

Using the throttle to regulate the airflow, allow the air to blow through the dry pipe and discharge into the cylinders. The cylinder cocks must be open;

b. Pressurizing the boiler with compressed air, then operate the locomotive under air pressure over a short distance of track. The cylinder cocks should be opened during the initial operation to prevent damaging the cylinders by hydraulic lock;

Note: Methods “1” or “2” may have to be performed several times to discharge all of the moisture from the cylinders, and steam pipes. If the locomotive is operated under air pressure, the air brake system should be made operational to provide safe stopping or other steps taken to control and stop the locomotive.

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c. Refer to NBIC Part 2, S1.5.5, *Use of Compressed Air to Drain Locomotive Components*, for additional information;

g) Drain and wash tender water spaces. The tank should be inspected afterward and any remaining water removed by siphon or vacuum. When dry, spray the water space with outdoor paint or a commercial rust preventative. Drain and dry tender tank hoses and clean screens;

h) On coal or wood burners, spray any exposed surfaces of the tender fuel space with outdoor paint or a commercial rust preventative. If the locomotive is to be stored outdoors for a long term, remove all coal and spray the surfaces as above or cover the coal space with a tarp or a roof;

i) On oil burners, drain and blow out all fuel lines, tank heater and blowback lines, and the burner itself. Drain sludge and water from the bottom of the fuel tank. Ensure that tank hatches are secure and the tank is vented to prevent condensation. Draining the oil tank is recommended if the fuel oil is known to lose its volatile content during storage;

j) After cleaning thoroughly, coat all side and main rods, cross heads, valve gear, guides, piston rods, brake pistons, feedwater pump pistons, and air pump pistons with water-resistant grease or a rust preventative. Grease should be applied to the junction of each axle and driving box and journal box to prevent water entering. Grease should be applied to junction of rod and pin in valve gear and rods to prevent water entering;

k) If the locomotive is moved after grease is applied, it will be necessary to reapply the coating to piston rods and guides;

Note: Heavy oil or unrefined oil such as any of the Bunker types (Bunker 6, etc.) should not be used for preservation of any components because the sulfur contained in it can accelerate corrosion. Standard motor oil or journal oil will not stick to and preserve wetted surfaces. All surfaces, to be so coated, must be dry. If moisture is a problem, steam cylinder oil should be applied.

l) Plain journal bearings should be inspected for water and repacked. Roller bearing boxes should have all moisture drained and the boxes filled with lubricant. Grease plugs should be screwed down so that the threads are not exposed;

m) If the locomotive is to be stored outdoors with questionable or no security, remove and store all cab gages, water glasses, lubricators, brass handles, seatboxes, and any other items that thieves or vandals might attack. Remove the whistle, bell, headlight and marker, and/or classification lights. Remove tools, radios, and spare parts. Secure wood or metal covers over all windows and doors, and board up the back of the cab. Secure all manholes on the top of the tender; and

n) Inspect stored locomotives regularly for signs of rust, corrosion, damage, deterioration, or vandalism and immediately take any corrective measures necessary.

S1.5.5 USE OF COMPRESSED AIR TO DRAIN LOCOMOTIVE COMPONENTS

a) The process of using air pressure to drain and empty auxiliary components such as the cylinders, superheater units, and piping completely of water offers several advantages over other methods.

b) The air compressor must be equipped with a suitable filter to enable it to supply oil-free air because the introduction of air that contains oil into the water/steam parts of the boiler and superheater will promote the formation of scale and water foaming when the locomotive is returned to service.

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§1.6 SAFETY VALVES

The minimum safety valve capacity in pounds per hour (kilograms per hour) shall be calculated by multiplying the boiler heating surface area by the factor from the appropriate chart in NBIC Part 2, Table S1.6 (1 pound steam/hr/sq. ft = 4.88 kg steam/hr/sq meter).

Table S1.6

Minimum Pounds of Steam/hr./sq. ft. of Steam Heating Surface

Firebox Heating Surface

- Type Factor
- Hand-Fired 8
- Stoker-Fired 10
- Oil-Fired 14

Flue Heating Surface

- Type Factor
- Hand-Fired 5
- Stoker-Fired 7
- Oil-Fired 8

Superheater Heating Surface

- Type Factor
- Hand-Fired 5
- Stoker-Fired 7
- Oil-Fired 8[dkp9]

§2.8.1 SAFETY VALVES

a) The following requirements shall be verified acceptable when performing inspections of safety valves.

- 1) Set pressures of safety valves installed shall be verified by operation or certification acceptable to the Jurisdiction.
- 2) Safety valve(s) shall be National Board capacity certified.
- 3) Safety valve(s) shall be sealed by an ASME “V” Stamp Holder or National Board “VR” repair firm.
- 4) The required safety valve capacity in pounds per hour (kg per hour) shall be calculated by multiplying boiler heating surface area by the type of fuel factor used (see NBIC Part 2, Table S2.8.1 for fuel factors). Excessive safety valve capacity should be avoided. (Only heating surface area above the grates shall be used when calculating heating surface for safety valve required capacity.)

Note: An additional pressure relief valve may be used in conjunction with the above required ASME safety valve if set at a lower pressure, although no credit for relieving capacity may be used.

- 5) Safety valve(s) shall have a test lever.
- 6) No isolation valve of any description shall be placed between the required safety valve(s) and the boiler, or on the discharge pipe between the valve and the atmosphere.
- 7) The piping connection between the boiler and the safety valve shall not be less than the inlet size of the safety valve, and the discharge pipe, if used, shall not be reduced between the safety valve and the point of discharge.

b) To reduce cycling stress on the boiler, it is recommended that a safety valve with a blowdown between 2% and 4% be used. The blowdown, however, should never exceed 6%.

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TABLE S2.8.1

Minimum Pounds of Steam per Hour per Square Foot of Heating Surface (1 lb. Steam/hr./sq. ft. [4.88 kg/hr./sq. m])

Boiler Heating Surface Firetube Boilers Watertube Boilers

- Hand-Fired 5 6
- Stoker-Fired 7 8
- Power Burner 8 10
- Hand-Fired Waterwall 8 8
- Stoker Waterwall 10 12
- Power Burner Waterwall 14 16 |

[dkp10]

S2.14.2 STOPPING ENGINE IN AN EMERGENCY

- a) Know how to stop the engine suddenly. For example, if someone or something runs out in front of the engine or some problem happens with whatever its belted up to:
- 1) Close throttle.
 - 2) Reverse valve quadrant position.
 - 3) Open throttle for a moment (this will quickly stop your engine).
 - 4) Close throttle.
 - 5) Open cylinder cocks.
- b) Steam traction engines do not have brakes, so this is a maneuver worth knowing and practicing. However, it should be practiced with the dome valve shut as this method of stopping the engine tends to be very hard on gears and castings. In regards to belt work, it is extremely important that total undivided attention is given to what it is belted up to. Be prepared to shut down quickly should something happen. |
- [dkp11]

S2.14.3 WATER GLASS BREAKAGE

Having a properly guarded water glass will prevent objects from coming in contact with the glass. However, water glasses do break. If the machine is operating when water glass breakage occurs:

- a) Close throttle.
- b) Set valve quadrant to neutral (middle notch).
- c) Disengage clutch.
- d) Close damper.
- e) Locate bottom water glass valve and shut off.
 - 1) The first four procedures will be difficult if the water glass is mounted back by the operator's platform.
 - 2) The bottom water glass valve is essential to locate and close first. This valve is below the waterline and can take the water dangerously close to the crownsheet if water is allowed to escape unchecked. This is where having the automatic type gage valves would be most desirable. Most traction engines do not have automatic type gage valves. Caution must be exercised at this time because 300 degree F steam and water will be spraying in every direction! There will be an inability to see much of anything except a cloud of water vapor, use a shovel or a coat or something to deflect the spray to be able to find that lower valve.
- f) Next, close the top gage valve; this one should just be blowing steam and obscuring visibility. There is no serious problem with steam being released because this valve is above the water line.

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- g) Next, use the try-cocks to determine water level of boiler. If bottom try-cock blows water, then inject water and replace water glass. However, if bottom try-cock does not blow water, and only blows steam, do not inject water and proceed to kill fire immediately. Do not move engine. Another method of determining the water level in the boiler other than using the try-cocks is to wet down a burlap sack and lay it on the barrel part of the boiler. Quickly pull it away and there will be a "sweat line" of where the actual water level is.

S2.14.4 RUNAWAY ENGINE AND GOVERNOR OVER SPEED

a) Probable causes: governor malfunction. Usually the governor belt either slips or breaks. Know the governor belt condition and keep its tension snug but not too tight. Also, packing nut could be too tight causing a binding on valve spindle; more often this will cause engine to not respond to load and usually will not “runaway.”

b) What to do in a runaway situation: Never leave the operator’s platform while engine is at governed speed.

In the case of a runaway engine:

- 1) Quickly close the throttle;
- 2) Move forward/reverse lever to center of quadrant;
- 3) Open cylinder cocks;
- 4) Close dome valve;
- 5) Close damper and steam down (this is not a boiler emergency; once engine has stopped there should be no danger).

c) In the unlikely event the throttle was to jam in conjunction with governor malfunction:

- 1) Move forward/reverse lever to center of quadrant. This will stop the engine even though steam is still being sent to the valve chest;
- 2) Close the dome valve; this would be the same as closing the throttle. Steam flow would then be stopped and the engine should be safe;
- 3) Close damper and steam down. |

[dkp12]S2.14.5 KILLING A FIRE

This is an important procedure to know, should a low water situation ever occur.

a) Close all dampers. This will stop incoming air which supports fire. Capping the smokestack is an additional way of checking draft to fire. However, it will cause a lot of smoke to emit around fire door.

b) Shovel dry sand or dry earth on the fire; this should immediately cool the fire to a safe level. Have a pile of dry sand or dirt in or around the steam engine area should a situation occur. It is important to remember that when trying to extinguish a fire, never stir the fire; this will only intensify the fire’s heat.

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c) Close the fire door.

d) Close the dome valve.

e) Leave the engine alone. It is especially important not to move the engine as this could slosh water onto a possibly overheated crown sheet.

