS MATERIALS FOR GIVEN TEMPERATURES

Materials	Modulus of Elasticity E = Value Given × 10^6 psi, for Temperature, °F, of																	
	−325	−200	−100	70	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
Carbon steels with C ≤ 0.30%	31.4	30.8	30.3	29.4	28.8	28.3	27.9	27.3	26.5	25.5	24.2	22.5	20.4	18.0	...	...	...	...
Carbon steels with C > 0.30%	31.2	30.6	30.1	29.2	28.6	28.1	27.7	27.1	26.4	25.3	24.0	22.3	20.2	17.9	15.4	...	...	...
Material Group A [Note (1)]	31.1	30.5	30.0	29.0	28.5	28.0	27.6	27.0	26.3	25.3	23.9	22.2	20.1	17.8	15.3	...	...	...
Material Group B [Note (2)]	29.6	29.0	28.6	27.8	27.1	26.7	26.2	25.7	25.1	24.6	23.9	23.2	22.4	21.5	20.4	19.2	17.7	...
Material Group C [Note (3)]	31.6	30.9	30.5	29.6	29.0	28.5	28.0	27.4	26.9	26.2	25.6	24.8	23.9	23.0	21.8	20.5	18.9	...
Material Group D [Note (4)]	32.6	31.9	31.4	30.6	29.9	29.4	28.8	28.3	27.7	27.0	26.3	25.6	24.7	23.7	22.5	21.1	19.4	...
Material Group E [Note (5)]	33.0	32.4	31.9	31.0	30.3	29.7	29.2	28.6	28.1	27.5	26.9	26.2	25.4	24.4	23.3	22.0	20.5	...
Material Group F [Note (6)]	31.2	30.7	30.2	29.2	28.4	27.9	27.3	26.8	26.2	25.5	24.5	23.2	21.5	19.2	16.5	...	...	...
Material Group G [Note (7)]	30.3	29.7	29.2	28.3	27.5	27.0	26.4	25.9	25.3	24.8	24.1	23.5	22.8	22.0	21.2	20.3	19.2	18.1
Material Group H [Note (14)]	...	...	30.2	29.0	28.2	27.5	27.0	26.4	26.0	25.5	25.1	...	...	...	...	...	...	...
Material Group I [Note (15)]	27.8	27.1	26.6	25.8	25.1	24.6	24.1	23.6	23.1	22.6	22.1	21.6	21.1	20.6	20.1	19.6	19.1	18.6
Material Group J [Note (16)]	31.1	30.3	29.7	28.6	27.8	27.2	26.6	26.0	25.4	24.7	24.1	23.5	22.9	...	...	...	...	...
S13800 [Note (8)]	31.5	30.9	30.3	29.4	28.7	28.1	27.5	26.9	26.3	25.7	25.0	24.4	...	...	...	...	...	...
S15500 [Note (9)]	30.5	29.9	29.4	28.5	27.8	27.2	26.7	26.1	25.5	24.9	24.3	23.7	...	...	...	...	...	...
S45000 [Note (10)]	31.6	31.0	30.4	29.5	28.8	28.2	27.6	27.0	26.4	25.8	25.1	24.5	...	...	...	...	...	...
S17400 [Note (11)]	30.5	29.9	29.4	28.5	27.8	27.2	26.7	26.1	25.5	24.9	24.3	23.7	...	...	...	...	...	...
S17700 [Note (12)]	31.6	31.0	30.4	29.5	28.8	28.2	27.6	27.0	26.4	25.8	25.1	24.5	...	...	...	...	...	...
S66286 [Note (13)]	31.0	30.6	30.2	29.2	28.5	27.9	27.3	26.7	26.1	25.5	24.9	24.2	...	...	...	...	...	...

Notes appear on following page.

