THE NATIONAL BOARD OF BOILER AND PRESSURE VESSEL INSPECTORS

SINCE 1919

# NATIONAL BOARD INSPECTION CODE COMMITTEE

# *AGENDA March 18 and 19, 2014*

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

*These agenda and minutes are subject to approval and are for committee use only. They are not to be duplicated or quoted for other than committee use.*

The National Board of Boiler & Pressure Vessel Inspectors
1055 Crupper Avenue
Columbus, Ohio 43229-1183
Phone: (614) 888-8320
FAX: (614) 847-1828

1. Adoption of Agenda
2. Announcements
    a. R. Schueler -Announcement
3. Minutes of April 2 & 3, 2013 Meeting Corrections
    a. Richard Stone Email revised to read richardbstone@verizon.net
    b. Attachment 5, NB13-1402 revise 1/4 in. to include (6 mm)
    c. Attachment 11, NB13-1408 revise 1/8 in. to include (1.5 mm)
    d. Corrected spelling George Scerbo's name
4. Educational Presentation
5. Errata
6. NBIC Negative Votes
    a. Results of Ballot NB13-1405, Failed 4 votes Approved and 4 Negative. (See summary of votes attached)
7. Items at Subcommittee Level
    a. NB13-1402 Bulged Stayed Firebox Sheets (See Minutes of previous meeting.)

Letter Ballot NB13-1402 **DATE:** October 7, 2013

Letter Ballot NB13-1402 MC has now closed. The ballot has passed. The voting results are:

19 Approved
0 Disapproved
0 Abstained
3 Not Returned

This wording will now become a part of the 2015 Edition.

8. Letter Ballots
    a. NB13-1410 Sample ballot – Use of NBIC Internet voting option
    b. NB13-1405 Throttle Pipe, Dry Pipes, Superheater Headers & Front End Steam Pipes

The corrected sentence is shown below and the missing word added in red. (revised R. Stone 7/10/2013)

3) Weld build-up may be used if the corroded section does not exceed 10 square inches in area and the depth of corrosion is less than 50% of the original wall thickness. If the corrosion depth or area exceeds one or both of these values, either the corroded section shall be replaced or the entire component replaced. All welded repairs shall be done in accordance with ASME Section I Part PW.

9. Old Business
    a. NB11-1805 Staybolts
    b. NB13-1401 Boiler Tube Seal Welding
    c. NB13-1403 Installation of Boiler Tubes & Arch Tubes
    d. NB13-1404 Fillet welded staybolts
    e. NB13-1406 Superheater Units
    f. NB13-1407 Bolts, Nuts, & Studs

g. NB13-1408 Threaded Boiler Studs

10. New Business
    a. NB13-1409 Method for Analyzing Bulges Created by Overheating in Stayed Boiler Surfaces
    b. NB14-1101 Diagram Weld Inspection
    c. NB14-1102 Diagram Weld Repair
11. Guest Questions
12. Next Meeting
13. Adjournment
14. 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 |
| (MN) | **Robert Schueler (Staff Secretary)** | Email schuelerr1@asme.org |
| (M) | **Steven M. Butler** | Email greenchili@tds.net |
| (M) | Robert Castiglione | Email Robert.castiglione@dot.gov |
| (M) | **David Conrad** | Email jdconrad@snet.net |
| (M) | **Robert Franzen** | Email ssoa2001@aol.com |
| (M) | **David Griner** | Email dgriner@arizonamechanicalengineering.com |
| (M) | **Steve Jackson** | Email sjackson@durangotrain.com |
| (M) | **Stephen Lee** | Email emerilcat@aol.com |
| (M) | **Doyle McCormack** | Email doyle396@comcast.net |
| (M) | **G. Mark Ray** | Email gmray@tva.gov |
| (M) | **Robert Reetz** | Email breetz@nd.gov |
| (M) | **George L. Scerbo** | Email glscerbo@cablespeed.com |
| (M) | **Richard Stone** | Email richardbstone@verizon.com |
| (M) | **Robert Yuill** | Email histmachry@windstream.net |

Subgroup Locomotives National Board Item No. NB11-1805
Current Level: Subgroup discussion

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.

Subgroup voted Date:

**Section: 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

g) Correct application of seal welding to staybolt heads

**Notes:**

1. An indicator of waterside corrosion on threaded staybolts is the lack of threads on the section of the staybolt body just above the sheet.

2. 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.

**Section: 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 having the required shape, thickness and diameter

d) Plugging of telltale holes except as permitted by 49 CFR Part 230.41

e) Waterside corrosion of the body and threads
f) Mud build up on the staybolt body and sheet waterside surfaces

g) Staybolt heads that have been covered over by welding
h) Correct application of seal welding to staybolt heads

**Notes:**

1. An indicator of waterside corrosion on threaded staybolts is the lack of threads on the section of the staybolt body just above the sheet. The section of the sheet through which the staybolt passes may have been subject to the same waterside corrosion and should be examined in combination with the staybolt.

2. 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, hammer test may be performed along with the boiler drain.
3. When a broken stay is found, the stays adjacent to it should be examined closely because these may have become overstressed by addition of the load from the broken stay.