S2.14.6 INJECTOR PROBLEMS

Injector problems are the number one reason for boiler operation malfunctions. An injector can be a very sensitive device. The ability to identify the reasons why it’s not working is the most important thing a steam engineer needs to know. The following are various problems and causes.

a) Failure to raise water from supply tank

- 1) Suction pipe clogged or tank supply valve turned off.
- 2) Leaks in suction pipe or hose, allowing air to enter above the level of water supply. A common problem when rubber or plastic hoses are used on suction side of injector.
- 3) Water supply too hot. Hot water will prevent injector from lifting water.
- 4) Obstruction in the lifting or combining tubes of the injector.

b) Injector lifts water but will not force it into the boiler.

- 1) Choked suction pipe or strainer/incomplete obstruction.
- 2) Supply valve not opened all the way.
- 3) Boiler valve closed.

4) Boiler check valve stuck closed.

5) Obstruction in delivery tube on injector.

6) Leaking injector overflow check valve.

7) Injector choked with lime.

c) Other injector problems.

1) Usually you have a hot injector because of improper operation. This is where a removable rubber hose

S2.14.12 SAFETY VALVE PROBLEMS

Testing of this critical safety device should be done each time the boiler is fired up. This is essential to ensure its continued safe operation. In the event the safety valve does not open at its preset pressure and trying to manually trip open valve lever is unsuccessful, close the damper and follow steam down procedure. After closing damper, start the injector. This will decrease the steam pressure. Under no circumstance should the blowdown valve be used to release pressure (blowing down will lower the water level considerably). Killing the fire should not be necessary; provided the water level is at a safe level and the steam pressure is dropping from running the injector. Do not continue to run engine, remove the valve and send to a certified shop for repair or replace the valve.

S2.14.13 SAFETY VALVE OPENS BUT WILL NOT CLOSE

This problem is more prevalent than valves that don't open. There is no immediate danger in a safety valve that won't close, the boiler is only losing steam. Try to manually open the valve a few times under pressure. This may seat the valve. Bringing your steam pressure down approximately 25 PSI will let the valve seat. If after dropping the pressure and it still does not seat, there may be an obstruction in the valve or a binding in the action of the valve. Follow normal steam down procedure. Remove valve and send to a certified shop for repairs or replace the valve. |

[dkp13]

S2.14.14 LEAKING PIPE PLUGS

Usually threads were not properly cleaned before installation or thread tape/sealant not properly applied. Under no circumstance should plugs be tightened with boiler under pressure. Usually the leak is very small and does not mean any immediate danger. Follow normal steam down procedure.

S2.14.15 MELTED GRATES

- a) Closing damper with a hot coal fire. This restricts air flow to the grates, although rare for a grate to melt from this, it is possible to warp or ruin a good set of grates. Grates need air flow to keep them cool. Closing damper all the way with a hot coal fire should only be done in an emergency.
- b) Carrying ashes too high in ash pan is usually the reason for melted grates. The hot coals in the ash pan touching the grates and the restricted air flow is going to damage the grates. In some cases a grate bar can entirely melt out leaving a huge hole in your fire bed and an intense fire burning in your ash pan. Follow normal steam down procedure.

S2.15 TABLES AND FIGURES

- a) [TABLE S2.8.1 Minimum Pounds of Steam per hour per Square Foot of Heating Surfaces][dkp14]
- b) TABLE S2.10.2 Sizes for Rivets Based on Plate Thickness
- c) TABLE S2.10.3.1 Maximum Allowable Working Pressure for Cylindrical Components – Single-Riveted Lap Joint
- d) TABLE S2.10.3.2 Maximum Allowable Working Pressure for Cylindrical Components – Double-Riveted Lap Joint

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e) All re-closing pressure relief valves shall be externally inspected for any corrosion or damage that might prevent the device from operating as designed;

- 1) All re-closing pressure relief valves on cargo tanks carrying lading corrosive to the pressure relief valve shall be removed from the cargo tank for inspection and testing;
- 2) Each re-closing pressure relief valve required to be removed and tested as specified in e) 1) above must open at the required test pressure and reseal to a leak-tight condition at 90% of the set-to discharge pressure or the pressure prescribed for the applicable cargo tank specifications. |

[dkp15]

the test shall include all appurtenances, all baffles, bulkheads, and upper coupler (fifth wheel) that comprise the cargo tank and shall be pressure tested at pressures established in NBIC Part 2, Table S6.13.6. The pressure test procedure shall include the following:

- a) The pressure test shall be performed in accordance with a test pressure that includes provision for the

inspector to perform an internal and external visual inspection of all surfaces of the cargo tank. For MC 338 cargo tanks, and cargo tanks not equipped with a manhole, an internal visual inspection is not required.

- 1) The visual external inspection shall be conducted while the cargo tank is under test pressure.
 - 2) The visual internal inspection shall be conducted after the pressure test is completed.
- b) When performing the pressure test all self-closing pressure relief valves, including emergency relief vents, and normal vents shall be removed for inspection and test, except for line safety devices that may be removed or left in place.
- 1) Each self-closing pressure relief valve that is an emergency relief vent shall be capable of opening at the required set pressure and seat to a leak-tight condition at 90% of the set-to-discharge pressure, or the pressure prescribed for the applicable cargo tank. It should be noted that self-closing pressure relief valves not tested or failing the pressure test must be repaired or replaced[dkp16];

S6.15.3.3 RUPTURE DISCS AND FUSIBLE PLUGS

All rupture discs required by NBIC Part 2, S6.15.1 l) 2) and fusible plugs required by NBIC Part 2, S6.15.1 m) shall be removed from the ton tank and inspected. The inspection shall include but not be limited to the following:

- a) All rupture discs shall be inspected for corrosion, leakage, and manufacturer tolerances;
- b) All fusible plugs shall be inspected for corrosion, loose, or deteriorated temperature sensitive materials;
- c) Any indication specified in a) and b) above will require the rupture disc or fusible plug to be replaced with devices specified in NBIC Part 2, S6.15.1 l) 2) and S6.15.1 m).[dkp17]

S6.15.3.4 SUCCESSFUL COMPLETION OF THE PERIODIC RETESTING

If the results of the periodic retest are successful, the ton tank shall be plainly and permanently stamped on one head or chime of each ton tank. The stamping shall include:

- a) The month and year of the test followed by a "V", and
- b) Dates of previous tests and all prescribed markings shall not be removed. Previous dates and markings on the ton tank's head or chime shall be legible.

S6.15.3.5 EXEMPTIONS TO PERIODIC HYDROSTATIC RETESTING

Ton tanks that satisfy DOT 106A and DOT 110A and are used exclusively for transporting fluorinated hydrocarbons and mixtures thereof, and are free from corroding components related to the ton tank may be exempted from the periodic hydrostatic retest if:

- a) The ton tank is given a complete internal and external visual inspection of all heads, shells, nozzles, couplings, pressure relief devices, i.e. pressure relief valves and rupture discs and fusible plugs for deterioration and leakage.
- b) The visual internal and external inspection is performed by qualified personnel, i.e., registered inspector, employee of the owner-user, etc.

S6.16 PRESSURE RELIEF DEVICES

S6.16.1 SCOPE

This Section provides details for the application, continued service inspection, and repair of pressure relief devices specified for overpressure protection of transport tanks.

Pressure relief devices are provided for all transport tanks to prevent internal pressure from exceeding design values. They may also be provided to prevent excessive internal vacuum. Overpressure protection may be provided by reclosing pressure relief valves, non-reclosing devices such as rupture disks or breaking bar or breaking pin valves, or combinations of pressure relief valves and non-reclosing devices.

S6.16.2 SAFETY CONSIDERATIONS

When inspections of pressure relief devices are being performed, inspectors should be aware that tests of these devices involve the discharge of the test fluid, which can result in high velocity fluid flow, possible high or low temperature fluids, and high noise levels. If a test is being performed with the service fluid, it should be a fluid that is safe for discharge and not toxic or hazardous. Due to the nature of fluids being transported, most testing will involve removing the device from the transport tank and testing it on a test stand. (See NBIC Part 2, S6.12.1, Pre-Inspection Activities.)

S6.16.3 INSTALLATION PROVISIONS

Incorrect installation of a pressure relief device can have a detrimental effect on device performance. The following provisions shall be followed when installing pressure relief devices on transport tanks:

- a) Inlet piping shall have an area at least equal to the pressure relief device inlet size with no restrictions

which can affect flow through the device;

- b) Pressure relief devices shall be installed to be in communication with the vapor space of the tank in its normal transport orientation as near as practicable on the longitudinal center line, and in the center of the tank;
- c) If discharge piping is provided, it shall have an area at least equal to the pressure relief device, be as short and straight as possible, and of a length that will not affect the pressure relief device flow performance. It will typically discharge upward, and should be directed away from personnel that may be around the tank at ground level;
- d) Provisions for protection of the outlet of pressure relief devices from contamination from the effects of rain, weather, etc., shall be provided. Where rain caps are provided, the fit shall not be tight enough to affect the valve performance;
- e) Pressure relief devices may be installed inside a protective housing consisting of mechanical elements designed to protect the valve during roll-over events. These elements shall not obstruct the outlet of the device;
- f) If a rupture disk is used in combination with a pressure relief valve, it shall be located inboard of the pressure relief valve;
- g) When a rupture disk is used in combination with a pressure relief valve, a device to detect leakage through the rupture disk, or actuation of the rupture disk, shall be provided. These devices detect leakage or actuation by observation of the accumulation of pressure between the disk and the pressure relief valve, and shall consist of a needle valve, try-cock, tell-tale indicator or pressure gage. Where a valve is provided, it shall be closed during normal operation. Leaking disks or disks, which have discharged, shall be replaced as soon as possible; and
- h) Block valves shall not be used on either device inlets or outlets.

S6.16.4 PRESSURE RELIEF DEVICE INSPECTION

For pressure relief valves, inspection shall consist of an External and Internal Visual Inspection and a Pressure Test to determine valve function. For non-reclosing pressure relief devices, inspection shall consist of an External and Internal Visual Inspection as well.

S6.16.5 SCHEDULE OF INSPECTIONS

Pressure relief devices shall be inspected at the frequency as required by NBIC Part 2, Tables S6.13.4, S6.14, or S6.16.3. For both an External Visual Inspection and a Pressure Test, the frequency of inspection for pressure relief devices shall be the same as the frequency required for inspection of the transport tank itself.