(10)

TABLE TM-1
MODULI OF ELASTICITY *E* OF FERROUS MATERIALS FOR GIVEN TEMPERATURES

Materials	Modulus of Elasticity E = Value Given × 10^3 MPa, for Temperature, °C, of																
	−200	−125	−75	25	100	150	200	250	300	350	400	450	500	550	600	650	700
Carbon steels with C ≤ 0.30%	216	212	209	202	198	195	192	189	185	179	171	162	151	137	...	...	...
Carbon steels with C > 0.30%	215	211	207	201	197	194	191	188	183	178	170	161	149	136	121	...	...
Material Group A [Note (1)]	214	210	207	200	196	193	190	187	183	177	170	160	149	135	121	...	...
Material Group B [Note (2)]	204	200	197	191	187	184	181	178	174	171	167	163	158	153	147	141	133
Material Group C [Note (3)]	218	213	210	204	200	197	193	190	186	183	179	174	169	164	157	150	142
Material Group D [Note (4)]	225	220	217	210	206	202	199	196	192	188	184	180	175	169	162	155	146
Material Group E [Note (5)]	228	223	220	213	208	205	201	198	195	191	187	183	179	174	168	161	153
Material Group F [Note (6)]	215	212	208	201	195	192	189	186	182	178	173	166	157	145	131	...	...
Material Group G [Note (7)]	209	204	201	195	189	186	183	179	176	172	169	165	160	156	151	146	140
Material Group H [Note (14)]	...	...	209	200	194	190	186	183	180	177	174	172	...	...	...	...	...
Material Group I [Note (15)]	192	187	184	178	173	170	167	163	160	157	154	151	148	145	142	139	135
Material Group J [Note (16)]	214	209	205	197	191	187	184	180	176	172	168	164	161	157	...	...	...
S13800 [Note (8)]	217	213	209	202	197	194	190	186	183	179	175	171	...	...	...	...	...
S15500 [Note (9)]	210	206	203	196	191	188	184	181	177	173	169	166	...	...	...	...	...
S45000 [Note (10)]	218	213	210	203	198	194	191	187	183	179	175	171	...	...	...	...	...
S17400 [Note (11)]	210	206	203	196	191	188	184	181	177	173	169	166	...	...	...	...	...
S17700 [Note (12)]	218	213	210	203	198	194	191	187	183	179	175	171	...	...	...	...	...
S66286 [Note (13)]	214	211	208	201	196	192	189	185	181	178	174	169	...	...	...	...	...

Notes appear on following page.

Action Item Request Form

8.3 CODE REVISIONS OR ADDITIONS

Request for Code revisions or additions shall provide the following:

a) Proposed Revisions or Additions

For revisions, identify the rules of the Code that require revision and submit a copy of the appropriate rules as they appear in the Code, marked up with the proposed revision. For additions, provide the recommended wording referenced to the existing Code rules.

Existing Text:

None

Circulator and thermic syphon neck to diaphragm welds are typically fillet welds and no guidance has been provided on the inspection of locomotive boiler fillet welds.

c) Background Information

Provide background information to support the revision or addition, including any data or changes in technology that form the basis for the request that will allow the Committee to adequately evaluate the proposed revision or addition. Sketches, tables, figures, and graphs should be submitted as appropriate.

When applicable, identify any pertinent paragraph in the Code that would be affected by

S1.4.2.18.1 CIRCULATOR & THERMIC SYPHON FILLET WELDS

1. The firebox shall be entered every 31 service days, Annual, and 1472 service day inspection to inspect circulator and syphon fillet welds.
2. All circulator and syphon fillet welds shall be visually inspected.
3. Welds showing evidence of cracking shall have the indication removed and repaired.
4. Where Visual Inspection (VT) indicates evidence of erosion or corrosion which reduces the installed size of the attaching fillet weld, the complete weld will be examined with a gauge set to indicate a weld size equivalent to the original equal leg fillet weld.
5. Any weld where more than one quarter (1/4) of its circumference is less than a 1/4” equal leg dimension will be restored to its original installed dimension.

SYPHON AND CIRCULATOR FILLET WELDS – Dave Griner

Syphons and circulators used a flanged opening in the throat and side sheets to provide a point of attachment. The flanged piece was designed to deal with the geometry of the syphons and circulators regarding expansion, the "neck" was inserted into the flanged opening, then attached via fillet weld. In some instances the neck was flared on the water side, but drawings can be seen where the "neck" was not flared, relying on the strength of the fillet weld alone.

Our point of discussion is the strength of this fillet weld in this application.

There were many hundreds of these applied to locomotives and it should be noted that an historical review of these appliances does not document failures at this point of attachment. However, there is ample evidence of cracking at the upper corners where attached to the crown sheet with other joint design. Also there have been observations of cracking in the flared section of the attachment, beyond the fillet weld. All of this suggests that the fillet weld application in this area endures the stresses in excess of other aspects of installation.