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

5. The plugging of telltale holes by refractory to prevent build up of foreign matter in the telltale hole is permitted for locomotives operating under FRA Jurisdiction per 49 CFR Section 230.41.

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

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

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

5. The plugging of telltale holes by refractory to prevent build up of foreign matter in the telltale hole is permitted for locomotives operating under FRA Jurisdiction per 49 CFR Section 230.41.

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

7. When the thickness of a staybolt driven head measured at the center has been reduced to 1/16" thickness either because of erosion during service or problems during installation, the staybolt shall be replaced.

8. When the diameter of a staybolt driven head has been reduced to less than 1/8" greater than the staybolt thread diameter at any location either because of erosion during service or problems when driven during installation, the staybolt shall be replaced.

Subgroup Locomotives National Board Item No. NB13-1401

Current Level: Subgroup discussion

NBIC Part 3 Paragraph(s): S1.2.9

Title: Boiler Tube Seal Welding
Date: Opened: Nov. 2007

Background: Committee generated.

Proposed Action:

1. Each Flue shall be expanded either partially or completely into the flue sheet hole prior to seal welding. Upon completion of seal welding the flue shall be expanded to the final setting or re-expanded lightly to confirm the seal welding has not loosened it.

2. Changing the method by which flues are installed from prossering and beading to expanding straight and seal welding shall be considered a repair.

3. Changing the method by which flues are expanded from the prosser method to the roller expander method shall be considered a repair.

4. When flues are installed by expanding straight and seal welding, the outer tube edge shall be even with the outer seal weld edge. 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 or overheating the tube.

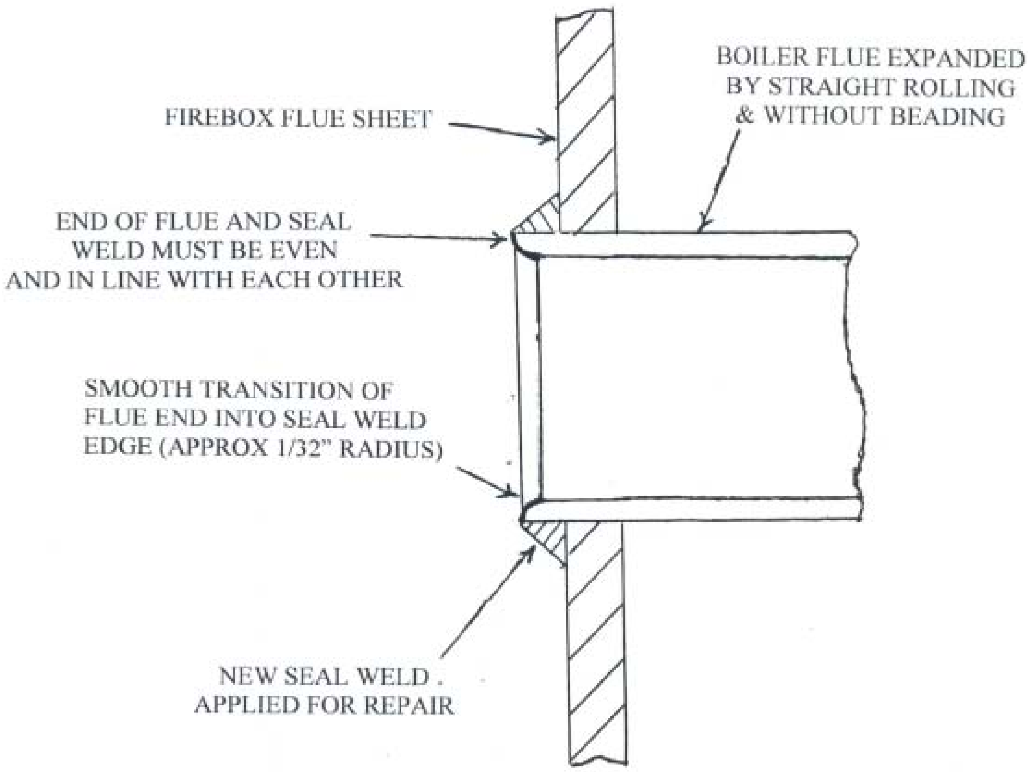
5. Flues that show cracks upon completion of the installation process shall be replaced. Repair is prohibited.

6. When flues are beaded, the bead edge shall contact the flue sheet around the entire flue circumference. Repair of a defective or incorrectly formed bead by welding is prohibited.

Voted by Subgroup: Date:

Rev

SEAL WELDING OF BOILER FLUES
EXPANDED BY STRAIGHT ROLLING




Revised July 10, 2013 by R Stone

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. NB13-1405

Current Level: Subgroup – First Ballot

NBIC Part 3 Paragraph(s): S1.2.9

Title: **Throttle Pipes, Dry Pipes, Superheater Headers & Front End Steam Pipes**

Date Opened: April 2013

Background:

None Provided

Proposed Action:

**Throttle Pipes, Dry Pipes, Superheater Headers & Front End Steam Pipes**

1) Throttle pipes, dry pipes, superheater headers, and front end steam pipes made from cast iron or wrought iron that are cracked or corroded to less than the minimum allowable thickness shall be removed from service. Repair is prohibited.