S6.16.6 EXTERNAL VISUAL INSPECTION OF PRESSURE RELIEF DEVICES

The following items shall be inspected during the External Visual Inspection.

- a) Pressure relief device nameplate data shall be reviewed, and the marked device set pressure compared to the transport tank data. The pressure relief device set pressure shall not exceed the tank maximum allowable working pressure (MAWP) except as permitted by the applicable transport tank specification Appendix.
- b) Where seals are provided to seal external adjustments of pressure relief valves, the seal must be intact and bear the identification of the organization responsible for performing the adjustment. If the valve has been repaired or reset, it must bear a supplemental nameplate identifying the organization responsible for the repair or resetting.
- c) Valves that have the set pressure adjustment permanently sealed by means such as a rivet or roll pin through the adjustment, shall be checked to ensure there has been no tampering with the set pressure adjustment.
- d) Check for evidence of leakage through the valve. For a valve installed with a rupture disk at the inlet, the rupture disk leakage detection device shall be checked for signs of leakage through the disk. When possible, this inspection should be performed with normal transport tank operating pressure present.
- e) All connecting bolting shall be present and tight.
- f) Evidence of rust or corrosion of the pressure relief device shall be investigated.
- g) Where drain holes are provided on the side of the valve, check that the drain holes are not plugged.
- h) Check that a valve spindle restraint (test gag) has not been left in place after pressure testing of the transport tank.
- i) Check for proper orientation of rupture disk devices. These devices will have a flow direction arrow or other designation such as inlet or vent side to designate the flow direction. Installation of rupture disk devices in the reverse direction can cause a disk to burst at a higher pressure than its marked burst pressure.

S6.16.7 PRESSURE TESTING OF PRESSURE RELIEF VALVES

A check of pressure relief valve operation shall be performed to ensure the valve is functioning properly. This testing shall be performed at the time of the transport tank pressure test when the tank pressure test will necessitate removal of the pressure relief valve. When the valve is removed for testing, the connection on the transport tank shall be inspected for corrosion or deposits which could block or reduce the connection area.

- a) Prior to the test, the inlet and outlet passages of the valve shall be visually inspected for corrosion or deposits of material which could affect valve operation.
- b) The test fluid shall be air or other suitable non-hazardous gas.
- c) The valve shall be installed on a test stand and a calibrated test gage of suitable range shall be used.
- d) Valves shall be tested for the following operational characteristics:
 - 1) Seat Leakage: The test pressure shall be increased to seat leakage test pressure at which there should be no leakage as determined by a bubble test. This pressure will typically be 90% of the stamped set pressure or the pressure prescribed for the applicable transport tank specification. There shall be no audible or visible leakage at the specified seat leakage test pressure.
 - 2) Set Pressure: The set pressure definition used by the valve manufacturer to originally set the valve shall be determined, and shall be used during evaluations of valve performance. For most transport tank valves this will usually be the “start” to “discharge” pressure which is the pressure at which the first audible discharge is detected. The test pressure shall be increased until the set pressure is determined. The valve shall open within the tolerance for set pressure as specified by the applicable transport tank specification.
 - 3) Re-seal pressure: The test pressure shall then be decreased and the pressure at which the valve reseals shall be recorded. The valve shall reseal at or above the pressure specified by the applicable transport tank specification, or above the normal transport tank operating pressure.
 - 4) It is recommended that the test sequence be repeated several times to ensure repeatable valve performance. Erratic performance may indicate damage to the valve, including damage or deposits on the seating surface.
- e) The results of testing shall be documented and be made available to the Inspector.
- f) Testing shall be performed by trained individuals from an organization acceptable to the Competent Authority.

S6.16.8 CORRECTION OF DEFECTS

Any failure of the valve to meet applicable test specifications shall be brought to the attention of the Inspector and owner, and steps shall be taken to correct the defect. If repairs are required they shall be performed by a qualified organization acceptable to the Competent Authority.

When a valve is to be repaired, it shall be completely disassembled, cleaned, all parts inspected, and repaired as necessary. It shall then be tested and all adjustments resealed with a seal identifying the repair organization. Parts replaced shall be from the valve manufacturer or meet the valve manufacturer’s specifications. Where soft goods such as gaskets, o-rings, and other seals are replaced, new parts shall be used.

Repairs shall be identified with a repair nameplate which includes the organization responsible for the repair, date of the repair, and a unique identifier, identifying repair documentation. The goal of the repair is to bring the valve back to a “like new” condition.

A valve found to be defective may be replaced by a new valve or previously repaired valve. Care shall be taken to ensure that the replacement valve meets the same requirements as the valve being replaced.

S6.16.9 INSPECTION OF RUPTURE DISKS AND NON-RECLOSING DEVICES

Rupture disks and other non-reclosing devices cannot be tested. In lieu of the required pressure test for a pressure relief valve, the disk and disk holder must be removed from the transport tank and the disk inlet and outlet surfaces visually inspected. (This is considered the “Internal Inspection.”) Signs of corrosion, damage, or deposits will require that the rupture disk be replaced.

A program to periodically replace rupture disks is recommended to prevent premature disk opening during normal operation. This can be caused by corrosion or deterioration of the disk or fatigue of the disk material due to cyclic operation of the transport tank and vibration during normal operation. The rupture disk manufacturer may have recommendations for the frequency of disk replacement. Replacement disks shall have the same specifications for burst pressure and coincident temperature as the disk being replaced, unless the service conditions for the transport vessel are being changed. It is recommended that replacement disks be specified by the complete disk description including model number, burst pressure, and coincident temperature, and the lot number from the disk being replaced. Disks and disk holders from different manufacturers shall not be interchanged. |

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SUPPLEMENT 8

~~PRESSURE DIFFERENTIAL BETWEEN SAFETY OR SAFETY RELIEF VALVE SETTING AND BOILER OR PRESSURE VESSEL OPERATING PRESSURE~~

S8.1 SCOPE

If a safety valve or safety relief valve is subjected to pressure at or near its set pressure, it will tend to weep or simmer, and deposits may accumulate in the seat and disk area. Eventually, this can cause the valve to freeze closed and thereafter the valve could fail to open at the set pressure. Unless the source of pressure to the boiler or pressure vessel is interrupted, the pressure could exceed the rupture pressure of the vessel. It is important that the pressure differential between the valve set pressure and the boiler or pressure vessel operating pressure is sufficiently large to prevent the valve from weeping or simmering.

S8.2 HOT WATER HEATING BOILERS

For hot water heating boilers, the recommended pressure differential between the pressure relief valve set pressure and the boiler operating pressure should be at least 10 psi (70 kPa), or 25% of the boiler operating pressure, whichever is greater. Two examples follow:

- a) If the safety relief valve of a hot water heating boiler is set to open at 30 psi (200 kPa), the boiler operating pressure should not exceed 20 psi (140 kPa).
- b) If the safety relief valve of a hot water heating boiler is set to open at 100 psi (700 kPa), the boiler operating pressure should not exceed 75 psi (520 kPa). Section IV of the ASME Code does not require that safety relief valves used on hot water heating boilers have a specified blowdown. Therefore, to help ensure that the safety relief valve will close tightly after opening and when the boiler pressure is reduced to the normal operating pressure, the pressure at which the valve closes should be well above the operating pressure of the boiler.

S8.3 STEAM HEATING BOILERS

For steam heating boilers, the recommended pressure differential between the safety valve set pressure and boiler operating pressure should be at least 5 psi (35 kPa), i.e., the boiler operating pressure should not exceed 10 psi (70 kPa).

Since some absorption-type refrigeration systems use the steam heating boiler for their operation, the boiler operating pressure may exceed 10 psi (70 kPa). If the boiler operating pressure is greater than 10 psi (70 kPa), it should not exceed 15 psi (100 kPa), minus the blowdown pressure of the safety valve. This recommendation can be verified by increasing the steam pressure in the boiler until the safety valve pops, then slowly reducing the pressure until it closes, to ensure that this closing pressure is above the operating pressure.

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S8.4 POWER BOILERS

For power boilers (steam), the recommended pressure differentials between the safety valve set pressure and the boiler operating pressure are as follows:

~~MINIMUM PRESSURE DIFFERENTIAL AS PERCENTAGE OF BOILER DESIGN PRESSURE~~

DESIGN PRESSURE : over 15 psi to 300 psi

10% but not less than 7 psi

(100 KPa to 2.10 MPa)

(50 KPa)

over 300 psi to 1000 psi

7% but not less than 30 psi
(2.14 MPa to 6.89 MPa)
(200 KPa)

over 1000 psi to 2000 psi
5% but not less than 70 psi
(6.89 MPa to 13.8 MPa)
(480 KPa)

over 2000 psi
per designer's judgment
(13.8 MPa)

Notes:

1. Above 2000 psi (13.8 MPa) the pressure differential between operating pressure and the maximum allowable working pressure is a matter for the designer's judgement, taking into consideration such factors as satisfactory operating experience and the intended service conditions.

2. Safety relief valves in hot water service are more susceptible to damage and subsequent leakage, than safety valves relieving steam. It is recommended that the maximum allowable working pressure of the boiler and safety relief valve setting for high temperature hot water boilers be selected substantially higher than the desired operating pressure, so as to minimize the time the safety relief valve must lift.

§8.5 PRESSURE VESSELS

Due to the variety of service conditions and the various designs of pressure relief valves, only general guidelines can be given regarding differentials between the set pressure of the valve and the operating pressure of the vessel. Operating difficulty will be minimized by providing an adequate differential for the application. The following is general advisory information on the characteristics of the intended service and of the pressure relief valves that may bear on the proper pressure differential selection for a given application. These considerations should be reviewed early in the system design since they may dictate the maximum allowable working pressure of the system.

To minimize operational problems it is imperative that the user consider not only normal operating conditions of the fluids (liquids or gases), pressures, and temperatures, but also start-up and shutdown conditions, process upsets, anticipated ambient conditions, instrument response time, and pressure surges due to quickclosing valves, etc. When such conditions are not considered, the pressure relief devices may become, in effect, a pressure controller, a duty for which it was not designed. Additional consideration should be given to the hazard and pollution associated with the release of the fluid. Larger differentials may be appropriate for fluids which are toxic, corrosive, or exceptionally valuable.