To evaluate the fillet weld strength, we will again use the American Welding Society (AWS) data as noted in the volume "The Procedure Handbook of Arc Welding", 14th Edition, 2000, published by The James F. Lincoln Arc Welding Foundation. Specifically, Section 2.3-1, Allowables for Welds.

Using the AWS values more closely shows loads allowed at the time, in contrast to those developed later by the ASME, where additional penalties are introduced in excess of the 30% noted in the AWS equation. That equation is:

$$f = 0.707 \times w \times t,$$

where;

f = Allowable Unit Force on Fillet Weld kips / linear inch

0.707 = For equal leg fillet welds the effective throat equals 0.707 x leg size.

w = Leg Size

t = 0.30 times Electrode Minimum Tensile Strength (penalty)

Table 2-8 delineates allowable loads as calculated by this equation for various weld sizes and weld metal strength levels.

Using this information along with dimensions typically used in the construction of the syphons and circulators we will evaluate the applicable welds.

Using a neck outside diameter of 5.5" and a wall thickness of 0.437, we find the weld circumference to be 17.279". Assuming an equal leg weld of 0.437, using E6010 electrodes, Table 2-8 provides a value of 5,570 psi per linear inch of weld. In this instance the total allowable load is 96,242.691 lbs (48.121 tons).

If the design load is taken as a pressure of 200 psi, pushing on the area of 5.5" diameter, we develop 4,751.67 lbs. Taken to a factor of safety of 4 this load then becomes 19,006.68 lbs. In addition we must consider the loads imposed by expansion, which are beyond this writer’s abilities. However, we can arbitrarily apply a loading of 30,000 lbs. Which develops a total loading of 49,006.68 lbs.

Using this value compared to the allowable limit of the weld we have an excess of strength of 1.96 to 1.

It appears that the fillet weld provides a more than adequate attachment method, and historically has proven as such.

It should be noted that the same weld designed under ASME criteria would not provide the same excess strength for the 0.437 leg size. If higher strength is required it will only come with the addition of weld metal, which in this instance would be considered detrimental.

NB14-1102

Action Item Request Form

8.3 CODE REVISIONS OR ADDITIONS

Request for Code revisions or additions shall provide the following:

a) Proposed Revisions or Additions

For revisions, identify the rules of the Code that require revision and submit a copy of the appropriate rules as they appear in the Code, marked up with the proposed revision. For additions, provide the recommended wording referenced to the existing Code rules.

Existing Text:

None

Circulator and thermic syphon neck to diaphragm welds are typically fillet welds and no guidance has been provided on the repair of locomotive boiler fillet welds.

c) Background Information

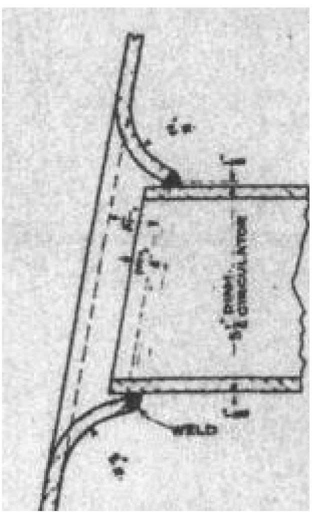
Provide background information to support the revision or addition, including any data or changes in technology that form the basis for the request that will allow the Committee to adequately evaluate the proposed revision or addition. Sketches, tables, figures, and graphs should be submitted as appropriate.

When applicable, identify any pertinent paragraph in the Code that would be affected by the revision or addition and identify paragraphs in the Code that reference the paragraphs that are to be revised or added.

S1.2.9.5.1 CIRCULATOR & THERMIC SYPHON FILLET WELDS

1. The weld to be restored will be ground to bright metal and Visually Inspected for indications prior to welding.
2. Indications will be evaluated to the indication acceptance criteria provided in the ASME Code, Section I (PW51).
3. Any unacceptable indication shall be removed prior to restoring the weld to the installed size.
4. Completed welds shall be Visually Inspected for unacceptable indications. Where repairs are required, the weld may be repaired once, if unacceptable on final inspection the entire weld shall be removed and replaced according to the initial installation criteria.
5. All welding will be conducted by welders qualified to the ASME Code, Section IX, for all positions (6G).
6. When any repair or restoration has been conducted to attachment welds, the boiler shall be hydrostatically tested to 1.25 times the MAWP.
7. A footnote will be attached to all records submitted to the FRA documenting inspections of the fillet weld, noting conditions found along with the signature of the inspector conducting the examination.

