K&T #14
Inspection Overview,
Observed Defects
& Corrective Actions

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Next Generation Rail Services

Overview

During the weekend of 11/17/17 to 11/19/17 I had the opportunity to perform a rather thorough inspection on the locomotive known as K&T 14. The first objective was to determine to what extent the previously contracted scope of work has or has not been completed. I am providing two percentages, the percentage of completion as it appears, and the percentage of the work which is salvageable.

The following is a breakdown of that list and what is observed of the locomotive as it sits:

Appears Complete, Salvagable (Percentages)

- Engineering/Project management

85%, 3% There is no documentation related to the repairs made to the boiler on site/ given the volume of rework required for the boiler to be made serviceable (among other issues) I consider there to have been no project management provided by the contractor.

- Boiler, Steam, & Combustion Systems

90%, 0% While work has been performed and there is the perception of completion, the work was performed contrary to what code or standard practice allows for. There are no MTR's (material test reports) available for any steel components installed into the boiler. Unfortunately, all of the work to the boiler must be corrected for reasons which will be explained in great detail in the final report. The ashpan is constructed of material which is too thin, and the grate supports are fabricated of thin steel weldments versus iron castings of an appropriate alloy.

- Assembly of Boiler to Frame

100%, 10% While the boiler is sitting on the frame, the method of attachment is not correct. The boiler is to be attached (in accordance with OEM and accepted railroad practices) via machined holes/taper fitted bolts to the cylinder saddle, and rivets at the smokebox joint.

As it sits, the boiler is attached via standard bolts through torch cut holes at the cylinder saddle and with hardware store carriage bolts at the smokebox joint. The furnace bearers (plates at front and rear of firebox) are also attached via torch cut holes but that is likely salvageable.

- Throttle & Control Systems

0%, 0% No work has been performed on these components

- Auxiliary System Application

30%, 0% While the air compressor and power reverse gear are mounted, the systems are not only incomplete but must be removed for boiler rework. Both appliances are mounted onto some studs which were replaced with pieces of all-thread, these must be removed and have proper studs put into their place.

- Cab/Jacket Operation System

85%, 10% The cab will need to be removed in order to facilitate the rework on the boiler. However, the interior wood work seems to have been done relatively well. The jacket is not installed correctly, there is no railway practice which calls for welding a framework to the boiler for the jacket to sit upon.

- Steam Piping Systems

0%, 0% No work has been performed on these components

- Air Systems

0%, 0%

- Running Gear & Valve Gear Systems

45%, 40% What work has been performed in reassembly of the machinery does appear to have been done correctly. It should be noted that all of the machine work to the machinery was performed by former contractors. Wasatch simply oversaw volunteers performing reassembly.

- Electrical

0%, 0% No work has been performed on these components

- Safety Systems

0%, 0% No work has been performed on these components

- Paint/Detail

20%, 20% What painting has been completed will not be affected by rework. This is presuming the paint utilized is of sufficient quality, the type of pint is not known.

- Operational/Mechanical Support

0%, 0% No work has been performed on these components

The second objective was to determine whether or not the boiler is salvageable. It IS, though there will be a significant amount of rework..

Applicable Codes

FRA:

The Federal Railroad Administration, the regulatory entity which has jurisdiction over the K&T 14. Regulatory information is contained within 49 CFR Part 230. Specifically stated within this component of the CFR is the following:

§ 230.29 Inspection and repair.

(a)Responsibility. The steam locomotive owner and/or operator shall inspect and repair all steam locomotive boilers and appurtenances under their control. They shall immediately remove from service any boiler that has developed cracks in the barrel. The steam locomotive owner and/or operator shall also remove the boiler from service whenever either of them, *or the FRA inspector*, considers it necessary due to other defects.

(b)Repair standards.

(1) All defects disclosed by inspection shall be repaired in accordance with *accepted industry standards* - which may include *established railroad practices*, or *NBIC* or *API* established standards - before the steam locomotive is returned to service. The steam locomotive owner and/or operator shall not return the steam locomotive boiler or appurtenances to service unless they are in good condition and safe and suitable for service.

(2) Any welding to unstayed portions of the boiler made pursuant to § 230.33 shall be made in accordance with *an accepted national standard for boiler repairs*. The steam locomotive owner and/or operator shall not return the steam locomotive boiler or appurtenances to service unless they are in good condition and safe and suitable for service.

While not explicitly stated, the FRA does recognize and often reference ASME standards.

NBIC:

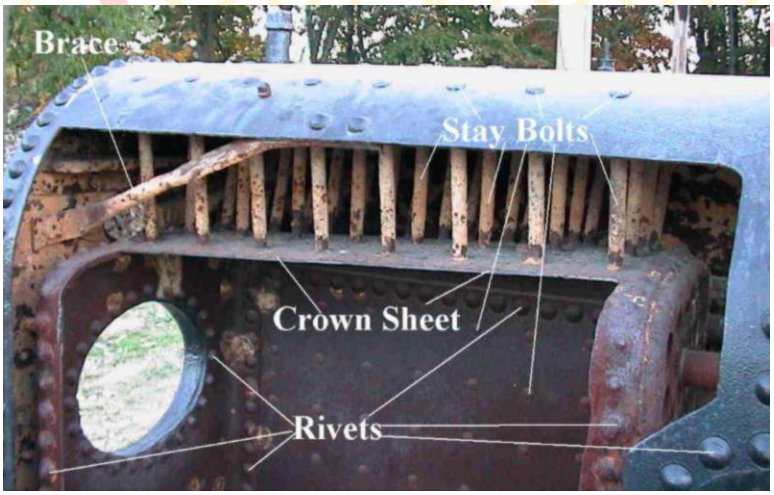
The *National Board Inspection Code* (NBIC) was first published in 1946 as a guide for chief inspectors. It has become an internationally recognized standard, adopted by most US and Canadian jurisdictions. The NBIC provides standards for the installation, inspection, and repair and/or alteration of boilers, pressure vessels, and pressure relief devices.

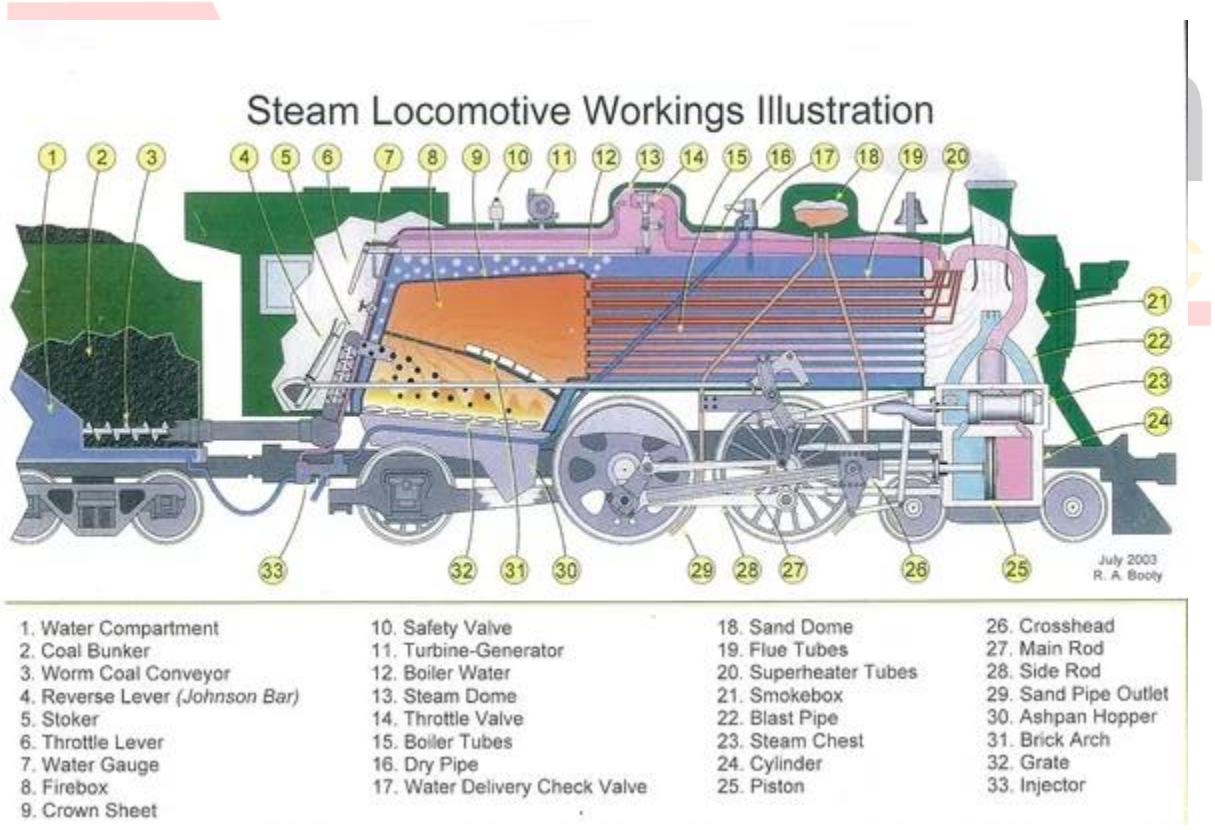
ASME:

The ASME Boiler & Pressure Vessel Code (BPVC) is an American Society of Mechanical Engineers (ASME) standard that regulates the design and construction of boilers and pressure vessels. The document is written and maintained by volunteers chosen for their technical expertise. The American Society of Mechanical Engineers works as an Accreditation Body and entitles independent third parties such as verification, testing and certification agencies to inspect and ensure compliance to the BPVC.

Locomotive Boiler Familiarity

The following images are provided for the purpose of lending visual aid in understanding the location of the mentioned components.





This image provides a perspective as to the manner in which the boiler is integrated into the locomotive.

Observed Defects

1) Rigid and Crown staybolts incorrectly installed.

The rigid bolts are installed utilizing a combination of filet welding and threading. The FRA does not allow for the application of filet welded bolts on non-chinese locomotives without prior written approval as it is not an accepted railroad practice nor (until summer of 2017) is it allowed by the ASME.

Though the ASME does now allow filet welded installation, they must be applied under specific criteria as laid forth in PL-30. Specifically, parts PL-30.4, PL-30.4.2, and PL-30.4.4. This in turn violates CFR49 Part 230.29 (b) (1).

PL-30.4 Staybolts may be attached by fillet welds provided the following conditions are met.

PL-30.4.1 The stress value for the smallest cross sectional area shall not exceed 7,500 psi (50 MPa).

PL-30.4.2 The weld leg length parallel to the longitudinal axis shall be greater than or equal to 1/4 in. (6.5 mm). The weld shear area parallel to the longitudinal axis shall be no less than 1.25 times the minimum cross sectional area of the staybolt (minus the cross-sectional area of the telltale hole) as determined by the following equation(see Figure PL-30.4.2-1):

PL-30.4.3 Staybolt ends directly exposed to the products of combustion shall extend past the fireside of the sheet no more than 3/8 in. (10 mm).

PL-30.4.4 The hole through which the staybolt is inserted shall be 1/64 in. to 1/16 in. (0.4 mm to 1.5 mm) larger than staybolt head diameter. The finished holes shall be true, cleaned of burrs, and nominally coaxial. The staybolt shall be nominally centered in the hole.

PL-30.4.2: A number of bolts do not have sufficient projection through fire side of the sheet to allow for 1/4” of weld without consuming the end of the bolt as prohibited by PW-19.2.

PL-30.4.4: All rigid and crown staybolts which can be observed from within the boiler have 1/8”+ clearance between the bolt and the sheet. Double allowable.

2) **Flexible bolts installed via filet through torch cut holes which are between 1/8” to 5/8” oversized. This violates PL-30.4.4, and also PW-29.3.**

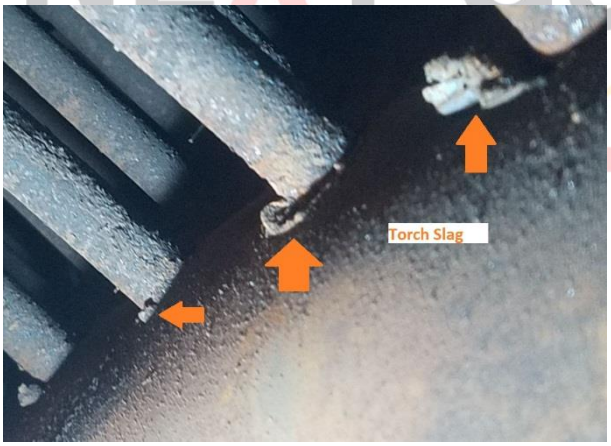
PW-29 BASE METAL PREPARATION

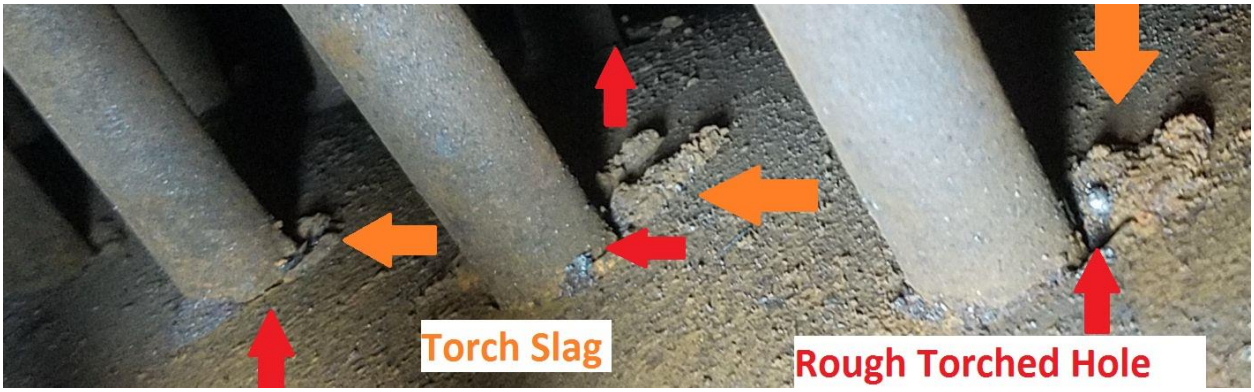
PW-29.1 The preparation of joints prior to welding may involve any of the conventional methods in use such as machining, thermal cutting, chipping, grinding, or combinations of these.

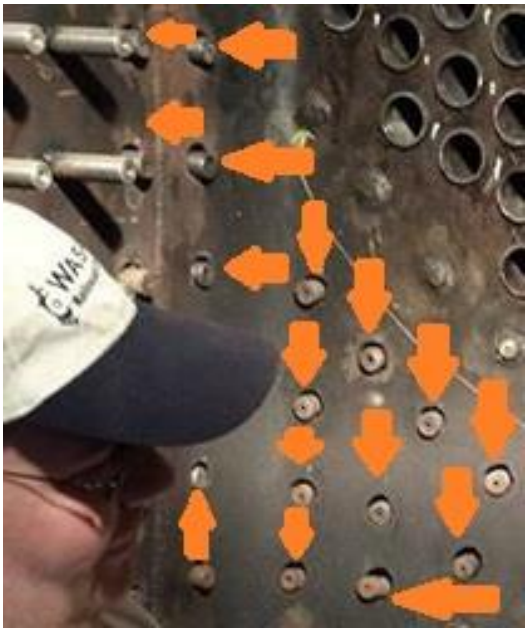
PW-29.2 Where thermal cutting is used, the effect on the mechanical and metallurgical properties of the base metal shall be taken into consideration.