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The blowdown characteristics and capabilities are the first consideration in selecting a compatible valve and operating margin. After a self-actuated release of pressure, the valve must be capable of reclosing above the normal operating pressure. For example: if the valve is set at 100 psi (700 kPa) with a 7% blowdown, it will close at 93 psi (640 kPa). The operating pressure must be maintained below 93 psi (640 kPa) in order to prevent leakage or flow from a partially open valve. Users should exercise caution regarding the blowdown adjustment of large, spring-loaded valves. Test facilities, whether owned by the manufacturer, repair house, or user, may not have sufficient capacity to accurately verify the blowdown setting. The setting cannot be considered accurate unless made in the field on an actual installation.

Pilot operated valves represent a special case from the standpoint of both blowdown and tightness. The pilot portion of some pilot operated valves can be set at blowdowns as short as 2%. This characteristic is not, however, reflected in the operation of the main valve in all cases. The main valve can vary considerably from the pilot depending on the location of the two components in the system. If the pilot is installed remotely from the main valve, significant time and pressure lags can occur, but reseating of the pilot ensures reseating of the main valve. The pressure drop in connecting piping between the pilot and the main valve must not be excessive, otherwise the operation of the main valve will be adversely affected.

Tightness capability is another factor affecting valve selection, whether spring-loaded or pilot operated. Tightness varies somewhat depending on whether metal or resilient seats are specified and also on such factors

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as corrosion and temperature. The required tightness and test method should be specified to comply at a pressure not lower than the normal operating pressure of the process. It should be remembered that any degree of tightness obtained should not be considered permanent. Service operation of a valve almost invariably reduces the degree of tightness.

The following minimum pressure differentials are recommended unless the safety or safety relief valve has been designed or tested in a specific or similar service and a smaller differential has been recommended by the manufacturer:

- a) For set pressures up to 70 psi (480 kPa), the recommended pressure differential is 5 psi (35 kPa);
- b) For set pressure between 70 and 1000 psi (480 kPa and 6.89 MPa), the recommended pressure differential is 10% of set pressure; and
- e) For set pressures above 1000 psi (6.89 MPa), the recommended pressure differential is 7% of set pressure.

NBIC PART 2 with Part 4 removed.docx

(NOTE: All general pressure relief device information that will be moved to part 4 is shown as strike through text. Detail PRD information in supplements has *not* been moved, examples: DOT, historic boilers)

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2.2.10.5 PRESSURE RELIEF DEVICES

See NBIC Part 4 ~~2,2.5~~ for the inspection of safety devices (pressure relief valves) used to prevent overpressure of boilers.

(FOLLOWING par. F. IS ALSO INCLUDED IN PART 4, but not deleted here for continuity of this section)

f. Pressure Relief Devices — pressure relief valves shall be a closed bonnet design with no manual lift lever. The pressure relief discharge should be connected to a closed, vented storage tank or

blowdown tank with solid piping (no drip pan elbow or other air gap). When outdoor discharge is

used, the following should be considered for discharge piping at the point of discharge:

1. Both thermal and chemical reactions (personnel hazard);
2. Combustible materials (fire hazard);
3. Surface drains (pollution and fire hazard);
4. Loop seal or rain cap on the discharge (keep both air and water out of the system);
5. Drip leg near device (prevent liquid collection); and
6. Heat tracing for systems using high freeze point fluids (prevent blockage).

2.3.5.2 SAFETY DEVICES

See NBIC Part **4** ~~2,2.5~~ for the inspection of safety devices (pressure relief valves and non-closing devices such as rupture disks) used to prevent the overpressure of pressure vessels.

- 1) See NBIC Part **4** ~~2,2.5~~ for the inspection of pressure relief devices used to prevent the overpressure of liquid ammonia vessels. Pressure relief devices in ammonia service shall not be tested in place using system pressure. Bench testing or replacement is required, depending on the type of pressure relief device used.
- 2) The Inspector shall note the replacement date marked on vessel safety valves and piping hydrostatic relief valves requiring replacement every five years.

2.4.8.2 SAFETY DEVICES

See NBIC Part **4** ~~2,2.5~~ for information on the inspection of pressure-relieving devices used to prevent the overpressure of piping systems.

2.4.8.3 QUICK-DISCONNECT COUPLING

Piping connections utilizing a quick-disconnect coupling should be checked to ensure that the coupling and its holding elements are fully engaged in their intended operating position. Means should be provided that warn the operator against disengaging the coupling or prevent the opening mechanism from operating unless the piping is completely depressurized.

2.5 PRESSURE RELIEF DEVICES: SEE NBIC PART 4 for the Inspection of Pressure Relief Devices

2.5.1 SCOPE

- a) The most important appurtenances on any pressurized system are the pressure relief devices provided for overpressure protection of that system. These are devices such as safety valves, safety relief valves, pilot valves, and rupture disks or other non-reclosing devices that are called upon to operate and reduce an overpressure condition.
- b) These devices are not designed or intended to control the pressure in the system during normal operation. Instead, they are intended to function when normal operating controls fail or abnormal system conditions are encountered.
- e) Periodic inspection and maintenance of these important safety devices is critical to ensure their continued functioning and availability when called upon to operate. See NBIC Part 2, 2.5.8 for recommended testing frequency for PRDs.
- d) Inspection areas of concern include:
 - 1) correct set pressure;
 - 2) safety considerations;
 - 3) device data;
 - 4) condition of the device;
 - 5) condition of the installation; and
 - 6) testing and operational inspection.

2.5.2 PRESSURE RELIEF DEVICE DATA

- a) Nameplate marking or stamping of the device should be compared to stamping on the protected pressure retaining item. For a single device, the set pressure shall be no higher than the Maximum Allowable Working Pressure (MAWP) marked on the protected pressure retaining item or system.
- b) If multiple devices are provided, the difference between set pressures shall not exceed that permitted by the original code of construction. The set pressure of additional devices may exceed the MAWP, as permitted by the original Code of Construction.
- e) Verify nameplate capacity and, if possible, compare to system capacity requirements.
- d) Check identification on seals and ensure they match nameplates or other identification (repair or reset nameplate) on the valve or device.

2.5.3 INSERVICE INSPECTION REQUIREMENTS FOR PRESSURE RELIEF DEVICE CONDITIONS

- a) Check for evidence that the valve or device is leaking or not sealing properly. Evidence of leakage through pressure relief valves may indicate that the system is being operated at a pressure that is too close to the valve's set pressure. See NBIC Part 2, Supplement 8.
- b) Seals for adjustments should be intact and show no evidence of tampering.
- e) Connecting bolting should be tight and all bolts intact.
- d) The valve or device should be examined for deposits or material buildup.
- e) Evidence of rust or corrosion should be checked.
- f) Check for damaged or misapplied parts.
- g) If a drain hole is visible, ensure it is not clogged with debris or deposits.
- h) Check for test gages left in place after pressure testing of the unit.
- i) Bellows valves shall be checked to ensure the bonnet vent is open or piped to a safe location. The vent shall not be plugged since this will cause the valve set pressure to be high if the bellows develops a leak.

Leakage noted from the vent indicates the bellows is damaged and will no longer protect the valve from the effects of back pressure.

2.5.4 INSERVICE INSPECTION REQUIREMENTS FOR PRESSURE RELIEF DEVICES INSTALLATION CONDITION

- a) Inspect inlet piping and ensure it meets the requirements of the original Code of Construction. For pressure relief valves, check that the inlet pipe size is not smaller than the device inlet size.
- b) Inspect discharge piping and ensure it meets the original Code of Construction. Check that the discharge pipe size is not smaller than the device outlet size.
- e) Check that the valve drain piping is open.
- d) Check drainage of discharge piping.
- e) Check that inlet and discharge piping are not binding or placing excessive stress on the valve body, which can lead to distortion of the valve body and leakage or malfunction.
- f) Check the condition and adequacy of piping supports. Discharge piping should be supported independent of the device itself.
- g) Check for possible hazards to personnel from the valve discharge or discharge pipe.
- h) Check that there are no intervening isolation valves between the pressure source and the valve inlet or between the valve outlet and its point of discharge. (Isolation valves may be permitted in some pressure vessel service. [(See NBIC Part 1, 5.3.6 e), and jurisdictional requirements. Isolation valves are not permitted for power boilers, heating boilers, or water heaters.]
- i) A change-over valve, which is used to install two pressure relief devices on a single vessel location for the purpose of switching from one device to a spare device, is not considered a block valve if it is arranged such that there is no intermediate position that will isolate both pressure relief devices from the protected system. Change-over valves should be carefully evaluated to ensure they do not have excessive pressure drop that could affect the pressure relief device operation or capacity. These devices are commonly used in pressure vessel service. They may also be used in some boiler applications. It is recommended that the Jurisdiction be contacted to determine their acceptability on boiler applications.

2.5.5 ADDITIONAL INSPECTION REQUIREMENTS

Additional items should be considered for the specified services.

2.5.5.1 BOILERS

- a) If boilers are piped together with maximum allowable working pressures differing by more than 6%, additional protective devices may be required on the lower pressure units to protect them from overpressure from the higher pressure unit.
- b) Hot Water Heating Boilers and Water Heaters
 - 1) These units generally do not use any water treatment and therefore may be more prone to problems with deposits forming that may impair a safety device's operation. Particular attention should be paid to signs of leakage through valves or buildups of deposits.
 - 2) Hot water boilers tend to have buildups of corrosion products since the system is closed with little makeup. These products can foul or block the valve inlet.
 - 3) Water heaters will have cleaner water due to continuous makeup. However, these valves usually have a thermal element that will cause the valve to open slightly when the water is heated and not removed from the system. When this hot water evaporates in the discharge piping, calcium deposits may tend to form in the valve inlet and outlet.

2.5.5.2 PRESSURE VESSELS AND PIPING

Standard practice for overpressure protection devices is to not permit any type of isolation valve either before or after the device. However, some pressure vessel standards permit isolation valves under certain controlled conditions when shutting down the vessel to repair a damaged or leaking valve. If isolation block valves are employed, their use should be carefully controlled by written procedures. Block valves should have provisions to be either cap-sealed or locked in an open position when not being used. For ASME Section VIII, Div. 1 pressure vessels, see UG-135, Appendix M, and jurisdictional rules for more information.