S1.2.9.5.1a CIRCULATOR & THERMIC SYPHON NECK TO DIAPHRAGM INSTALLATION



Subgroup Locomotives

National Board Item Number: NB14-1801

Current Level: Subgroup discussion

NBIC Part 3 Paragraph(s): S1.2.9.7 Title: Ferrules (Figure S1.2.9.7)

Date: Opened: January 2014

Background:
Committee generated to correct errors in existing text, add additional information to the document and add a new figure to the document.

Original Text
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 recessed depth shall not exceed 1/16" 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 application of ferrules where none were used before shall be considered a repair.

f) The application without ferrules, where none were used before shall be considered a repair. *(Note to group: This item reads incorrectly)*

Proposed Text & Changes
S1.2.9.7 FERRULES (SEE NBIC PART 3, FIGURE S1.2.9.7)

a) Ferrous or non-ferrous ferrules may be ~~used~~ installed into tube sheet or firebox sheet holes on either or both ends of flues and arch tubes. ~~by installing the ferrules into tube sheet or firebox sheet holes as required.~~

b) If the ferrule width is to be made wider than the tube sheet hole width in order to enable the ferrule to be flared outward (belled) on the sheet water side, the additional width of the ferrule shall should not exceed 1/4" (0.250" & 6.4 mm) unless the original design requires a different dimension. be used.

c) Each ferrule shall should be secured into position in the sheet hole by expanding the ferrule prior to insertion of the flue or arch tube unless the original design requires a different ferrule installation method. be used. When required by the original design the ferrule in addition to being expanded into the hole, may be flared outward (belled) on the tube sheet waterside to aid sealing and to aid guiding the flue and arch tube into the hole during installation. The ferrule expansion shall should be performed using a roller type expander or a prosser-type expander. If the prosser-type expander it shall should be either the combination roller-prosser design or the segmented pin design.

d) c) Protrusion of the installed ferrule beyond the either edges of either tube flue sheet is permitted provided the ferrule does not interfere with the further flue and arch tube installation, expansion and attachment procedures. These procedures include beading and seal welding the flues and arch tubes to the tube sheet.

e) b) If ferrules are to be recessed within the tube sheet holes, the recess depth shall should not exceed 1/16" (0.0625" & 1.59 mm) measured from the tube flue sheet fireside edge.

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. (*Note to Group: This topic has been moved to a separate document for Boiler Tube Installation.)*

f) f) The deletion of ferrules application without ferrules, where none where these were used before is considered to be a repair.

g) e) The application of ferrous ferrules where none were used before is considered to be a repair.

h) The application of non-ferrous ferrules where none were used before is considered to be an alteration unless provision is made to account for or control galvanic corrosion between the non-ferrous ferrule and the ferrous flue, arch tube and tube sheet. If this provision is made, the substitution is considered to be a repair.