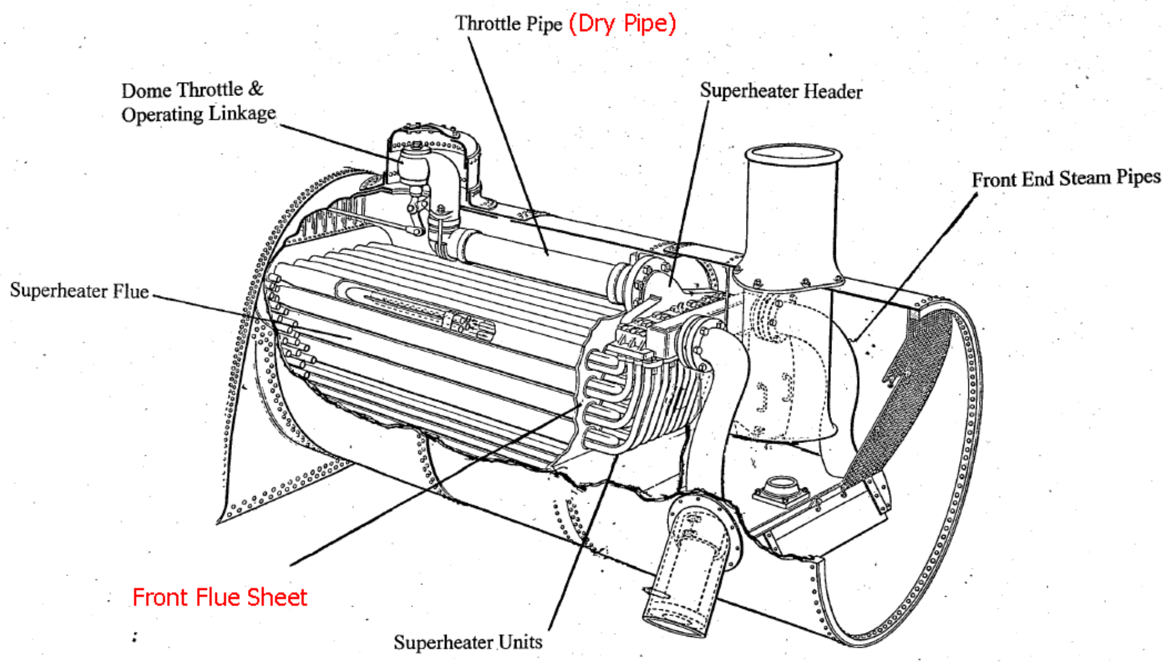
2) Throttle pipes dry pipes, superheater headers, and front end steam pipes made from steel that are cracked may be repaired.

3) Weld build-up may be used if the corroded section does not exceed 10 square inches in area and the depth of corrosion is less than 50% of the original wall thickness. If the corrosion depth or area exceeds one or both of these values, either the corroded section shall be replaced or the entire component replaced. All welded repairs shall be done in accordance with ASME Section I Part PW.

4) When cracks are repaired or new sections installed the welds shall be the full penetration-type and be radiographically examined.

5) Throttle pipes, dry pipes, superheater headers, and front end steam pipes shall be supported by hangers or other structural means to prevent placing bending loads on the adjacent mating parts and attachment studs. All pins, bolts and nuts used to attach these parts shall be equipped with a mechanical retainer such as a cotter pin or be fitted with double nuts, to prevent loosening.

STEAM PIPES & SUPERHEATER ARRANGEMENT




Subgroup voted 4 votes disapproved and 4 votes approved. Date: July 23, 2013

Summary of letter ballot NB13-1405 - Disapproved

**COMMITTEE CORRESPONDENCE**

**COMMITTEE:** SG on Locomotive Boilers

**TO**: SG on Locomotive Boilers

**ADDRESS WRITER**
**CARE OF:** The National
Board of Boiler & Pressure
Vessel Inspectors
1055 Crupper Avenue
Columbus, Ohio 43229-1183
Phone: (614) 888-8320
Fax: (614) 847-1828

**FROM**: Robin Hough
NBIC Secretary

**SUBJECT**: Letter Ballot NB13-1405 LB

**DATE:** August 6, 2013

Gentlemen:

Letter Ballot NB13-1405 LB has now closed. The ballot failed. The voting results are:

| | |
|---|---|
| 4 | Approved |
| 4 | Disapproved |
| 0 | Abstain |
| 1 | Not Voting |
| 2 | Not Returned |

The project manager of this action item, Mr. Richard Stone has examined the comments received and has developed a revised document to be letter balloted this week.