2.5.5.3 RUPTURE DISKS

- a) Rupture disks or other non-reclosing devices may be used as sole relieving devices or in combination with safety relief valves to protect pressure vessels.
- b) The selection of the correct rupture disk device for the intended service is critical to obtaining acceptable disk performance. Different disk designs are intended for constant pressure, varying pressure, or pulsating pressure. Some designs include features that make them suitable for back pressure and/or internal vacuum in the pressure vessel.
- c) The margin between the operating pressure and the burst pressure is an important factor in obtaining acceptable performance and service life of the disk. Flat and pre-bulged solid metal disks are typically used with an operating pressure that is no more than 60% to 70% of the burst pressure. Other designs are available that increase the operating pressure to as much as 90% of the burst pressure. Disks that have been exposed to pressures above the normal operating pressure for which they are designed are subject to fatigue or creep and may fail at unexpectedly low pressures. Disks used in cyclic service are also subject to fatigue and may require a greater operating margin or selection of a device suitable for such service.
- d) The disk material is also critical to obtaining acceptable service life from the disk. Disks are available in a variety of materials and coatings, and materials that are unaffected by the process fluid should be used. Disks that experience corrosion may fail and open at an unexpectedly low pressure.
- e) Disk designs must also be properly selected for the fluid state. Some disk types are not suitable for use in liquid service. Some disks may have a different flow resistance when used in liquid service, which may affect the sizing of the disk.
- f) Information from the rupture disk manufacturer, including catalog data and installation instructions, should be consulted when selecting a disk for a particular service.
- g) For rupture disks and other non-reclosing devices, the following additional items should be considered during inspections:

- 1) The rupture disk nameplate information, including stamped burst pressure and coincident temperature, should be checked to ensure it is compatible with the intended service. The coincident temperature on the rupture disk shall be the expected temperature of the disk when the disk is expected to burst and will usually be related to the process temperature, not the temperature on the pressure vessel nameplate.
- 2) Markings indicating direction of flow should be checked carefully to ensure they are correct. Some rupture disks when installed in the incorrect position may burst well above the stamped pressure.

3) The marked burst pressure for a rupture disk installed at the inlet of a safety relief valve shall be equal to or less than the safety relief valve set pressure. A marked burst pressure of 90% to 100% of the safety relief valve set pressure is recommended. A disk with a non-fragmenting design that cannot affect the safety relief valve shall be used.

Note: If the safety relief valve set pressure is less than the vessel MAWP, the marked burst pressure may be higher than the valve set pressure, but no higher than the MAWP.

4) Check that the space between a rupture disk and a safety relief valve is supplied with a pressure gage, try cock, or telltale indicator to indicate signs of leakage through the rupture disk. The safety relief valve shall be inspected and the leaking disk shall be replaced if leakage through the disk is observed.

5) If a rupture disk is used on a valve outlet, the valve design must be of a type not influenced by back pressure due to leakage through the valve. Otherwise, for nontoxic and non-hazardous fluids, the space between the valve and the ruptured disk shall be vented or drained to prevent the accumulation of pressure.

6) For rupture disks installed on the valve inlet, the installation should be reviewed to ensure that the combination rules of the original Code of Construction have been applied. A reduction in the valve capacity up to 10% is expected when used in combination with a non-reclosing device.

7) The frequency of inspection for rupture disks and other non-reclosing devices is greatly dependent on the nature of the contents and operation of the system and only general recommendations can be given. Inspection frequency should be based on previous inspection history. If devices have been found to be leaking, defective, or damaged by system contents during inspection, intervals should be shortened until acceptable inspection results are obtained. With this in mind, the inspection frequency guidelines specified in NBIC Part 2, 2.5.8 are suggested for similar services.

8) Rupture disks are often used to isolate pressure relief valves from services where fouling or plugging of the valve inlet occurs. This tendency should be considered in establishing the inspection frequency.

9) Since these devices are for one time use, a visual inspection is the only inspection that can be performed. Rupture disks that are installed using a specified bolting torque procedure cannot be reused after inspection and must be replaced.

10) It is recommended that all rupture disks be replaced periodically to prevent unintended failure while in service due to deterioration of the device.

Rupture disks should be checked carefully for damage prior to installation and handled by the disk edges, if possible. Any damage to the surface of the ruptured disk can affect the burst pressure.

2.5.6 PACKAGING, SHIPPING AND TRANSPORTATION

a) The improper packaging, shipment, and transport of pressure relief devices can have detrimental effects on device operation. Pressure relief devices should be treated with the same precautions as instrumentation, with care taken to avoid rough handling or contamination prior to installation.

b) The following practices are recommended:

1) Valves should be securely fastened to pallets in the vertical position to avoid side loads on guiding surfaces except threaded and socket-weld valves up to 2 in. (50mm) may be securely packaged and cushioned during transport;

- 2) Valve inlet and outlet connection, drain connections, and bonnet vents should be protected during shipment and storage to avoid internal contamination of the valve. Ensure all covers and/or plugs are removed prior to installation;
- 3) The valve should not be picked up or carried using the lifting lever. Lifting levers should be wired or secured so they cannot be moved while the valve is being shipped or stored. These wires shall be removed before the valve is placed in service;
- 4) Pilot valve tubing should be protected during shipment and storage to avoid damage and/or breakage.

2.5.7 TESTING AND OPERATIONAL INSPECTION OF PRESSURE RELIEF DEVICES

- a) Pressure relief valves must be tested periodically to ensure that they are free to operate and will operate in accordance with the requirements of the original Code of Construction. Testing should include device set or opening pressure, reclosing pressure, where applicable, and seat leakage evaluation. Tolerances specified for these operating requirements in the original Code of Construction shall be used to determine the acceptability of test results.
- b) Testing may be accomplished by the owner on the unit where the valve is installed or at a qualified test facility. In many cases, testing on the unit may be impractical, especially if the service fluid is hazardous or toxic. Testing on the unit may involve the bypassing of operating controls and should only be performed by qualified individuals under carefully controlled conditions. It is recommended that a written procedure be available to conduct this testing.
 - 1) The Inspector should ensure that calibrated equipment has been used to perform this test and the results should be documented by the owner.
 - 2) If the testing was performed at a test facility, the record of this test should be reviewed to ensure the valve meets the requirements of the original Code of Construction. Valves which have been in toxic, flammable, or other hazardous services shall be carefully decontaminated before being tested. In particular, the closed bonnet of valves in these services may contain fluids that are not easily removed or neutralized. If a test cannot be performed safely, the valve shall be disassembled, cleaned, and decontaminated, repaired, and reset.
 - 3) If a valve has been removed for testing, the inlet and outlet connections should be checked for blockage by product buildup or corrosion.
- c) Valves may be tested using lift assist devices when testing at full pressure may cause damage to the valve being tested, or it is impractical to test at full pressure due to system design considerations. Lift assist devices apply an auxiliary load to the valve spindle or stem, and using the measured inlet pressure, applied load and other valve data allow the set pressure to be calculated. If a lift assist device is used to determine valve set pressure, the conditions of NBIC Part 3, 4.5.3 shall be met. It should be noted that false set pressure readings may be obtained for valves which are leaking excessively or otherwise damaged.
- d) If valves are not tested on the system using the system fluid, the following test mediums shall be used:
 - 1) High pressure boiler safety valves, high temperature hot water boiler safety relief valves, low pressure steam heating boilers: steam;
 - 2) Hot water heating boiler safety relief valves: steam, air, or water;
 - 3) Hot water heater temperature and pressure relief valves: air or water;

- 4) Air and gas service process safety relief valves: air, nitrogen, or other suitable gas;
- 5) Liquid service process pressure relief valves: water or other suitable fluid;
- 6) Process steam service safety relief valves: steam or air with manufacturer's steam to air correction factor.

Note: Valves being tested after a repair must be tested on steam except as permitted by NBIC Part 3, 4.5.2.

e) As an alternative to a pressure test, the valve may be checked by the owner for freedom of operation by activating the test or "try" lever (manual check). For high pressure boiler and process valves, this test should be performed only at a pressure greater than 75% of the stamped set pressure of the valve or the lifting device may be damaged. This test will only indicate that the valve is free to operate and does not provide any information on the actual set pressure. All manual checks should be performed with some pressure under the valve in order to flush out debris from the seat that could cause leakage.

Note: The manual check at 75% or higher is based on lift lever design requirements for ASME Section I and VIII valves. Code design requirements for lifting levers for ASME Section IV valves require that the valve be capable of being lifted without pressure.

f) If a valve is found to be stuck closed, the system should immediately be taken out of service until the condition can be corrected, unless special provisions have been made to operate on a temporary basis (such as additional relief capacity provided by another valve).

g) If a pressure test indicates the valve does not open within the requirements of the original Code of Construction, but otherwise is in acceptable condition, minor adjustments (defined as no more than twice the permitted set pressure tolerance) shall be made by an organization accredited by the National Board to reset the valve to the correct opening pressure. All adjustments shall be resealed with a seal identifying the responsible organization and a tag shall be installed identifying the organization and the date of the adjustment.

h) If a major adjustment is needed, this may indicate the valve is in need of repair or has damaged or misapplied parts. Its condition should be investigated accordingly.

i) Systems with multiple valves will require the lower set valves to be held closed to permit the higher set valves to be tested. A test clamp or "gag" should be used for this purpose. The spring compression screw shall not be tightened. It is recommended that the test clamps be applied in accordance with the valve manufacturer's instructions when the valve is at or near the test temperature, and be applied hand tight only to avoid damage to the valve stem or spindle.

j) Upon completion of set pressure testing, all pressure relief valve gags shall be removed.

2.5.8 RECOMMENDED INSPECTION AND TEST FREQUENCIES FOR PRESSURE RELIEF DEVICES

a) Power Boilers

1) Pressure less than 400 psig (2.76 MPa): Manual check every 6 months; pressure test annually to verify nameplate set pressure or as determined by operating experience as verified by testing history.

2) Pressure greater than 400 psig (2.76 MPa): Pressure test to verify nameplate set pressure every three years or as determined by operating experience as verified by testing history.