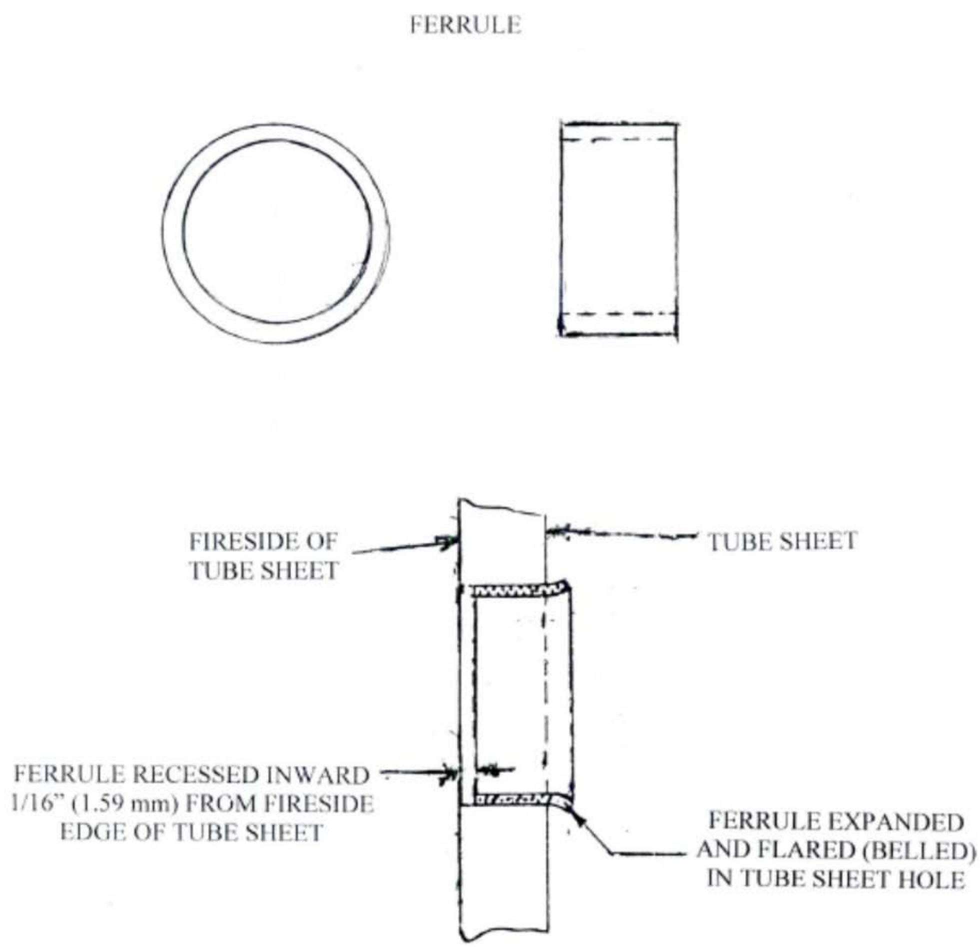
i) The substitution of non-ferrous ferrules for ferrous ferrules and the application of of non-ferrous ferrules where none were used before is considered to be an alteration unless provision is made to account for or control galvanic corrosion between the non-ferrous ferrule and the ferrous flue, arch tube and tube sheet. If this provision is made, the substitution is considered to be a repair.

~~j) The substitution of non-ferrous ferrules for ferrous ferrules is considered to be an alteration unless provision is made to account for or control galvanic corrosion between the non-ferrous ferrule and the ferrous flue, arch tube and tube sheet. If this provision is made, the substitution is considered to be a repair.~~

New Figure S1.2.9.7 is attached and is to be included as part of this action.

FERRULE FOR BOILER FLUES

Figure S1.2.9.7



Subgroup Locomotives

National Board Item Number: **14-1802**

Current Level: Subgroup discussion

NBIC Part 3 Figure S1.2.2-b Title: Riveted Staybolt Head Dimensions & Figure S1.2.2-c Title: Threaded Staybolt Inspection