PW-29.3 The method of base metal preparation used shall leave the welding groove with reasonably smooth surfaces and free from deep notches, striations, or irregularities. The surfaces for welding shall be free of all scale, rust, oil, grease, or other foreign materials.

PW-29.3: The surfaces left behind (throughout the firebox) by the torch cutting are not free of torch scale or slag (foreign material), and are also notched and consistently textured with deep striations. This in turn violates CFR49 Part 230.29 (b) (1). Hundreds such locations exist.







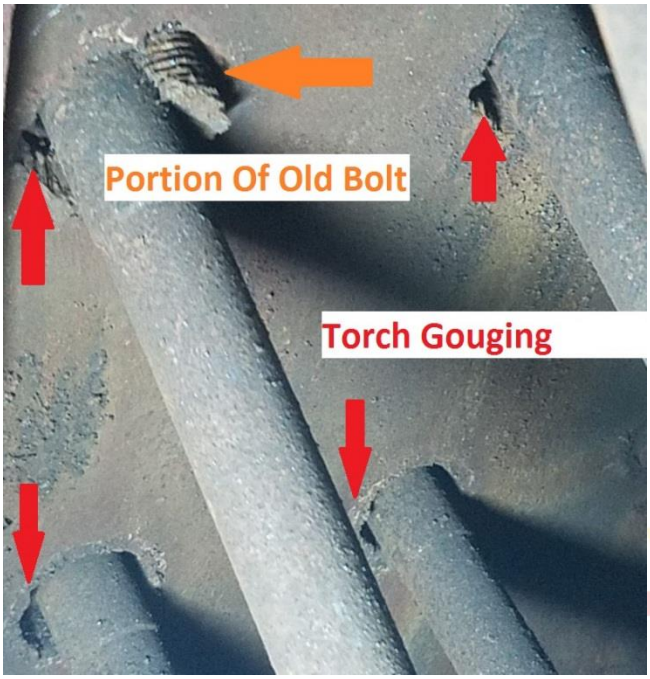
The above depicts holes well in excess of 1/8” oversize on fluesheet

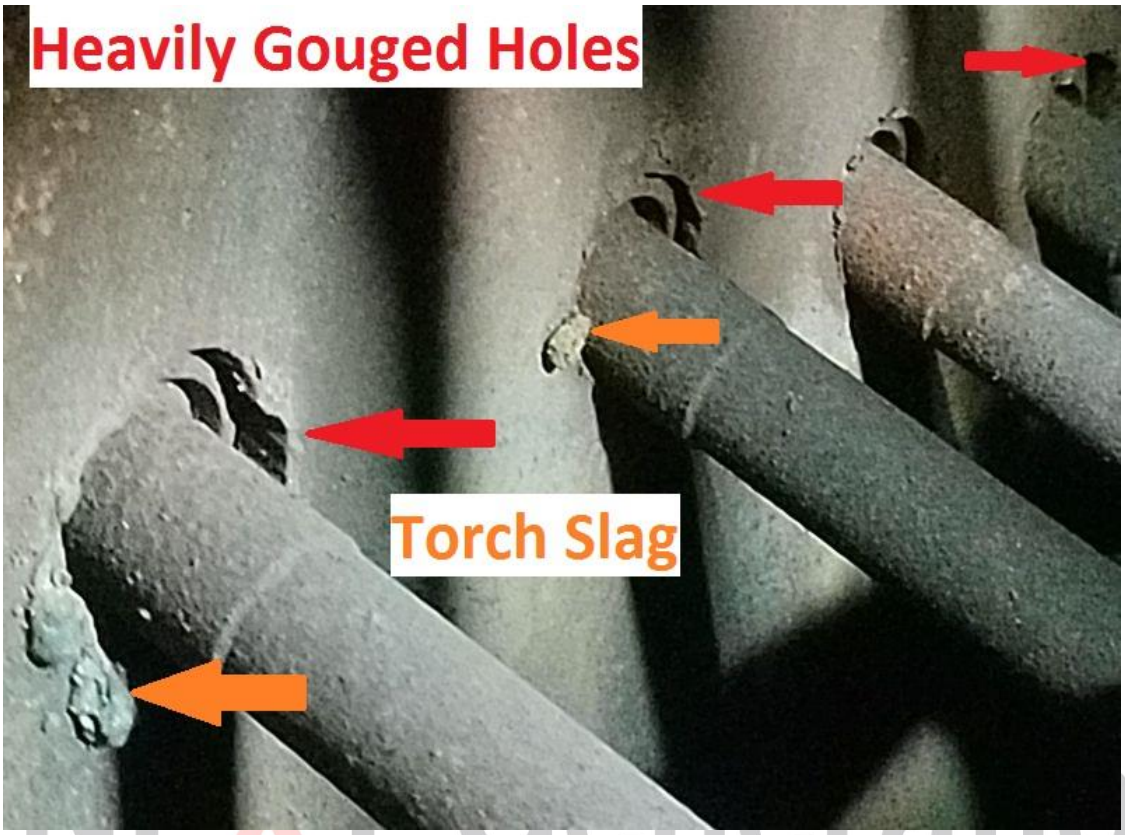
Orange denotes 2” diameter torch cut holes.

Red denotes holes in excess of ¼” oversize in FR crownsheet

3) **All New Holes for flexible sleeves thermally enlarged. Torch scale, slag, gouges, and striations not removed prior to welding.**

In addition to the violations to code consistent with PW-29.3, the accompanying photos depict a portion of an original rigid bolt remaining alongside of (and partially consumed by) a rough cut hole. This in turn violates CFR49 Part 230.29 (b) (1). This boiler has approximately 300 flexible bolts.





4) **Rivets do not meet the specifications set forth in ASTM A31-B**

The tensile strength exceeds the maximum limit set forth by the A31 grade B material specification. This in turn violates CFR49 Part 230.29 (b) (1), and NBIC Section 3, S1.1.3.1 material specifications for locomotive boilers.

TABLE 1 Chemical Requirements

	Grade A		Grade B	
	Heat Analysis	Product Analysis	Heat Analysis	Product Analysis
Carbon, max, %	. . .	. . .	0.28	0.31
Manganese, %	0.30–0.60	0.27–0.63	0.30–0.80	0.27–0.83
Phosphorus, max, %	0.040	0.048	0.040	0.048
Sulfur, max, %	0.050	0.058	0.050	0.058

determined shall be reported to the purchaser or his representative and shall conform to the requirements for heat analysis in accordance with Table 1.

5.3 *Product Analysis*—An analysis may be made by the purchaser from finished materials representing each heat. The chemical composition thus determined shall conform to the requirements for product analysis prescribed in Table 1.

5.4 Application of heats of steel to which bismuth, selenium, tellurium, or lead has been intentionally added shall not be permitted.

5.5 Chemical analyses shall be performed in accordance with Test Methods, Practices, and Terminology A751.

6. Mechanical Properties

6.1 *Rivet Bend Tests*:

6.1.1 The rivet shank of Grade A steel shall stand being bent cold through 180° flat on itself, as shown in Fig. 1, without cracking on the outside of the bent portion.

6.1.2 The rivet shank of Grade B steel shall stand being bent cold through 180° without cracking on the outside of the bent portion in accordance with Table 2.

6.2 *Rivet Flattening Tests*—The rivet head shall stand being flattened, while hot, to a diameter 2½ times the diameter of the shank, as shown in Fig. 2, without cracking at the edges.

6.3 *Bar Tensile Properties*—Bars shall conform to the tensile requirements in accordance with Table 3.

6.4 *Bar Bend Tests*:

6.4.1 The test specimen for Grade A steel bars shall stand being bent cold through 180° flat on itself without cracking on the outside of the bent portion.