:rmh

**Ballot Votes NB13-1405**

| Name | Email | Votes | Vote Date |
|---|---|---|---|
| David Griner | dgriner@arizonamechanicalengineering.com | Approve | 07/14/13 |
| George Scerbo | glscerbo@cablespeed.com | Approve | 07/13/13 |
| Matt Janssen | mjanssen@vaporlocomotive.com | Approve | 07/18/13 |
| Richard Stone | richardbstone@verizon.net | Approve | 07/09/13 |
| Bob Reetz | breetz@nd.gov | Disapprove | 07/23/13 |
| J. David Conrad | jdconrad@snet.net | Disapprove | 07/11/13 |
| Linn Moedinger | linnwm@supernet.com | Disapprove | 07/10/13 |
| Robert Yuill | histmachry@windstream.net | Disapprove | 07/10/13 |
| Doyle McCormack | doyle396@comcast.net | Not Voted | N/A |
| Steve Jackson | sjackson@durangotrain.com | Not Voted | N/A |
| Robert Schueler | rschuele@nationalboard.org | Not Voting | 07/10/13 |

**Comments for Ballot NB13-1405**

| Name | Comment | Date Created |
|---|---|---|
| Bob Reetz | First, change the location from S1.2.9 to S1.2.14 and name the figure as "Figure S1.2.14". After the title, add "(See Figure S1.2.14)". Second, change "are" to "is" in 1) and 2). Third, reword the last sentence in 1) to read "Repair is prohibited, but pinholes and defects not exceeding 0.25 inches in length or width may be repaired by brazing. "Fourth, reword the third sentence in 3) to read "All welded repairs shall be done in accordance with NBIC Part 3 and ASME Section I Part PW." Fifth, in 3) add "replaced" at the end of the second sentence. Sixth, in 4)change "radiographically" to volumetrically". Lastly, we need metric equivalents added where needed. Should these items be addressed, I will change my vote to "approve". | 07/23/2013 |
| J. David Conrad | Repairs to cracks in cast iron superheater headers and admission pipes are sometimes possible with brazing or metal stitching. | 07/11/2013 |
| Robert Yuill | Section 4; change radiographic examination to volumetric examination, or add volumetric examination to the radiographic examination. I question the practicality of RT on some of the header areas. UT will provide another method in inspection. Section 1; is the repair of any defects anywhere on a cast iron header prohibited, or only in the pressure containing areas. Could flanges or tee slots be repaired? | 07/10/2013 |
| Linn Moedinger | I agree with the overall proposal, however in the case of cast iron pipes, I believe we need to address the common issue of pitting which is usually present from the foundry. These isolated pits can corrode through the pipe creating a | 07/10/2013 |

| | | |
|---|---|---|
| | leak that can safely be repaired by brazing. | |
| Richard Stone | This is the revised draft that our Sub-Group revised and voted to accept at the April 2013 meeting. However, at the time of the April 2013 meeting the voted draft did not have the required NB Item Number assigned to it so it could be accepted by the National Board. This required the voted draft to be resubmitted to the Sub-Group for re-approval. The attached pdf text has one missing word on the second sentence of item #3. The missing word is replaced and it is to be located as the last word in the sentence. The corrected sentence is: "If the corrosion depth or area exceeds one or both of these values, either the corroded section shall be replaced or the entire component replaced". | 07/09/2013 |

Late comment from G. Mark Ray – Received after vote closed
Fellow members of the committee -

Regarding the repair of superheater headers – TVRM successfully repaired the flange of a T-slot header (non-pressure boundary) so I agree that this kind of repair should not be disallowed. Also, what about repairs to throttle flanges? TVRM is currently having a pattern built to reproduce the balanced throttle used by Southern Railway (both the 2-8-0's and 2-8-2's used this throttle). This is being done because a recently unearthed drawing of the throttle verified how wore out the components were. No recovery is possible since all the parts are cast iron.

Replacement of the dry pipe end pieces with weldments is a reasonable effort. TVRM has done this and I am aware of the other locomotives that have had entirely new dry pipes built. TVRM has also fabricated new front end steam pipes for a locomotive currently in service.

TVRM's next adventure is into replacement superheater headers.

Shouldn't the repair criteria align with Title 49 Part 230 (60% versus 50%) to eliminate confusion? I don't know the technical basis for either value.

Will steel piping be subject to more flow accelerated corrosion than cast iron? This may be inconsequential given the inspections and expected usage of steam locomotives in today's world.

Subgroup Locomotives National Board Item No. NB13-1405

Current Level: Subgroup – Second Ballot

NBIC Part 3 Paragraph(s): ~~S1.2.9~~ S1.2.14

Title: **Throttle Pipes, Dry Pipes, Superheater Headers & Front End Steam Pipes**

Date Opened: April 2013

Background:

~~None Provided~~ The reason for adding this section is to provide guidance for repair of these locomotive boiler components. Two accidents have occurred to steam locomotives over the past 30 years when the dry pipe collapsed and caused the locomotive to operate out of control. Although neither accident caused injury equipment damage did occur. In addition other accidents that resulted in injury and fatalities have occurred to steam locomotives during the years of 1910 - 1950 when these were in normal railroad service.

Proposed Action:

**Throttle Pipes, Dry Pipes, Superheater Headers & Front End Steam Pipes**

1) Throttle pipes, dry pipes, superheater headers, and front end steam pipes made from cast iron ~~or wrought iron that are cracked~~ and have cracks greater than 0.25 inches (6 mm) in length or width or have corroded to less than the minimum allowable thickness shall be removed from service. ~~Repair is prohibited.~~ Cracks not exceeding 1.00 inches (25.4 mm) in length or 0.25 inches (6.4 mm) in width may be repaired by brazing. Pinholes and defects not exceeding 0.25 inches (6.4 mm) in diameter may be repaired by brazing. Repair by welding is prohibited.