3) Pressure tests should be performed prior to bringing the boiler down for planned internal inspection so needed repairs or adjustments can be made while the boiler is down.

b) High Temperature Hot Water Boilers Pressure test annually to verify nameplate set pressure or as determined by operating experience as verified by testing history. For safety reasons, removal and testing on a steam test bench is recommended. Such testing will avoid damaging the safety valve by discharge of a steam-water mixture, which could occur if the valve is tested in place.

e) Low Pressure Steam Heating Boilers

Manual check quarterly; pressure test annually prior to steam heating season to verify nameplate set pressure.

d) Hot Water Heating Boilers

Manual check quarterly; pressure test annually prior to heating season to verify nameplate set pressure.

Note: The frequencies specified for the testing of pressure relief valves on boilers is primarily based on differences between high pressure boilers that are continuously manned, and lower pressure automatically controlled boilers that are not monitored by a boiler operator at all times. When any boiler experiences an overpressure condition such that the safety or safety relief valves actuate, the valves should be inspected for seat leakage and other damage as soon as possible and any deficiencies corrected.

e) Water Heaters

Manual check every two months. Due to the relatively low cost of safety valves for this service, it is recommended that a defective valve be replaced with a new valve if a repair or resetting is indicated.

f) Pressure Vessels and Piping

Frequency of test and inspection of pressure relief devices for pressure vessel and piping service is greatly dependent on the nature of the contents and operation of the system and only general recommendations can be given. Inspection frequency should be based on previous inspection history. If valves are found to be defective or damaged by system contents during inspection, intervals should be shortened until acceptable inspection results are obtained. Where test records and/or inspection history are not available, the following inspection and test frequencies are suggested:

Service Inspection Frequency

Steam Annual

Air and Clean Dry Gases Every three years

Pressure relief valves in combination with rupture disks

Every five years

Propane, Refrigerant Every five years

All Others Per inspection history

g) Establishment of Inspection and Test Intervals

Where a recommended test frequency is not listed, the valve user and Inspector must determine and agree on a suitable interval for inspection and test. Some items to be considered in making this determination are:

- 1) Jurisdictional requirements;
- 2) Records of test data and inspections from similar processes and similar devices in operation at that facility;
- 3) Recommendations from the device manufacturer. In particular, when the valve includes a non-metallic part such as a diaphragm, periodic replacement of those parts may be specified;
- 4) Operating history of the system. Systems with frequent upsets where a valve has actuated require more frequent inspection;
- 5) Results of visual inspection of the device and installation conditions. Signs of valve leakage, corrosion or damaged parts all indicate more frequent operational inspections;
- 6) Installation of a valve in a system with a common discharge header. Valves discharging into a common collection pipe may be affected by the discharge of other valves by the corrosion of parts in the outlet portion of the valve or the buildup of products discharged from those valves;
- 7) Ability to coordinate with planned system shutdowns. The shutdown of a system for other maintenance or inspection activities is an ideal time for the operational inspection and test of a pressure relief valve;
- 8) Critical nature of the system. Systems that are critical to plant operation or where the effects of the discharge of fluids from the system are particularly detrimental due to fire hazard, environmental damage, or toxicity concerns all call for more frequent inspection intervals to ensure devices are operating properly;
- 9) Where the effects of corrosion, blockage by system fluid, or ability of the valve to operate under given service conditions are unknown (such as in a new process or installation), a relatively short inspection interval, not to exceed one year or the first planned shutdown, whichever is shorter, shall be established. At that time the device shall be visually inspected and tested. If unacceptable test results are obtained, the inspection interval shall be reduced by 50% until suitable results are obtained.

h) Establishment of Service Intervals

- 1) The above intervals are guidelines for periodic inspection and testing. Typically if there are no adverse findings, a pressure relief valve would be placed back in service until the next inspection. Any unacceptable conditions that are found by the inspection shall be corrected immediately by repair or replacement of the device. Many users will maintain spare pressure relief devices so the process or system is not affected by excessive downtime.
- 2) Pressure relief valves are mechanical devices that require periodic preventive maintenance even though external inspection and test results indicate acceptable performance. There may be wear on internal parts, galling between sliding surfaces or internal corrosion, and fouling which will not be evident from an external inspection or test. Periodic re-establishment of seating surfaces and the replacement of soft goods such as o-rings and diaphragms are also well advised preventive maintenance activities that can prevent future problems. If the valve is serviced, a complete disassembly, internal inspection, and repair as necessary, such that the valve's condition and performance are restored to a like-new condition, should be done by an organization accredited by the National Board.
- 3) Service records with test results and findings should be maintained for all overpressure protection devices. A service interval of no more than three inspection intervals or ten years,

whichever is less, is recommended to maintain device condition. Results of the internal inspection and maintenance findings can then be used to establish future service intervals.

SEE PART 4 for Supplement 8 6

SUPPLEMENT 8

~~PRESSURE DIFFERENTIAL BETWEEN SAFETY OR SAFETY RELIEF VALVE SETTING AND BOILER OR PRESSURE VESSEL OPERATING PRESSURE~~

~~S8.1 SCOPE~~

~~If a safety valve or safety relief valve is subjected to pressure at or near its set pressure, it will tend to weep or simmer, and deposits may accumulate in the seat and disk area. Eventually, this can cause the valve to freeze closed and thereafter the valve could fail to open at the set pressure. Unless the source of pressure to the boiler or pressure vessel is interrupted, the pressure could exceed the rupture pressure of the vessel. It is important that the pressure differential between the valve set pressure and the boiler or pressure vessel operating pressure is sufficiently large to prevent the valve from weeping or simmering.~~

~~S8.2 HOT WATER HEATING BOILERS~~

~~For hot water heating boilers, the recommended pressure differential between the pressure relief valve set pressure and the boiler operating pressure should be at least 10 psi (70 kPa), or 25% of the boiler operating pressure, whichever is greater. Two examples follow:~~

- ~~a) If the safety relief valve of a hot water heating boiler is set to open at 30 psi (200 kPa), the boiler operating pressure should not exceed 20 psi (140 kPa).~~
- ~~b) If the safety relief valve of a hot water heating boiler is set to open at 100 psi (700kPa), the boiler operating pressure should not exceed 75 psi (520 kPa). Section IV of the ASME Code does not require that safety relief valves used on hot water heating boilers have a specified blowdown. Therefore, to help ensure that the safety relief valve will close tightly after opening and when the boiler pressure is reduced to the normal operating pressure, the pressure at which the valve closes should be well above the operating pressure of the boiler.~~

~~S8.3 STEAM HEATING BOILERS~~

~~For steam heating boilers, the recommended pressure differential between the safety valve set pressure and boiler operating pressure should be at least 5 psi (35 kPa), i.e., the boiler operating pressure should not exceed 10 psi (70 kPa). Since some absorption type refrigeration systems use the steam heating boiler for their operation, the boiler operating pressure may exceed 10 psi (70 kPa). If the boiler operating pressure is greater than 10 psi (70 kPa), it should not exceed 15 psi (100 kPa), minus the blowdown pressure of the safety valve. This recommendation can be verified by increasing the steam pressure in the boiler until the safety valve pops, then slowly reducing the pressure until it closes, to ensure that this closing pressure is above the operating pressure.~~

~~S8.4 POWER BOILERS~~

~~For power boilers (steam), the recommended pressure differentials between the safety valve set pressure and the boiler operating pressure are as follows:~~

MINIMUM PRESSURE DIFFERENTIAL AS PERCENTAGE OF BOILER DESIGN PRESSURE

DESIGN PRESSURE : over 15 psi to 300 psi

10% but not less than 7 psi

(100 KPa to 2.10 MPa)

(50 KPa)

over 300 psi to 1000 psi

7% but not less than 30 psi

(2.14 MPa to 6.89 MPa)

(200 KPa)

over 1000 psi to 2000 psi

5% but not less than 70 psi

(6.89 MPa to 13.8 MPa)

(480 KPa)

over 2000 psi

per designer's judgment

(13.8 MPa)

Notes:

1. Above 2000 psi (13.8 MPa) the pressure differential between operating pressure and the maximum allowable working pressure is a matter for the designer's judgement, taking into consideration such factors as satisfactory operating experience and the intended service conditions.

2. Safety relief valves in hot water service are more susceptible to damage and subsequent leakage, than safety valves relieving steam. It is recommended that the maximum allowable working pressure of the boiler and safety relief valve setting for high temperature hot water boilers be selected substantially higher than the desired operating pressure, so as to minimize the time the safety relief valve must lift.

S8.5 PRESSURE VESSELS

Due to the variety of service conditions and the various designs of pressure relief valves, only general guidelines can be given regarding differentials between the set pressure of the valve and the operating pressure of the vessel. Operating difficulty will be minimized by providing an adequate differential for the application.

The following is general advisory information on the characteristics of the intended service and of the pressure relief valves that may bear on the proper pressure differential selection for a given application. These considerations should be reviewed early in the system design since they may dictate the maximum allowable working pressure of the system.

To minimize operational problems it is imperative that the user consider not only normal operating conditions of the fluids (liquids or gases), pressures, and temperatures, but also start-up and shutdown conditions, process upsets, anticipated ambient conditions, instrument response time, and pressure surges due to quick closing valves, etc. When such conditions are not considered, the pressure relief devices may become, in effect, a pressure controller, a duty for which it was not designed. Additional consideration should be given to the hazard and pollution associated with the release of the fluid. Larger differentials may be appropriate for fluids which are toxic, corrosive, or exceptionally valuable.

The blowdown characteristics and capabilities are the first consideration in selecting a compatible valve and operating margin. After a self-actuated release of pressure, the valve must be capable of reclosing above the normal operating pressure. For example: if the valve is set at 100 psi (700 kPa) with a 7% blowdown, it will close at 93 psi (640 kPa). The operating pressure must be maintained below 93 psi (640 kPa) in order to prevent leakage or flow from a partially open valve. Users should exercise caution regarding the blowdown adjustment of large, spring-loaded valves. Test facilities, whether owned by the manufacturer, repair house, or user, may not have sufficient capacity to accurately verify the blowdown setting. The setting cannot be considered accurate unless made in the field on an actual installation.

Pilot-operated valves represent a special case from the standpoint of both blowdown and tightness. The pilot portion of some pilot-operated valves can be set at blowdowns as short as 2%. This characteristic is not, however, reflected in the operation of the main valve in all cases. The main valve can vary considerably from the pilot depending on the location of the two components in the system. If the pilot is installed remotely from the main valve, significant time and pressure lags can occur, but reseating of the pilot ensures reseating of the main valve. The pressure drop in connecting piping between the pilot and the main valve must not be excessive, otherwise the operation of the main valve will be adversely affected.