Location: S1.2.2 Threaded Staybolts

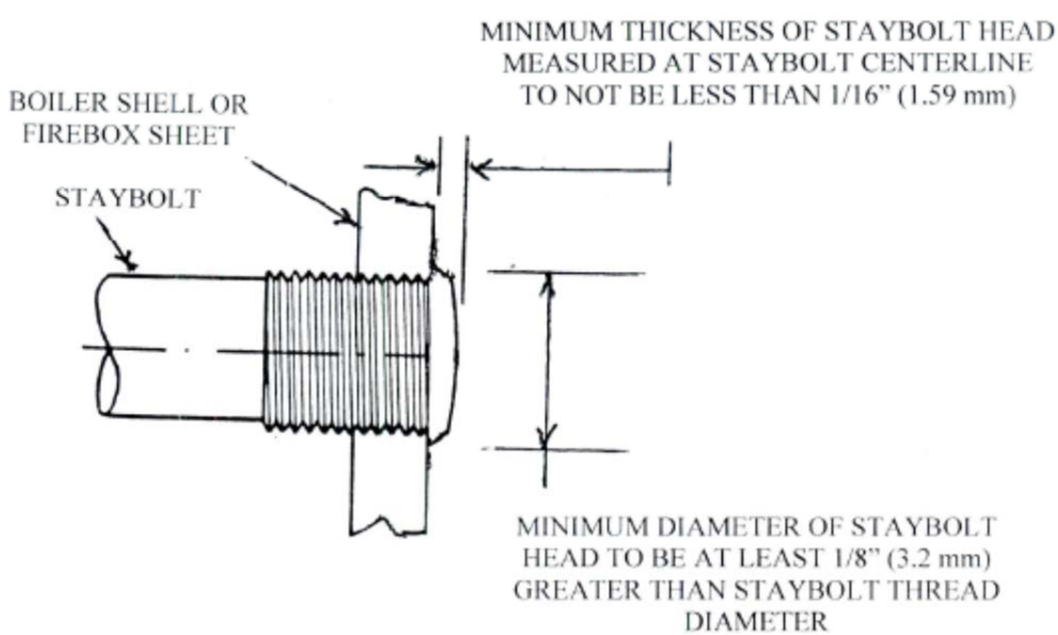
Date: Opened: February 2014

Background:
Committee generated to correct problems reported by NBIC users understanding Figure S1.2.2-b "Riveted Staybolt Head Dimensions" and to add new Figure S1.2.2-c "Threaded Staybolt Inspection" to section S1.2.2 Threaded Staybolts.

Attachment of Figures S1.2.2-b & S1.2.2-c

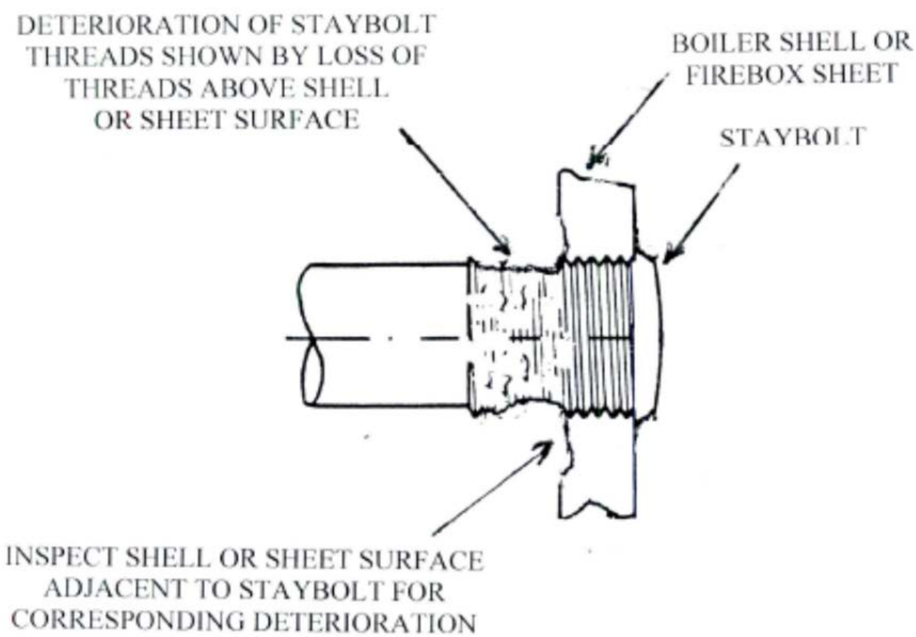
RIVETED STAYBOLT HEAD DIMENSIONS

Figure S1.2.2-b



THREADED STAYBOLT INSPECTION

Figure S1.2.2-c



NB-1701 Fillet Welded Staybolt Inspection NBIC Part 2

S 1.4.2.9

g) Threadless fillet-welded staybolts shall be inspected for corrosion wear of more than 2/10 (measured in 10ths) of the original dimensions of the head and shaft.

h) Threadless fillet-welded staybolts shall be inspected for leakage or signs of leakage and if leakage in excess of sweat porosity is indicated, the weld shall be removed and the stay rewelded.

Endnote

Reference : DEUTSCHE BAHN AG, Instruction for the Maintenance of the Steam Locomotive Boilers,
DS 991 99 05 (Dv 946 Part 1), Ed. 1st June 1994

NB15-1702 Fillet Welded Staybolt Repair   NBIC Part 3

S 1.2.5.1 Threadless Fillet-Welded Staybolts

a) The replacement of threadless fillet-welded staybolts is permissible.
b) Existing threadless fillet-welded staybolts that leak shall be repaired by re-welding after mechanically removing the old weld. Only the leaking stays are to be re-welded.
c) Minor leakages (sweat pores) may be repaired by gently caulking the fillet weld, however, identifiable cracks shall be repaired by re-welding.