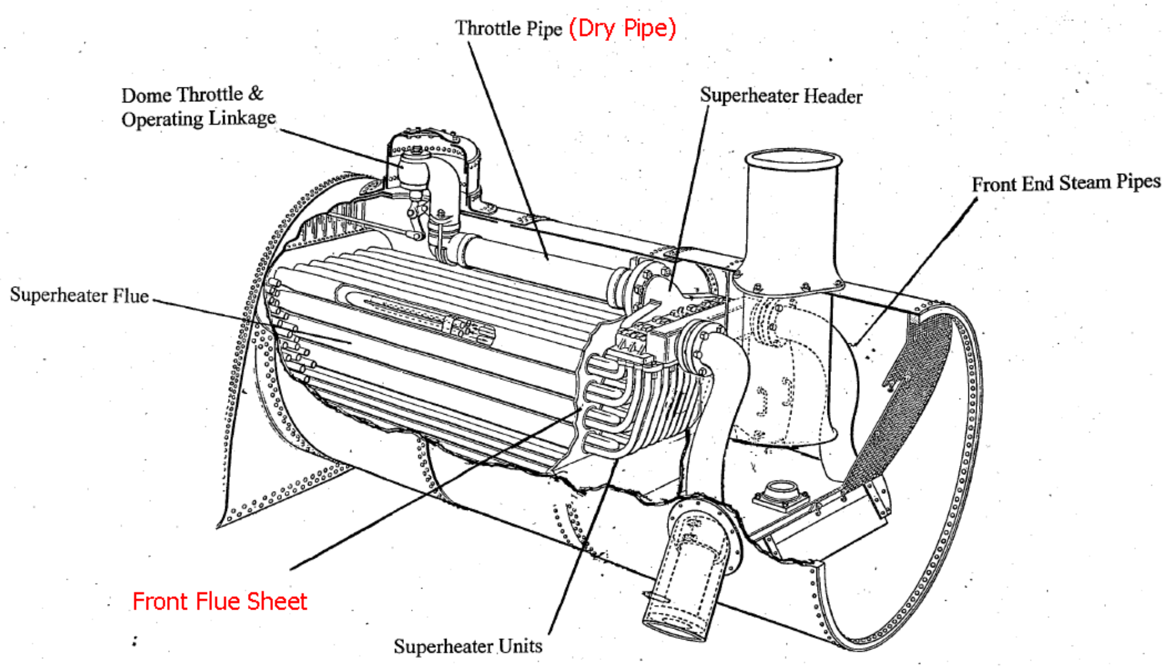
2) Cracks in throttle pipes, dry pipes, superheater headers, and front end steam pipes made from steel ~~that are cracked~~ may be repaired by welding. All welded repairs shall be done in accordance with NBIC Part 3 and ASME Section I Part PW. The welds shall be the full penetration-type and shall be volumetrically examined.

3) Weld build-up may be used for repair of steel components provided ~~if~~ the corroded section does not exceed 10 square inches (64.52 square centimeters) in area and the depth of corrosion is less than 50% of the original wall thickness. If the corrosion depth or area exceeds one or both of these values, either the corroded section shall be replaced by a new section installed using full penetration welds or the entire component replaced. All weld build-up ~~welded~~ repairs shall be done in accordance with NBIC Part 3 and ASME Section I Part PW. All welds shall be volumetrically examined. If weld build-up is done in the interior of components subject to steam flow, the interior welded surfaces shall be ground smooth to prevent forming edges between the original and repaired surfaces.

4) When ~~cracks are repaired or~~ new replacement sections are installed in steel components the interior edges of the new and original surfaces subject to steam flow shall be set even with each other to prevent edges. All ~~the~~ welds shall be the full penetration-type, shall be done in accordance with NBIC Part 3 and ASME Section I Part PW and be volumetrically ~~radiographically~~ examined. Replacement flanges may be installed by welding in accordance with NBIC Part 3 and ASME Section I Part PW.

5) Throttle pipes, dry pipes, superheater headers, and front end steam pipes shall be supported by hangers or other structural means to prevent placing bending loads on the adjacent mating parts and attachment studs. All pins, bolts and nuts used to attach these parts to each other and to the boiler shall be equipped with a mechanical retainer such as a cotter pin or be fitted with double nuts, to prevent loosening.

## STEAM PIPES & SUPERHEATER ARRANGEMENT



**COMMITTEE CORRESPONDENCE**

**COMMITTEE:** SG on Locomotive Boilers

**TO**: SG on Locomotive Boilers

**ADDRESS WRITER CARE OF:** The National Board of Boiler & Pressure Vessel Inspectors
1055 Crupper Avenue
Columbus, Ohio 43229
Phone: (614) 888-8320
Fax: (614) 847-1828

**FROM**: Robin Hough
NBIC Secretary

**SUBJECT**: Letter Ballot NB13-1405 LB

**DATE:** August 6, 2013

Gentlemen:

Letter Ballot NB13-1405 LB has now closed. The ballot passed. The voting results are:

| | |
|---|---|
| 9 | Approved |
| 0 | Disapproved |
| 0 | Abstain |
| 0 | Not Voting |
| 5 | Not Returned |

This ballot will now be forwarded to the Subcommittee on Repairs and Alterations for their review.