Tightness capability is another factor affecting valve selection, whether spring loaded or pilot operated. Tightness varies somewhat depending on whether metal or resilient seats are specified and also on such factors as corrosion and temperature. The required tightness and test method should be specified to comply at a pressure not lower than the normal operating pressure of the process. It should be remembered that any degree of tightness obtained should not be considered permanent. Service operation of a valve almost invariably reduces the degree of tightness. The following minimum pressure differentials are recommended unless the safety or safety relief valve has been designed or tested in a specific or similar service and a smaller differential has been recommended by the manufacturer:

- a) For set pressures up to 70 psi (480 kPa), the recommended pressure differential is 5 psi (35 kPa);
- b) For set pressure between 70 and 1000 psi (480 kPa and 6.89 MPa), the recommended pressure differential is 10% of set pressure; and
- e) For set pressures above 1000 psi (6.89 MPa), the recommended pressure differential is 7% of set pressure.

NB10-1301 Part 2, SG Inspection Specific

Task Group on Anhydrous Ammonia Nurse Tank Inspection

Task Group Members: Greg McRae (Trinity), Stan Staniszewski (DOT), Jim Getter (Worthington Cylinders), Bob Reetz (State of North Dakota)

June 11, 2012 Draft

This would be a new section of Part 2. It should be numbered 2.3.6.5 and come directly after 2.3.6.4., the current section on "Liquid Ammonia Vessels". (Present 2.3.6.5 would be renumbered as 2.3.6.6)

2.3.6.5 ANHYDROUS AMMONIA NURSE TANKS

- a) Nurse tanks (considered as implements of husbandry) are anhydrous ammonia pressure vessels on farm wagons, not exceeding a capacity of 3,000 water gallons (11,355 liters), used for agricultural application of liquid anhydrous ammonia to farm fields as fertilizer. Nurse tanks come under United States Department of Transportation (DOT) requirements and may also be subject to various local jurisdictional requirements. Nurse tanks should be inspected closely at least once per seasonal use. Inspections of nurse tanks include the following items. These items are not meant to be all inclusive.
- b) Inspection shall consist of the following:
 - 1) Pressure Vessel - Verify that the pressure vessel is constructed for anhydrous ammonia service and that it is ASME stamped and National Board registered, as required by the jurisdiction. Check that the data plate is legible and not painted over or sand blasted. If the data plate is missing or illegible, welding is prohibited, and the tank shall be tested and operated under the DOT Hazardous Material Regulation (HMR) as required in Title 49 Code of Federal Regulations (CFR) 173.315m or the tank shall be removed from service. Post-construction welding, if any, to the pressure vessel, nozzles or support legs shall be in accordance with NBIC procedures and stamping as required in Part 3. (Also see ANSI K61.1 for the definition of repair.) Cracks, dents, bulges, cuts, gouges and corrosion shall not exceed the acceptance criteria of Section 2.3.6.4 (f).
 - 2) Valves and Fittings - Verify that the pressure relief device is ASME constructed and National Board capacity certified, has correct capacity and set pressure, is date current, and is not leaking, corroded or painted. Check that a rain cap is installed. Ensure that the hydrostatic relief valve is set for 350-400 psi (2415-2760 kPa), is in place in or on the liquid withdrawal valve and that it is in good condition and date current. A liquid level float gage shall be installed and be operable. In addition, a fixed liquid level gage (85% gage) shall be operable and unobstructed by tape or paint. A pressure gage with a clear lens and with a 0-400 psi (0-2760 kPa) dial range shall be installed and be observed to be operable. A liquid withdrawal valve shall be in place and observed to be in good condition. Liquid and vapor fill valves shall be in operable condition and their end fittings protected with valve covers. In addition, check that no galvanized, brass, or cast iron fittings are installed.

- 3) Nurse Tank Painting, Decals, and Marking – The paint shall be white or aluminum, the painted surface not damaged or faded, and the tank surface not rusted. A nurse tank unique owner identification number shall be observed to be in place. A DOT approved slow-moving vehicle (SMV) emblem or sign shall be installed at the rear. Legible transfer and safety decals shall be in place near the fill valves. “INHALATION HAZARD” markings or decals shall be observed to be in place on each side. On each side and on each end, observe that “DOT 1005” markings or decals and “ANHYDROUS AMMONIA” markings or decals are in place. (Note that these markings or decals are not required on the end of a tank with valves and fittings on that end.) Liquid and vapor valves shall be observed to be color coded or labeled for liquid or vapor. Markings for tests and inspections required due to a missing or illegible data plates shall be in place as required by DOT Hazardous Material Regulations.
- 4) Safety Specific and Miscellaneous Equipment - Roll-over protection for valves and appurtenances, to include the pressure relief device, shall be observed to be in place. This required protection must include any bottom liquid withdrawal valves. Observe that the transfer hose, if so equipped, is date current and in good condition (not cut to the cords or showing stretch damage, bulging, or kinking). Check that a fitting is in place to secure the transfer hose (if so equipped) during transport and storage. Protective gloves and Z87 rated goggles shall be observed to be in a safety kit on the nurse tank. A safety water container [5 gallon (19 liter) minimum capacity] with adequate withdrawal hose shall be on the nurse tank and be in usable condition.
- 5) Trailer and Running Gear – Ensure that the hitch and undercarriage are in good repair. Observe that welds are not cracked or the rails bent. The trailer tires shall be in serviceable condition with no cuts to the cords. Two safety chains and hooks shall be in place with one hitch pin and lock pin available. The tank to trailer anchorage shall be satisfactory and any bolting tightened. Spring leaves shall not be cracked or broken on inspection and the ends secured.

Subject: 2010 Edition, Part 2, Supplement 2, S2.10.4.1 – Staybolts

File Number: NB11-1601

Prop. Page: 141

Proposal:

Update the text and reference tables in S2.10.4.1 for two purposes:

- Correct errors in equations (both typographical and mathematical)
- Introduce consideration for, and distinction between, iron and steel staybolts

Current wording:

A08 S2.10.4.1 STAYBOLTS

Table S2.10.4.1 may be used to determine the MAWP for corroded staybolts. The table **A09** is based on a stress value of 7,500 psi (51.7 MPa) for staybolts that was the value used in the ASME Section 1, 1971 Edition. The table identifies a calculated MAWP based on measuring the staybolt spacing on the crown sheet and the minimum diameter of the corroded staybolt. See Table S2.10.4.1.

Thickness of Stayed Surface, in.	Staybolt Spacing (Maximum Pitch), in.																				
	3.5	3.625	3.75	3.875	4	4.125	4.25	4.375	4.5	4.625	4.75	4.875	5	5.125	5.25	5.375	5.5	5.625	5.75	5.875	6
0.19	85	80	74	70	65	61	58	55	52	49	46	44	42	40	38	36	35	33	32	30	29
0.2	95	88	82	77	72	68	64	61	57	54	51	49	46	44	42	40	38	37	35	34	32
0.21	104	97	91	85	80	75	71	67	63	60	57	54	51	49	46	44	42	40	39	37	36
0.22	115	107	100	93	88	82	78	73	69	66	62	59	56	53	51	49	46	44	42	41	39
0.23	125	117	109	102	96	90	85	80	76	72	68	65	61	58	56	53	51	48	46	44	43
0.24	136	127	119	111	104	98	92	87	82	78	74	70	67	64	61	58	55	53	50	48	46
0.25	148	138	129	121	113	106	100	95	89	85	80	76	72	69	66	63	60	57	55	52	50
0.26	160	149	139	130	122	115	108	102	97	92	87	82	78	75	71	68	65	62	59	57	54
0.27	172	161	150	141	132	124	117	110	104	99	94	89	85	80	77	73	70	67	64	61	59
0.28	185	173	162	151	142	134	126	119	112	106	101	96	91	87	82	79	75	72	69	66	63
0.29	199	185	173	162	152	143	135	127	120	114	108	103	97	93	88	84	81	77	74	71	68
0.3	213	198	185	174	163	153	144	136	129	122	116	110	104	99	95	90	86	82	79	76	72
0.31	227	212	198	185	174	164	154	146	138	130	123	117	111	106	101	96	92	88	84	81	77
0.32	242	226	211	198	185	174	164	155	147	139	132	125	119	113	108	103	98	94	90	86	82
0.33	258	240	224	210	197	185	175	165	156	148	140	133	126	120	115	109	104	100	95	91	88
0.34	273	255	238	223	209	197	185	175	165	157	148	141	134	128	122	116	111	106	101	97	93
0.35	290	270	252	236	222	209	197	185	175	166	157	149	142	135	129	123	117	112	107	103	99
0.36	307	286	267	250	235	221	208	196	185	176	166	158	150	143	136	130	124	119	114	109	104
0.37	324	302	282	264	248	233	220	207	196	185	176	167	159	151	144	137	131	125	120	115	110
0.38	342	318	298	279	262	246	232	219	207	196	185	176	167	159	152	145	138	132	127	121	116
0.39	360	335	313	294	275	259	244	230	218	206	195	185	176	168	160	153	146	139	133	128	122
0.4	379	353	330	309	290	273	257	242	229	217	206	195	185	177	168	160	153	147	140	134	129
0.41	398	371	346	324	304	286	270	255	241	228	216	205	195	185	177	169	161	154	147	141	135
0.42	417	389	364	340	320	300	283	267	252	239	227	215	204	195	185	177	169	162	155	148	142
0.43	437	408	381	357	335	315	297	280	265	251	237	225	214	204	194	185	177	169	162	155	149
0.44	480	447	418	391	367	345	325	307	290	275	261	247	235	224	213	203	194	186	178	170	163
0.45	502	468	437	409	384	361	340	321	304	287	272	259	246	234	223	213	203	194	186	178	171
0.46	524	489	457	428	402	378	356	336	317	300	285	270	257	245	233	222	212	203	194	186	178
0.47	547	510	477	447	419	394	371	350	331	314	297	282	268	255	243	232	222	212	203	194	186
0.48	571	532	497	466	437	411	387	365	345	327	310	294	280	266	254	242	231	221	212	203	194