6.4.2 The test specimen for Grade B steel bars shall stand being bent cold through 180° without cracking on the outside of the bent portion to an inside diameter which shall have a relation to the diameter of the specimen in accordance with Table 4.

7. Dimensions, Mass, and Permissible Variations

7.1 *Rivets*:

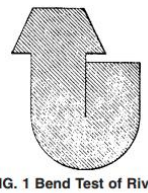


FIG. 1 Bend Test of Rivet

TABLE 2 Bend Requirements, Rivets

Diameter of Rivet Shank, in.	Ratio of Bend Diameter to Diameter of River Shank	
	Grade A	Grade B
¾ and under	flat	1
Over ¾	flat	1½

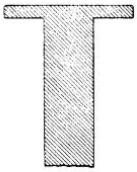


FIG. 2 Flattening Test of Rivet

TABLE 3 Tensile Requirements, Bars

	Grade A	Grade B
Tensile strength, psi (MPa)	45 000–55 000 (310–380)	58 000–68 000 (400–470)
Yield point, min, psi (MPA)	23 000 (160)	29 000 (200)
Elongation in 8 in. or 200 mm, min, %	27	22
Elongation in 2 in. or 50 mm, min, %	33	25

TABLE 4 Bend Requirements, Bars

Specimen Diameter, in.	Ratio of Bend Diameter to Diameter of Specimen	
	Grade A	Grade B
¾ and under	flat	½
Over ¾	flat	1

7.1.1 The dimensions of rivets shall conform to B18.1.2 for nominal diameters in. and larger and B18.1.1 for nominal diameters 7/16 in. and less.

7.1.2 Snap gage measurement shall be made at the point of minimum diameter, but it is not required that the rivet shall turn completely in the gage. Measurements of the maximum tolerance shall be made with a ring gage, all rivets to slip full to the head in the gage of the required size for the various diameters.

7.2 *Bars*—The diameter of hot-finished rivet bars shall not vary from the size specified by more than the amounts in accordance with Table 5.

8. Workmanship, Finish, and Appearance

8.1 *Rivets*—The finished rivets shall be true to form, concentric, and free of injurious defects.

8.2 *Bars*:

8.2.1 Bars shall be free of visible pipe, undue segregation, and injurious surface imperfections.

8.2.2 *Surface Finish*—The bars shall have a commercial hot-wrought finish obtained by conventional hot rolling. See 4.4 for producer's descaling option.

AADFW, INC.
1350 Westpark Way
Euless, TX 76040
(817) 540-0153

ACCREDITED
TESTING CERT. # 0603.01

Tensile Test Certificate

ASTM A 370-17 Rounded Per ASTM E 29-13

Prime: General ID: N/A

Jason Sobczynski
Next Generation Rail SVC
138 Farly Lane
Alvaton, KY 42122

PH: (404) 550-2823 FX:

Date Issued : 12/05/2017
Lab Number : L17173785
PO Number : KT14-1
Location: AADFW Lab
Date Tested : 11/30/2017
File Number : 0090492-00
Rev Date : Rev: 00

Part #: 1
Material: Low Carbon Steel

Specification: ASTM A 31 -14

Hardness Test Location: Core

Equipment	Method	REV
Tensile: Satec 120 HVL, SN:1290	ASTM A 370	17
Hardness: Newage Model Ni-300c, SN:91907	ASTM E 18	17e1

Bar Type: Round
Specification: N/A
Material:

Yield Criterion: Upper Yield
Rev:

Gage Length: 2.0 "

Elongation: % in 4D

	------ Dimensions (in) ------			---- Ultimate ----		-------Yield -------		Elong	R. A.	Hard.
Sample Req:		Dia.	Dia Final	(lbs)	(ksi)	(lbs)	(ksi)	(pct)	(pct)	HRB (W)
1		0.492	0.314	15105	79.5	12020	63.0	31	59	82

Disposition: For Review Only, based only on test data reported above. Nadcap requirement: Strain Rate prior to yield is .003 - .007 in/in/min; strain rate after yield is approximately .125 in/in/min. I certify that these are accurate and true results of the indicated tests performed in accordance with the AADFW applicable test procedures and relate only to the samples tested. AADFW is accredited by A2LA, Mechanical field of testing, Cert # 0603.01. All sample identification information was supplied by the customer.

AADFW, Inc. _____ Jeremy Wilson, B.S., P.E., C.W.I., Metallurgist

5) **Interior Firebox Corners, Plate Misalignment, Lack of Full Penetration Weld**

PW-9.3.1 lays out permissible tolerances associated with sheet misalignment, the maximum allowable is 25% of sheet thickness. Misalignment on the waterside of the sheet are up to 83% or 5/16". This in turn violates CFR49 Part 230.29 (b) (1).

PW-9.3.1 Alignment of Shells and Vessels (Including Pipe or Tube Used as a Shell). In longitudinal shell joints, the middle lines of the adjoining thicknesses shall be in alignment within the fabricating tolerances specified in PW-33.

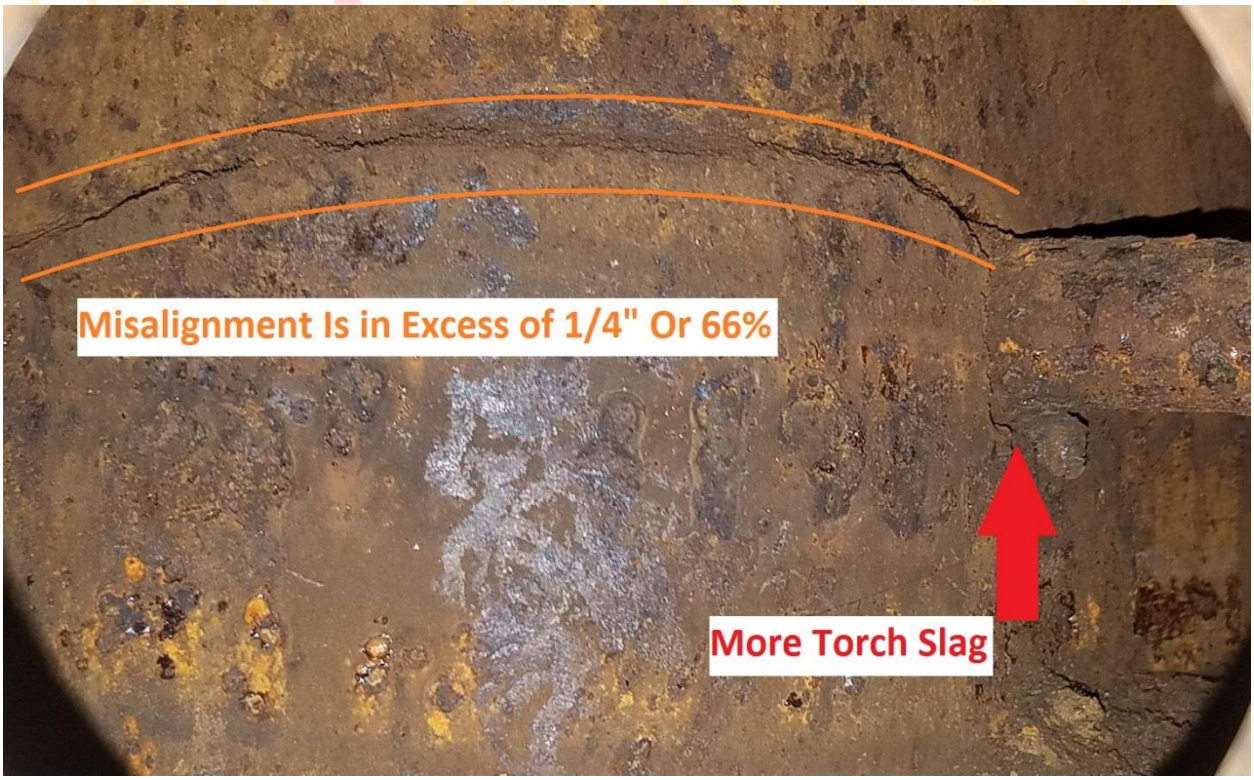
Alternatively, the middle lines of plates of differing thickness may be offset so that the inside or outside diameters of the thinner and thicker portions of the shell form a continuous surface, provided the following conditions are met:

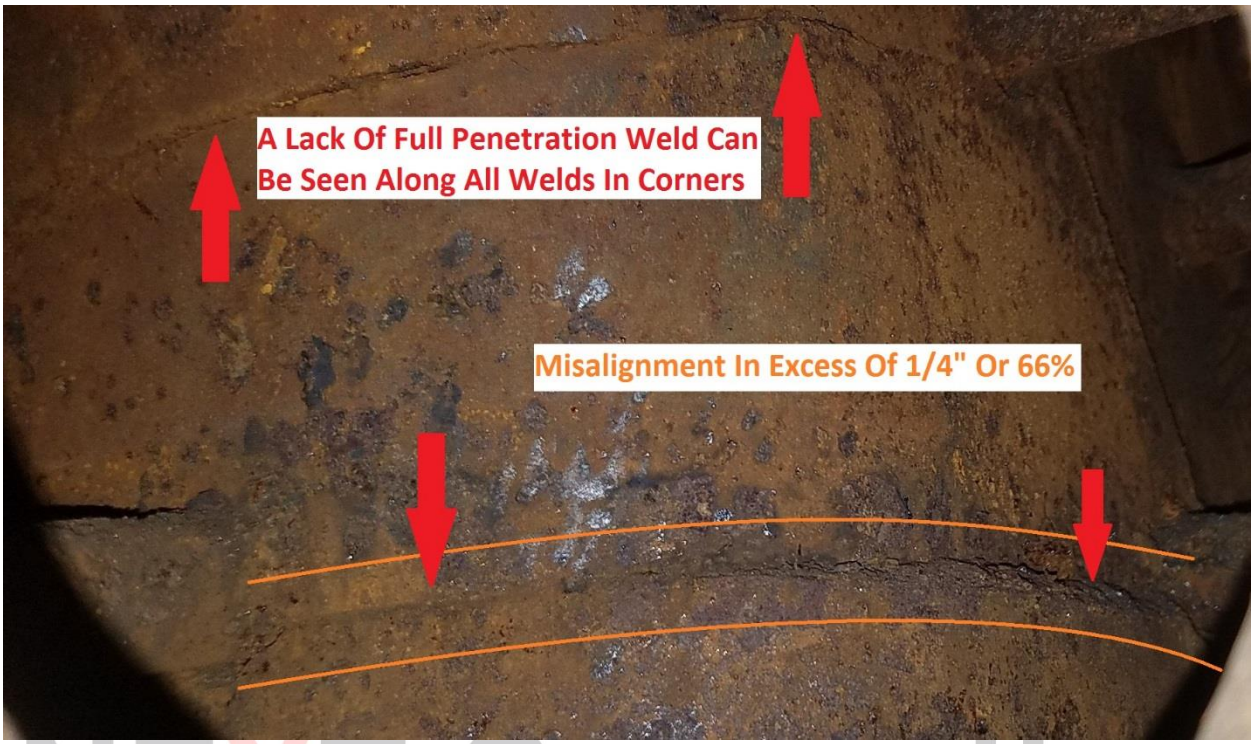
(a) The ratio of the thickness of the thicker plate to the thickness of the thinner plate shall not exceed 2:1.

(b) The maximum design temperature shall not exceed 750°F (400°C).

TABLE PW-33
ALIGNMENT TOLERANCE OF SECTIONS TO BE BUTT WELDED

Section Thickness, In. (mm)	Direction of Joints in Cylindrical Shells	
	Longitudinal In. (mm)	Circumferential In. (mm)
Up to ½ (13), incl.	$\frac{1}{4}t$	$\frac{1}{4}t$
Over ½ (13) to ¾ (19), incl.	⅛ (3.0)	$\frac{1}{4}t$
Over ¾ (19) to 1½ (38), incl.	⅛ (3.0)	$\frac{3}{16}$ (5)
Over 1½ (38) to 2 (50), incl.	⅛ (3.0)	$\frac{1}{8}t$
Over 2 (50)	Lesser of $\frac{1}{16}t$ or ⅜ (10)	Lesser of $\frac{1}{8}t$ or ¾ (19)





PW-9.1. states that all welds are to be full penetration. It can be seen from the above photos that there is no 1 in 3 blending of the above limit offset, and no sign of weld coming through to the waterside of the plate. This in turn violates CFR49 Part 230.29 (b) (1).

PW-9 DESIGN OF WELDED JOINTS

PW-9.1 Longitudinal, circumferential, and other joints, uniting the material used for drums, shells, or other pressure parts, except as otherwise provided in PG-31, PG-39, PW-41, PWT-11, and Part PFT shall be full penetration butt welds. The welds should preferably be of the double-welded butt type, but may also be of the single-welded butt type with the filler metal added from one side only when made to be the equivalent of the double-welded butt joint by providing means for accomplishing complete penetration.

6) **A Portion Of The New Firebox Was Replaced With Flat Plate In A Tight Radius**

A sharply radiused portion of the new firebox was cut out and replaced with a piece of flat plate. This is contrary to O.E.M. design and violates railroad standard practice, and NBIC code. PW-9.3.1 states that the “middle lines” of the plate are to be aligned, these are not as one is radiused and the other straight. When replacing a portion of any boiler it is to replaced “in kind” to the original. This in turn violates CFR49 Part 230.29 (b) (1).

PW-9.3.1 Alignment of Shells and Vessels (Including Pipe or Tube Used as a Shell). In longitudinal shell joints, the middle lines of the adjoining thicknesses shall be in alignment within the fabricating tolerances specified in PW-33.

Alternatively, the middle lines of plates of differing thickness may be offset so that the inside or outside diameters of the thinner and thicker portions of the shell form a continuous surface, provided the following conditions are met:

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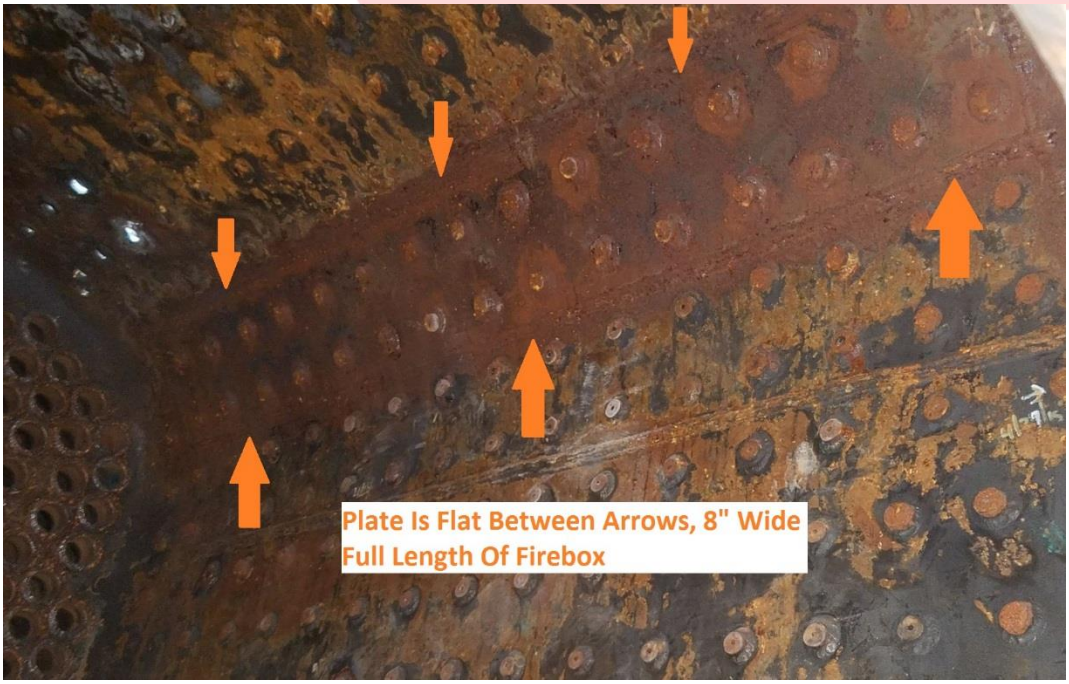
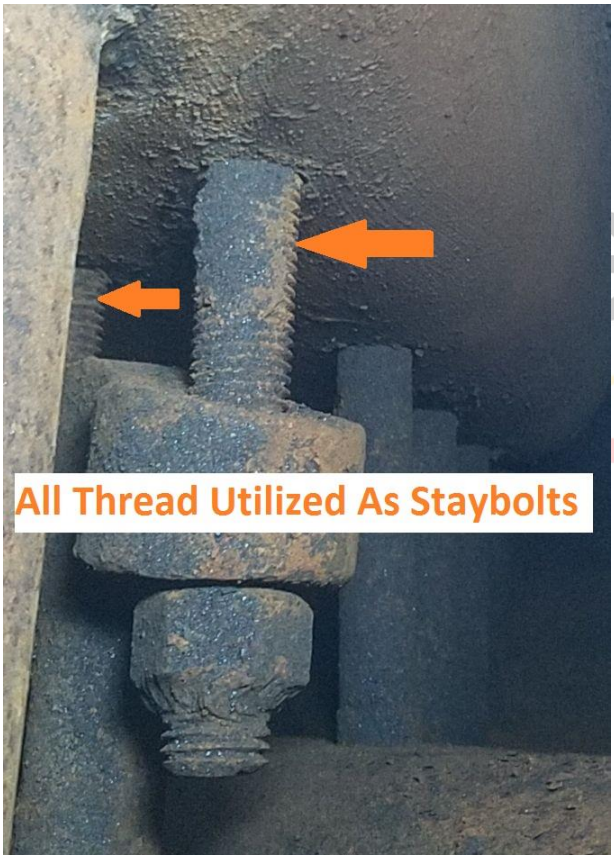
(b) The maximum design temperature shall not exceed 750°F (400°C).



7) **“All Thread” Utilized As Staybolt Material**

All of the staybolts between the belly braces and rear tubesheet consist of an “all thread” material. ASME and NBIC specify that acceptable staybolt materials shall comply with SA36 or SA675. Commercially made “all thread” does not comply with either of these material specifications. This style of belly brace is designed to utilize a flexible staybolt, there is a socket beneath the nuts which do not generally contact the brace. This in turn violates CFR49 Part 230.29 (b) (1).

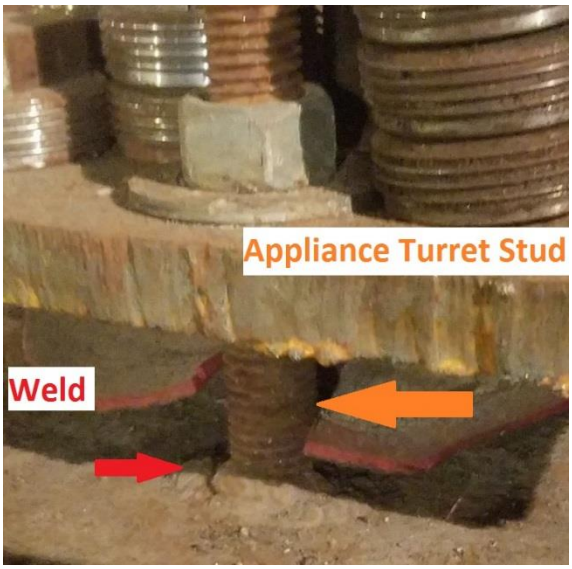


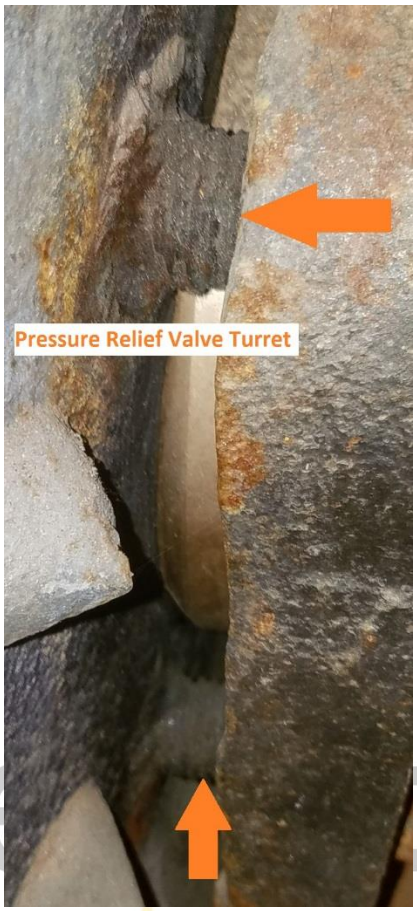
8) "All Thread" Utilized As Studs At 62 Locations Around The Barrel And Firebox, Installed Into Torch Cut Holes

A commercial grade "all thread" material was utilized. There are no commercially available "all thread" materials which are approved for welding into steam boilers. The pieces of "all thread" were installed into torch cut holes. Code does not allow for the welding of threads into a pressure vessel. This in turn violates CFR49 Part 230.29 (b) (1).

PW-5.2 Carbon or alloy steel having a carbon content of more than 0.35% shall not be used in welded construction or be shaped by oxygen cutting or other thermal cutting processes.

Type	Ferritic Steels			
Grade	B7, B7M		B16	
Description	Chromium-Molybdenum [Note (3)]		Chromium-Molybdenum-Vanadium	
	Range	Product Variation, Over or Under [Note (2)]	Range	Product Variation, Over or Under [Note (2)]
Carbon	0.37–0.49 [Note (4)]	0.02	0.36–0.47	0.02
Manganese	0.65–1.10	0.04	0.45–0.70	0.03
Phosphorus, max	0.035	0.005 over	0.035	0.005 over
Sulfur, max	0.040	0.005 over	0.040	0.005 over
Silicon	0.15–0.35	0.02	0.15–0.35	0.02
Chromium	0.75–1.20	0.05	0.80–1.15	0.05
Molybdenum	0.15–0.25	0.02	0.50–0.65	0.03
Vanadium	...	...	0.25–0.35	0.03
Aluminum, max % [Note (5)]	...	...	0.015	...





There are multiple locations around the pressure vessel at which these incorrectly applied studs are pressure retaining. These are especially concerning because when they do fail there would be a sudden and uncontrolled release of steam. Due to the proximity of the effected attachments to crew or the public, it is almost guaranteed scalding injuries would occur.

9) **Bolts Welded Into The Vessel As Studs For Attachment Of Delivery Tee, Bolts Installed Through Torch Cut Holes**

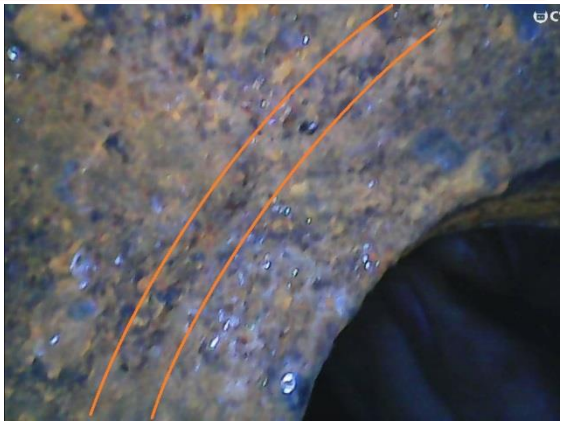
The issues with the bolts are no different than those of the studs, the use of bolts is not a compliant practice. The bolts are installed through torch cut holes, leaving behind gouging and striations. As discussed above, PW-29.3 prohibits these physical conditions. The integrity of the reinforcing ring has been compromised. This in turn violates CFR49 Part 230.29 (b) (1).