:rmh

**Ballot Votes NB13-1405**

| Name | Email | Votes | Vote Date |
|---|---|---|---|
| Bob Reetz | breetz@nd.gov | Approve | 10/03/13 |
| David Griner | dgriner@arizonamechanicalengineering.com | Approve | 10/14/13 |
| J. David Conrad | jdconrad@snet.net | Approve | 10/18/13 |
| Linn Moedinger | linnwm@supernet.com | Approve | 10/01/13 |
| Matt Janssen | mjanssen@vaporlocomotive.com | Approve | 10/28/13 |
| Richard Stone | richardbstone@verizon.net | Approve | 10/01/13 |
| Robert Yuill | histmachry@windstream.net | Approve | 10/07/13 |
| Steve Jackson | sjackson@durangotrain.com | Approve | 10/08/13 |
| Steven Butler | greenchili@tds.net | Approve | 10/01/13 |
| Doyle McCormack | doyle396@comcast.net | Not Voted | N/A |
| G. Mark Ray | gmray@tva.gov | Not Voted | N/A |
| George Scerbo | glscerbo@cablespeed.com | Not Voted | N/A |
| Stephen Lee | salee@wrrc.us | Not Voted | N/A |

**Ballot Comments NB13-1405**

| Name | Comment | Date Created |
|---|---|---|
| Matt Janssen | In reading Mr. Conrad's comments I do not feel sufficiently informed on the background statement to support this ballot. In 1), there appears to be a contrast between the first and second sentence as to what size crack can actually be repaired. I also believe the first sentence should be "that have cracks" instead of "and have cracks..." I agree the drawing is very helpful, however, I am unsure about the continuity of "flue sheet" vs. "tubesheet" terms. I think this is a nice item and I would approve it if I understood the crack size (<2" x .25"?) as well as had clarification on the background statement. | 10/13/2013 |
| J. David Conrad | I agree with the text of the proposal as re-modified. I continue to disagree with the "Background" reason given. The examples cited were not failures of repairs, rather they were failures of old parts which were not inspected using methods currently required. | 10/08/2013 |
| Bob Reetz | I like the illustration included as those not familiar with the design of locomotive boilers or with the terminology used will quickly understand the issue. | 10/03/2013 |

Subgroup Locomotives National Board Item No. NB13-1406

Current Level: Subgroup

NBIC Part 3 Paragraph(s): To be determined
Title: **Superheater Units**

Date Opened: April 2013

Background:

None Provided

Proposed Action:

1) Superheater units that are worn to less than the minimum allowable wall thickness shall be removed from service and either repaired or replaced.

2) When cracks are repaired or new sections installed the welds shall be the full penetration-type.

3) Weld build-up may be used if the corroded section does not exceed 10 square inches in area and the corrosion depth does not exceed 50% of the original wall thickness. If the corrosion depth or area exceeds one or both of these values, the corroded section shall be replaced.

4) Superheater units shall align with and attach to the superheater header without having to be forced.

5) Cinder shields and tube supports, and tube bands may be attached to superheater units by welding. These welds do not require inspection. The use of fillet welds to attach these items is acceptable.

Subgroup Date:

Subgroup Locomotives National Board Item No. NB13-1406

Current Level: Subgroup

NBIC Part 3
Paragraph(s): To be determined Title: **Superheater Units**

Date Opened: April 2013,revised by R. Stone 10-20-2013

Background: None Provided
The purpose of this document is to provide guidance for the repair of locomotive boiler superheater units.

Subgroup Locomotives National Board Item No. NB13-1406

Current Level: Subgroup

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

Date Opened: April 2013

Background: None Provided

The purpose of this document 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 forming 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) Superheater unit tubes and parts shall be cut to or made to the required length and alignment. Bends in superheater unit tubes and parts shall be formed to the correct shape and curvature. Tubes and parts that are cut too short or which cannot be aligned correctly shall not be used.

4) Replacing the forged connection ball ends of Ball-End type superheater units with cast, fabricated or machined connection ball ends is a repair.

5) Damage and cuts on the surfaces of forged connection ball ends of Ball-End type superheater units may be repaired by weld build up. The welding shall be done in accordance with NBIC Part 3 and ASME Section I Part PW. The weld repaired surfaces then shall be returned back to the required profile by machining, grinding and lapping.

6) The connection ends of superheater units shall align with and attach to the superheater header without having to be forced into their attachment location or placing bending loads on their connection fasteners, fittings, washers or clamps.

7) The fasteners, fittings, washers and clamps used to attach and secure the ends of superheater units to the superheater header shall fit to their respective parts and assemble together without being forced or creating damage or misalignment between the superheater unit end and the superheater header. Threaded fittings and threaded fasteners shall have the required length of thread engagement as required by the original design. Changing the location, number, or size or design of the fasteners, fittings or clamps from the original design is an alteration.

8) The replacement of forged return bends with cast or fabricated return bends, or the reverse, is a repair.

9) Replacement return bends, tubes bends and tube shall have the same bend radius, ID and interior cross section area subject to steam flow as the original design parts. The use of replacement return bends, tube bends and tube that have a larger or smaller bend radius, ID or interior cross section area is an alteration.