Endnote

Reference : DEUTSCHE BAHN AG, Instruction for the Maintenance of the Steam Locomotive Boilers,
DS 991 99 05 (Dv 946 Part 1), Ed. 1st June 1994

Subgroup Locomotives National Board item No. NB13-1406

Current level : Subgroup

NBIC Part 3 Paragraph(s): S1.2.15 Title: **Superheater Units**

Date Opened: April 2013
Background:

From:	Bob Ferrell/NationalBoard
To:	linnwm <linnwm@supernet.com>
Cc:	Robin Hough/NationalBoard@NationalBoard
Date:	04/09/2014 02:27 PM
Subject:	Fw: NB13-1406, minutes and errata

Hi Linn:
Here is the status of 1406. I believe we should push it through to SC R/A as moved by Subgroup Locomotives in December. Let me know. The action is attached.
Also attached is the draft of the minutes and a pdf of Supplement 1 with errata marked.
[attachment "errata from supplement S1.pdf" deleted by Robin Hough/NationalBoard] [attachment "March 18-19 2014 Minutes final.docx" deleted by Robin Hough/NationalBoard]
For your information, I have confirmed with Gary Scribner and Robin Hough that "**Notes**" are not mandatory if the word **shall** is not in the note.

Please review the minutes and get back to me next week if possible. I have placed a copy of Supplement 1 errata in the cloud for the group to review.

I also suggest that Task groups and Project mangers be assigned to all working action items. This requirement is in the NBIC procedures.

Thanks, Bob

Robert E. Ferrell
Senior Staff Engineer
The National Board
614 431 3222 direct line
614 888 8320 x404
614 431 3208 Fax

----- Forwarded by Bob Ferrell/NationalBoard on 04/09/2014 01:58 PM -----

From:	Robin Hough/NationalBoard
To:	Bob Ferrell/NationalBoard@NationalBoard,
Date:	04/09/2014 01:53 PM
Subject:	Fw: NB13-1406

Okay it looks like the ballot ended in Subgroup Locomotives in December of last year. I think I held off forwarding it on to the SC on Repair and Alteration because of the meeting in January I thought that R/A would discuss it there. Apparently they did not discuss it at the meeting or if they did George did not deem it votable. Let me know what you want me to do, and you probably need the okay of Linn on this, if you want me to forward it to the SC on R/A or what.

Thanks,

Robin Hough
NBIC Committee Coordinator
The National Board of Boiler and Pressure Vessel Inspectors
1055 Crupper Avenue
Columbus, OH 43229
614-888-8320 x 228
614-431-3236 Direct Line
----- Forwarded by Robin Hough/NationalBoard on 04/09/2014 01:46 PM -----

From:	Robin Hough/NationalBoard
To:	"Ray, G. Mark" <gmray@tva.gov>, "Reetz, Bob D." <breetz@nd.gov>, <robert.castiglione@dot.gov>, Bob Schuel linnwm@redrose.net, mjanssen@vaporlocomotive.com, richardbstone@verizon.net, histmachry@windstream.net
Date:	12/05/2013 03:58 PM
Subject:	NB13-1406

Gentlemen:

The subject letter ballot has now closed. The item was unanimously approved without comment. The ballot will now be forwarded to the SC on Repair and Alteration for their review. For specific voting details, view the attached committee correspondence or visit the National Board website.

Thank you,

Robin Hough
NBIC Committee Coordinator
The National Board of Boiler and Pressure Vessel Inspectors
1055 Crupper Avenue
Columbus, OH 43229
614-888-8320 x 228
614-431-3236 Direct Line

[attachment "NB13-1406 Closure.docx" deleted by Robin Hough/NationalBoard]

The purpose of this action is to provide guidance for the repair of locomotive boiler Superheater units.

Proposed Action:

1) Cracks in superheater unit components, including superheater return bends, tube sections and connection ends made from steel may be repaired by welding. All weld repairs shall be done in accordance with NBIC Part 3 and ASME Section I Part PW.

2) When new replacement parts and tubes are installed in steel superheater unit components the interior edges of the new and original surfaces subject to steam flow shall be set concentric with each other and, when practical, these surfaces and the completed welds should be ground smooth to prevent formingn raised edges between the original and new interior surfaces. Welds shall be the full penetration-type, unless the original design requires a

different weld configuration be used, and shall be done in accordance with NBIC Part 3 and ASME Section I Part PW.

3)