10) **Non-compliant Application Of Nozzles And Scab Patches To Belly Of Barrel**

Reinforcing liners for the application of washout plug sleeves were applied via filet weld after the tubes were installed. Holes were then cut for application of the sleeves (referred to as nozzles), though the nozzles appear to have only been welded to the liner. This is determined via exterior inspection revealing inadequate beveling around the nozzle for full penetration 1 ¼" of material, and a borescope inspection which shows a seem on the waterside of the nozzle.
These conditions are in contradiction to PW-16.1

PW-16 MINIMUM REQUIREMENTS FOR ATTACHMENT WELDS

PW-16.1 General. Except as permitted in PW-16.5 and PW-16.6, nozzles and other connections to shells, drums, and headers shall be attached by full penetration welds applied from one or both sides, partial penetration welds applied from both sides, fillet welds applied from both sides, or fillet and partial penetration welds on opposite sides. In addition to the strength calculations required in



Orange lines show seam between nozzle and boiler barrel. This seam is large enough to show up through the thick layer of debris in the belly.

11) **Dome Studs Welded**

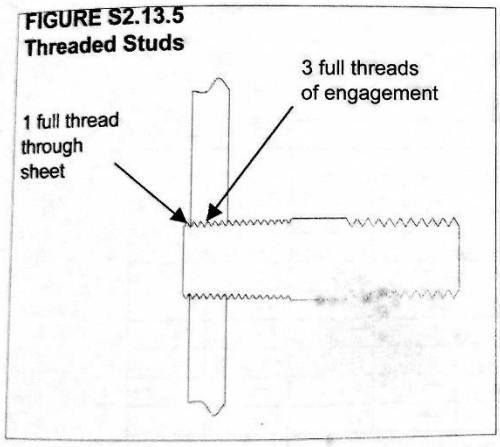
All of the dome studs have been seal welded in direct contradiction to NBIC Part 3 S2.13.5, the studs are no longer suitable for service. This in turn violates CFR49 Part 230.29 (b) (1).

S2.13.5 THREADED STUDS

a) Studs threaded into the boiler or firebox sheets shall not be seal welded. (See NBIC Part 3, Figure S2.13.5).

b) When studs are replaced, they shall extend at least one full thread through the sheet on the opposite side of installation. Replacement studs shall have a minimum of three threads of engagement.

FIGURE S2.13.5
Threaded Studs

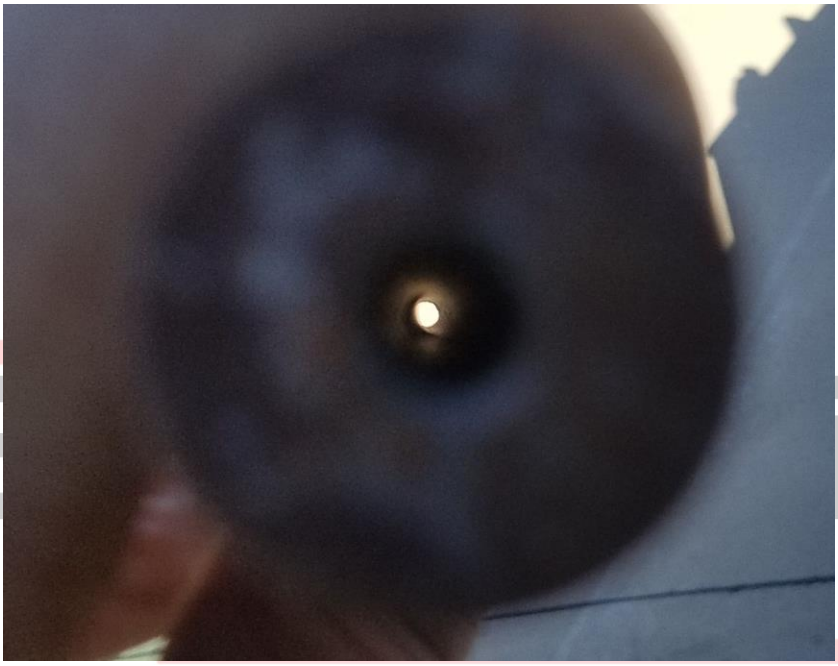


12) **Side Grate Bearers**

The side grate bearers consist of thin steel fabrications. Standard practice dictates these to be heavy/solid iron castings of an appropriate alloy. This is required as steel will burn, warp, and quickly fail.

13) **Rigid Bolt Telltale Holes Drilled From Both Sides**

The telltale holes are drilled from both ends of the bolt, many do not lineup from one end to the other. Numerous bolts exhibit holes which are misaligned by ½ of the hole diameter. This results in an inability to clear telltales in accordance with CFR 49 230.38 (c) as is evidenced by numerous broken drill bits left behind in the installed bolts. Bolts must be cleared so that when a bolt breaks, steam/water can be observed escaping.

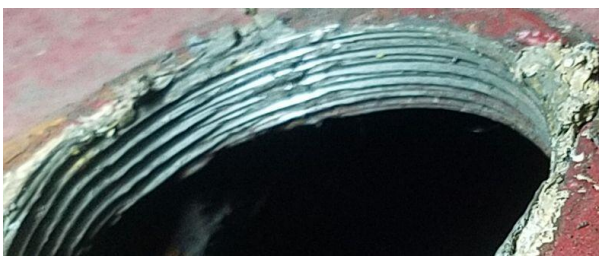


14) Incorrectly installed Saddle Bolts

The saddle bolts (bolts connecting the smokebox to the cylinder casting) are of incorrect design and installed incorrectly. Railroad standard practice calls for the saddle bolts to be of a taper fitted type bolt, these are commercially available, straight shank, black oxide bolts. The bolts were installed through dramatically oversized torch cut holes, versus the tight and machined fit standard practice calls for. Additionally, standard practice dictates that bolts be installed from the inside with nuts on the exterior, these bolts are installed upside down.

15) Washout Plugs Of Incorrect Material, Holes Cross-Threaded

All washout plugs are machined from a steel material. It is a well-accepted fact that steel plugs will seize in their threaded hole when utilized in locomotive boiler service, standard practice dictates the use of SB-61 bronze. Several holes are severely cross threaded.

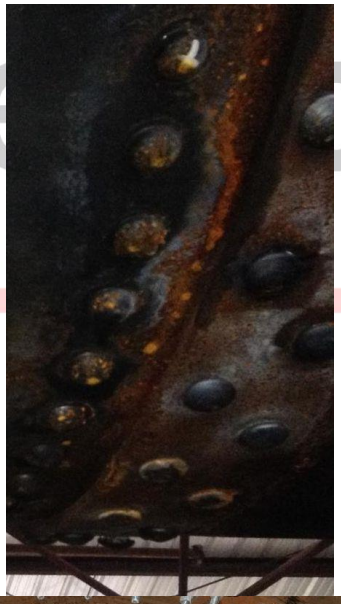


16) **Dry Pipe Seal Welded To Front Tubesheet**

The front end of the drypipe has been seal welded to the front tubesheet. This is contrary to railroad standard practice as the drypipe is to be a removable component.