10) Superheater unit supports, tube bands and cinder shields may be repaired by welding. The replacement of superheater unit supports, tube bands and cinder shields is a repair.

11) Repaired superheater units shall be tested by hydrostatic pressure upon completion of the repair and prior to installation into the locomotive boiler. The hydrostatic test pressure should follow the manufacturers original requirements. If this is not known, the hydrostatic test pressure shall not be less than 1.25 x MAWP. If it is necessary to hydrostatic test the superheater units after these have been installed in the boiler, the hydrostatic test pressure shall not exceed 1.25 x MAWP.

Original Proposed Text Of This Draft - Now Obsolete (Use For Reference Only)

~~1) Superheater units that are worn to less than the minimum allowable wall thickness shall be removed from service and either repaired or replaced.~~

~~2) When cracks are repaired or new sections installed the welds shall be the full penetration-type.~~

~~3) Weld build-up may be used if the corroded section does not exceed 10 square inches in area and the corrosion depth does not exceed 50% of the original wall thickness. If the corrosion depth or area exceeds one or both of these values, the corroded section shall be replaced.~~

~~4) Superheater units shall align with and attach to the superheater header without having to be forced.~~

~~5) Cinder shields and tube supports, and tube bands may be attached to superheater units by welding. These welds do not require inspection. The use of fillet welds to attach these items is acceptable.~~

Subgroup voted

Subgroup Locomotives National Board Item No. NB13-1407

Current Level: Subgroup discussion

NBIC Part 3 Paragraph(s): To be determined
Title: **Bolts, Nuts & Studs**

Date Opened: April 2013

Subgroup Locomotives National Board Item No. NB13-1407

Current Level: Subgroup discussion

NBIC Part 3
Paragraph(s): S1.2.7.1

Title: **Bolts, Nuts, ~~Studs~~ & 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:

1) The bolts, nuts and washers used on locomotive boilers shall be maintained, repaired or replaced in accordance with the directions of the original equipment manufacturer (OEM). If this information is not available, the following procedures shall be used.

2) Bolts, nuts and washers that are bent, twisted, deformed, cracked or broken shall be replaced.

3) Bolts and nuts that have damaged threads that cannot be returned to the original dimensions by re-threading, or have cracked, broken or missing threads shall be replaced.

4) Bolts, nuts and washers that have wastage, corrosion or mechanical damage, including cuts, grooving and abrasion, on the head, body, shank or threads shall be replaced.

5) Bolts, nuts and washers that have been welded or tack welded may remain in service until disassembly is made and then shall be replaced. Reuse is prohibited.

***Note to group: My reason for requiring these welded fasteners be replaced and not be reused is the welding damages the steel from which these fasteners are made (the steel generally has a high manganese content and frequently it is an alloy steel that is not intended to be welded). It also destroys any heat treatment process that fasteners were given during manufacture, which weakens them further. In addition, the welds have to be removed by grinding which also cuts into the fastener's surfaces.***

6) Bolts and nuts that have mechanical damage on the head or body that prevents use of the required size or type of wrench or socket for removal, installation and tightening shall be replaced.

7) When bolts or nuts have to be heated for removal and the metal temperature that exceeds 800°F (427°C) but remains below 1100°F (593°C), the bolt or nut that was heated may be reused provided it passes inspection for the types of damage listed in Items #1 to #6 of this section and does not show any softening or reduction of hardness. If the bolt or nut is heated to a metal temperature that exceeds 1100°F (593°C), it shall be replaced. The associated bolt, nut or washer that attaches to or contacts the heated item may be reused if inspection shows it has not been distorted, damaged or suffered a reduction of hardness.

***Note to group: My wording is arranged to enable you to use a torch to warm a stuck nut or bolt in order to remove it while simultaneously providing inspection precautions in the event the stuck part requires considerable heating to remove it. The reason for this is heating to high temperature can damage the metal structure, which will reduce its strength, distort the parts fit and shape, and destroy or damage its heat treatment process. This in turn will cause the bolt or nut to fail if it is returned to service. My two metal temperature ranges are based on hardened and heat-treated superheater bolts and nuts. Their temperature during service is in the 750°F range while heating them using a torch to temperatures above 1100°F will damage and weaken their heat treatment process and metal structure. Therefore heating above 1100°F can lead to failure.***

8) The use of replacement bolts, nuts and washers that are made to a higher or lower strength or grade specification than the original parts is an alteration.

9) Replacement bolts, nuts and washers shall have the same fit up, alignment and thread engagement length as the original parts.

~~1) Bolts and studs that are cracked, have damaged threads that cannot be returned to the original dimensions by re-threading, or have corrosion or~~

~~mechanical damage that has reduced the thickness of any section to less than the thread minor diameter shall be replaced.~~

~~2) Nuts that are cracked, have damaged threads that cannot be returned to the original dimensions by rethreading, or have corrosion or mechanical damage that has reduced the body thickness of any section greater than 5% shall be replaced.~~

Subgroup voted Date:

Subgroup Locomotives National Board Item No. NB13-1408
Current Level: Subgroup

NBIC Part 3 Paragraph(s): To be Determined
Title: **Threaded Boiler Studs - Taper Thread & Straight Thread Types**

Date Opened: April 2013

Background: None provided

None Provided

Proposed Action:

When threaded boiler studs of the taper and straight thread types are installed into through holes on the boiler, the stud threads shall extend the entire thickness of the plate but not extend more than 1/8" beyond the plate water side surface unless required by the design.

Threaded boiler studs of the taper and straight thread types shall create a tight and leak free joint at completion of assembly. Seal welding shall not be used unless this is specified by the original design.

Threaded boiler studs of the taper and straight thread types that leak during service shall be repaired by tightening or be replaced. If seal welding is to be performed it is an alteration. Prior to the seal welding taking place the leaking parts shall be inspected to identify the cause of the leak and the condition of the parts.

Replacing a taper thread boiler stud with a straight thread boiler stud, or making the opposite replacement, is an alternation.

Installing a taper thread or straight thread boiler stud of a larger diameter into the boiler is an alteration if the larger hole diameter reduces the plate hole efficiency to a lower value than the efficiency of the boiler rivet seam. The boiler rivet seam efficiency used for the comparison is the rivet seam having the same orientation (longitudinal or circumferential) as the stud holes.

Subgroup voted Date:

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

   (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 = $\frac{5 \text{ x } W \text{ x } p^3}{384 \text{ x } E \text{ x } I}$

   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:

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

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

**Deflection At MAWP & Normal Operating Temperature**

**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**

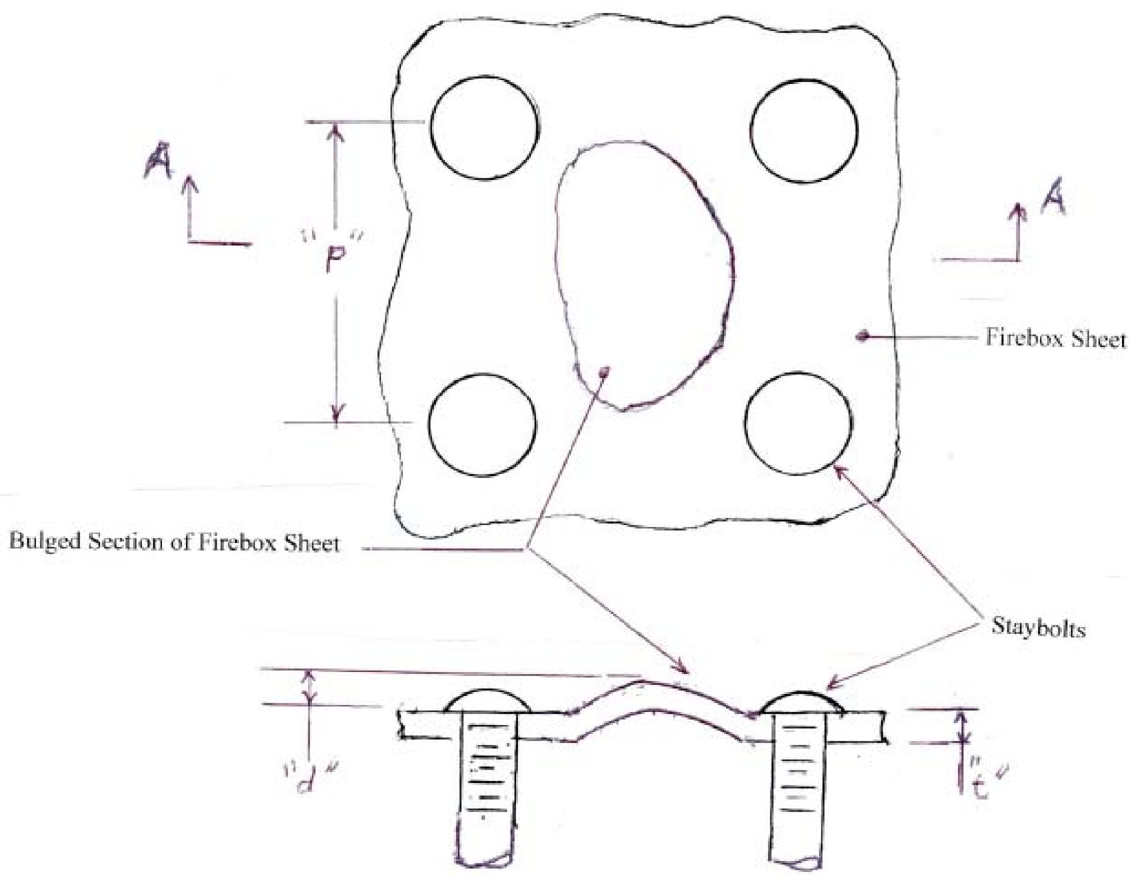
$$\frac{29{,}000{,}000 - 151{,}515}{29{,}000{,}000} \times 100 = 99.47\%$$

**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

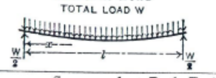
p = staybolt pitch

t = firebox sheet thickness

d = depth of bulge

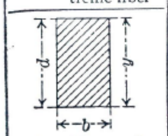
b = width of beam section = 1"

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: Deflections at Critical Points |
|---|---|---|---|---|
| **Case 1.** — Supported at Both Ends, Uniform Load  | $s = -\frac{W}{2Zl}x(l-x)$ | 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.*

NB14-1101

**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