17) **Attachment Of Smokebox To Boiler Barrel**

The boiler and smokebox have been joined by generic/hardware store carriage bolts. Standard railroad practice calls for attachment via rivets. The exterior of the bolts were heated and driven with an air hammer, presumably to make them look more like rivets. This Joint will allow movement between the boiler and the smokebox which will ultimately lead to cracking in the frame.



18) **No Flexible Bolts In Backhead**

The firebox of the 14's boiler has received *most* of an AAR flexible staybolt pattern. While upgrading a locomotive boiler to having a full AAR flexible bolt pattern is a railroad standard practice, and highly advisable, it must be done in full. In this case, the backhead received no flexible bolts. The result of this incomplete installation will result a high occurrence of broken bolts around the backhead due to allowance for additional movement along the ends of the sidesheets.

19) **The First Three Rows Of The Crownsheet Bolt Holes**

The first three rows of bolts had dramatically oversized holes (double bolt diameter, several of which are still visible. Those still visible are approximately 7/16" oversized. Approximately 18 bolts have been removed to allow for the weld build up of the holes. This was done so poorly that the original enlarged diameter is still visible at multiple locations as well as pockets of slag within the welds.

While it is unclear as to why, the water side surface of the sheet has been built up with weld. The thickness of the .375" sheet has increased to over .625". I conclude that this was done for the purpose of hiding sheet misalignment. The welding rod utilized for this welding is not appropriate for use on pressure vessels.

Holes Prior To Welding Of Bolts

20) **Crown To Doorsheet Fit-up**

The welded joint between the crownsheet and doorsheet was found to be far in excess of ASME/NBIC parameters. These standards were discussed above regarding the corners. In addition to the sheet misalignment, the accompanying photo depicts torch cut holes, and threads present in the welds joining the bolts to the crownsheet.

What was unable to be adequately captured in photos is the amount of misalignment. At the center of the crownsheet it as almost full sheet thickness. In order to achieve this fit up, only the leading edge of the doorsheet knuckle was bent upward. When the new sheet was made the knuckle was bent about 10 degrees beyond 90 to allow for fit up. Instead of just the leading edge, the transition in alignments should have flowed back into the radius.

21) Material Test Reports (MTR's)

No MTR's are present for any of the material which was installed into the boiler. The materials lacking MTR's consist of the firebox sheets, rigid bolts, crown bolts, rivets, tubes, caps, sleeves, and stud material.

Corrective Actions

1) **Rigid and Crown staybolts incorrectly installed.**

Due to the incorrect method of installation, all crown staybolts, and rigid staybolts must be removed and replaced. In order to properly install new staybolts, the firebox sheets must also be replaced due to the oversized, and damaged holes.

2) **Flexible bolts installed via filet through torch cut holes which are between 1/8" to 5/8" oversized.**

Due to the incorrect method of installation, all flexible staybolts must be removed and replaced. In order to properly install new staybolts, the firebox sheets must also be replaced due to the oversized, and damaged holes.

3) **Holes for flexible sleeves thermally enlarged. Torch scale, slag, gouges, and striations not removed prior to welding.**

Once all flexible bolts are removed, the accompanying sleeves will then need to be removed. This will facilitate reclaiming the holes in the external firebox sheets via welding following proper hole preparation.

4) **Rivets do not meet the specifications set forth in ASTM A31-B**

All rivets must be replaced with rivets made of code material. This would be done in conjunction with replacing the interior firebox sheets to correct for defects 1, and 2.

5) **Interior Firebox Corners, Plate Misalignment, Lack of Full Penetration Weld**

The defects associated with the corners require their replacement. This will be done in conjunction with items 1, 2, and 4.

6) **A Portion Of The New Firebox Was Replaced With Flat Plate In A Tight Radius**

This defect requires the replacement of the flat plate with a piece of material formed to properly match the centerline of the adjoining plate. This will be corrected in conjunction with items 1, 2, and 3.

7) **“All Thread” Utilized As Staybolt Material**

These pieces of non-code, improper design material will be replaced with flexible staybolts. This will be accomplished in conjunction with items 1, 2, 3, and 4.

8) **“All Thread” Utilized As Studs At 62 Locations Around The Barrel And Firebox, Installed Into Torch Cut Holes**

All “all thread” studs must be replaced with studs of a proper material, and utilizing a proper installation practice. There are 3 repair options and they would need to be discussed with the FRA to determine which they are most comfortable with, though all 3 do meet code requirements. The repair options are: 1) Full penetration welded installation of code material, 2) Weld build up and re-tapping of all effected holes, 3) Replace the boiler barrel with one of new, all welded construction.

While the 3rd option may seem intimidating, it is relatively simple and may well be the fastest and most cost-effective option. In the course of replacing the boiler barrel items would be addressed with new construction rather than rework.

9) **Bolts Welded Into The Vessel As Studs For Attachment Of Delivery Tee, Bolts Installed Through Torch Cut Holes**

The reinforcing ring requires replacement to correct for the torch cut holes. Depending upon the appearance of the fluesheet once the non-code material is removed, a patch may be required.

10) **Non-compliant Application Of Nozzles And Scab Patches To Belly Of Barrel**

The “scab patches” need to be removed need to be removed from the boiler barrel to facilitate liners of riveted attachment in keeping with OEM construction. Following the application of the liners, Huron washout sleeves will be applied in accordance with OEM practice which consists of threading them into the barrel.

11) **Dome Studs Welded**

All dome studs require replacement due to the seal welding.

12) Side Grate Bearers

The side grate bearers require replacement with an appropriate design, properly alloyed, iron casting.

13) Rigid Bolt Telltale Holes Drilled From Both Sides

All bolts with misaligned holes require replacement due to the inability to be able to clear the telltale with a drill bit. This condition has already revealed itself as a problem as evidenced by some 12+ drill bits having broken off due to the misaligned holes.

14) Incorrectly installed Saddle Bolts

Due to the oversized holes, the bottom of the smokebox will require replacement to accommodate the installation of custom machined, taper fitted bolts. This installation practice for ALCO, Baldwin, and Lima, as well as every mainline railroad within the United States.

15) Washout Plugs Of Incorrect Material, Holes Cross-Threaded

All cross-threaded holes will be re-threaded, and all plugs will be made new of SB-61/C922, code compliant, bronze material.

16) Dry Pipe Seal Welded To Front Tubesheet

Once the drypipe is removed it can be determined whether or not the effected portion is of iron or steel construction. If it is iron it will require replacement, if it is steel it can be repaired.

17) Attachment Of Smokebox To Boiler Barrel

All carriage bolts need to be removed and replaced with hot driven rivets in accordance with standard practice.

18) No Flexible Bolts In Backhead

While correcting items 1, 2, 4, and 5, 2 rows of flexible sleeves (and then bolts) need to be installed around the perimeter of the backhead staybolt pattern. This is required as a component of the AAR flexible pattern installed throughout the other appropriate areas of the firebox. Without the installation of these, the rigid bolts would break on a very regular basis.

19) The First Three Rows Of The Crownsheet Bolt Holes

These torch-cut, oversized, and then incorrectly repaired holes require replacement of the effected sheet. This will be accomplished in conjunction with items 1, and 2.

20) Crown To Doorsheet Fit-up

This defect requires replacement of either the doorsheet or the crownsheet. This will be accomplished in conjunction with items 1, 2, 4, 5, and 6.

21) Material Test Reports (MTRs)

Any new installation material, for which a material test report does not exist, must be replaced. Currently, there are no MTRs available for the staybolts, firebox sheets, flexible sleeves or caps, flues, rivets, etc.

At this point, even if MTRs were made available, there is no "chain of custody" which could show that the MTRs are applicable to the material which was installed. All recently installed material must then be replaced.

Corrective Costs

The cost associated with repairing these defects will be approximately 30% more than what has currently been invested into creating them. This is due to the required labor associated with the disassembly, repair of base material, and re-fabrication of new firebox components.