TS = Tensile Strength 55 000 psi
t = Thickness of Stayed Surface, in.
S = 13 800 psi

$$P = t^2 \cdot S \cdot C / p^2$$

For Thicknesses 0.4375 and less, C = 2.1
For Thicknesses larger than 0.4375, C=2.2
MAWP is expressed in psi

NATIONAL BOARD INSPECTION CODE • PART 2 — INSPECTION

140.1

Proposed wording:

S2.10.4.1 STAYBOLTS

The maximum allowable working pressure for symmetrically spaced corroded staybolts will be calculated using the formula provided in either of the 2 following paragraphs or the accompanying tables. Equations calculate MAWP based on measuring the staybolt spacing on the stayed surface and the minimum diameter of the corroded staybolt.

a) IRON STAYBOLTS

Staybolts which are of iron or of unknown material shall be calculated using the following formula or Table S2.10.4.1.a. The table is based on a stress value of 7,500 psi (51.7 MPa) for staybolts. Refer to ASME Section 1, 1971 Edition, Table PG-23.3 for allowable loads for all staybolts.

$$P = \frac{\pi \left[\frac{d}{2} \right]^2 S}{p^2}, S = 7,500 \text{ (51.7 MPa)}$$

b) STEEL STAYBOLTS

Staybolts of known, steel material shall be calculated using the following formula or Table S2.10.4.1.b. The table is based on a stress value of 11,300 psi (78.0 MPa) for staybolts. Refer to ASME Section 1, 1971 Addenda for allowable loads for all staybolts.

$$P = \frac{\pi \left[\frac{d}{2} \right]^2 S}{1.1 \times p^2}, S = 11,300 \text{ (78.0 MPa)}$$

Staybolt Spacing, in.	Actual Diameter of Corroded Iron Staybolts, in.																																															
	0.35	0.375	0.4	0.425	0.45	0.475	0.5	0.525	0.55	0.575	0.6	0.625	0.65	0.675	0.7	0.725	0.75	0.775	0.8	0.825	0.85	0.875	0.9																									
3.5	59	68	77	87	97	108	120	133	145	159	173	188	203	219	236	253	270	289	308	327	347	368	389																									
3.625	55	63	72	81	91	101	112	124	136	148	161	175	189	204	220	236	252	269	287	305	324	343	363																									
3.75	51	59	67	76	85	95	105	115	127	138	151	164	177	191	205	220	236	252	268	285	303	321	339																									
3.875	48	55	63	71	79	89	98	108	119	130	141	153	166	179	192	206	221	236	251	267	283	300	318																									
4	45	52	59	66	75	83	92	101	111	122	133	144	156	168	180	194	207	221	236	251	266	282	298																									
4.125	42	49	55	63	70	78	87	95	105	114	125	135	146	158	170	182	195	208	222	236	250	265	280																									
4.25	40	46	52	59	66	74	82	90	99	108	117	127	138	149	160	171	183	196	209	222	236	250	264																									
4.375	38	43	49	56	62	69	77	85	93	102	111	120	130	140	151	162	173	185	197	209	222	236	249																									
4.5	36	41	47	53	59	66	73	80	88	96	105	114	123	133	143	153	164	175	186	198	210	223	236																									
4.625	34	39	44	50	56	62	69	76	83	91	99	108	116	125	135	145	155	165	176	187	199	211	223																									
4.75	32	37	42	47	53	59	65	72	79	86	94	102	110	119	128	137	147	157	167	178	189	200	211																									
4.875	30	35	40	45	50	56	62	68	75	82	89	97	105	113	121	130	139	149	159	169	179	190	201																									
5	29	33	38	43	48	53	59	65	71	78	85	92	100	107	115	124	133	142	151	160	170	180	191																									
5.125	27	32	36	41	45	51	56	62	68	74	81	88	95	102	110	118	126	135	144	153	162	172	182																									
5.25	26	30	34	39	43	48	53	59	65	71	77	83	90	97	105	112	120	128	137	145	154	164	173																									
5.375	25	29	33	37	41	46	51	56	62	67	73	80	86	93	100	107	115	122	130	139	147	156	165																									
5.5	24	27	31	35	39	44	49	54	59	64	70	76	82	89	95	102	110	117	125	133	141	149	158																									
5.625	23	26	30	34	38	42	47	51	56	62	67	73	79	85	91	98	105	112	119	127	135	143	151																									
5.75	22	25	29	32	36	40	45	49	54	59	64	70	75	81	87	94	100	107	114	121	129	136	144																									
5.875	21	24	27	31	35	39	43	47	52	56	61	67	72	78	84	90	96	103	109	116	123	131	138																									
6	20	23	26	30	33	37	41	45	49	54	59	64	69	75	80	86	92	98	105	111	118	125	133																									
6.125	19	22	25	28	32	35	39	43	47	52	57	61	66	72	77	83	88	94	100	107	113	120	127																									
6.25	18	21	24	27	31	34	38	42	46	50	54	59	64	69	74	79	85	91	97	103	109	115	122																									
6.375	18	20	23	26	29	33	36	40	44	48	52	57	61	66	71	76	82	87	93	99	105	111	117																									
6.5	17	20	22	25	28	31	35	38	42	46	50	54	59	64	68	73	78	84	89	95	101	107	113																									
6.625	16	19	21	24	27	30	34	37	41	44	48	52	57	61	66	71	75	81	86	91	97	103	109																									
6.75	16	18	21	23	26	29	32	36	39	43	47	51	55	59	63	68	73	78	83	88	93	99	105																									
6.875	15	18	20	23	25	28	31	34	38	41	45	49	53	57	61	66	70	75	80	85	90	95	101																									
7	15	17	19	22	24	27	30	33	36	40	43	47	51	55	59	63	68	72	77	82	87	92	97																									

S = 7,500 psi
P = MAWP psi

$$P = \frac{\pi \left[\frac{d}{2} \right]^2 S}{p^2}$$

d = Minimum diameter of corroded staybolt, in.
p = staybolt spacing, in.

Table S2.10.4.1.a [US Customary Units]
Maximum Allowable Working Pressure Based on the Load Carrying Capacity of a Single Corroded Iron Staybolt

Staybolt Spacing, mm	Actual Diameter of Corroded Iron Staybolts, mm																								
	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15	15.5	16	16.5	17	17.5	18	18.5	19	19.5	20	20.5	21	21.5	22
90	501	553	607	663	722	783	847	914	983	1054	1128	1204	1283	1365	1449	1535	1624	1716	1810	1906	2005	2107	2211	2317	2426
92.5	475	523	574	628	683	742	802	865	930	998	1068	1140	1215	1292	1371	1453	1538	1624	1713	1805	1898	1994	2093	2194	2297
95	450	496	544	595	648	703	760	820	882	946	1012	1081	1152	1225	1300	1378	1458	1540	1624	1711	1800	1891	1984	2080	2178
97.5	427	471	517	565	615	667	722	778	837	898	961	1026	1093	1163	1234	1308	1384	1462	1542	1624	1709	1795	1884	1974	2067
100	406	448	491	537	585	634	686	740	796	854	914	976	1039	1105	1173	1244	1316	1390	1466	1544	1624	1706	1791	1877	1965
102.5	386	426	468	511	557	604	653	704	758	813	870	929	989	1052	1117	1184	1252	1323	1395	1470	1546	1624	1704	1787	1871
105	368	406	446	487	530	575	622	671	722	774	829	885	943	1003	1064	1128	1193	1261	1330	1400	1473	1548	1624	1702	1783
107.5	351	387	425	465	506	549	594	640	689	739	791	844	900	957	1015	1076	1138	1203	1268	1336	1405	1477	1550	1624	1701
110	336	370	406	444	483	524	567	612	658	706	755	806	859	914	970	1028	1087	1149	1211	1276	1342	1410	1480	1551	1624
112.5	321	354	388	424	462	501	542	585	629	675	722	771	821	873	927	983	1039	1098	1158	1220	1283	1348	1415	1483	1553
115	307	339	372	406	442	480	519	560	602	646	691	738	786	836	887	940	995	1051	1108	1167	1228	1290	1354	1419	1486
117.5	294	324	356	389	424	460	497	536	576	618	662	707	753	801	850	901	953	1007	1062	1118	1176	1236	1297	1360	1423
120	282	311	341	373	406	441	477	514	553	593	634	677	722	768	815	864	914	965	1018	1072	1128	1185	1244	1303	1365
122.5	271	298	327	358	390	423	457	493	530	569	609	650	693	737	782	829	877	926	977	1029	1082	1137	1193	1251	1310
125	260	287	314	344	374	406	439	474	509	546	585	624	665	708	751	796	842	889	938	988	1039	1092	1146	1201	1258
127.5	250	275	302	330	360	390	422	455	490	525	562	600	639	680	722	765	809	855	902	950	999	1050	1102	1155	1209
130	240	265	291	318	346	375	406	438	471	505	541	577	615	654	694	736	778	822	867	914	961	1010	1060	1111	1163
132.5	231	255	280	306	333	361	391	422	453	486	520	556	592	630	668	708	749	792	835	879	925	972	1020	1069	1119
135	223	246	270	295	321	348	377	406	437	468	501	535	570	607	644	682	722	763	804	847	891	936	983	1030	1078
137.5	215	237	260	284	309	336	363	391	421	452	483	516	550	585	621	658	696	735	775	817	859	903	947	993	1039
140	207	228	251	274	298	324	350	378	406	436	466	498	530	564	599	634	671	709	748	788	829	871	914	958	1003
142.5	200	220	242	264	288	312	338	364	392	420	450	480	512	544	578	612	648	684	722	760	800	840	882	924	968
145	193	213	234	255	278	302	326	352	379	406	435	464	494	526	558	591	626	661	697	734	773	812	852	893	935
147.5	187	206	226	247	269	292	315	340	366	392	420	448	478	508	539	572	605	639	674	710	747	784	823	863	903
150	180	199	218	239	260	282	305	329	354	379	406	434	462	491	522	553	585	618	651	686	722	758	796	834	873
152.5	175	192	211	231	251	273	295	318	342	367	393	419	447	475	505	535	566	598	630	664	698	734	770	807	845
155	169	186	205	224	243	264	286	308	331	355	380	406	433	460	488	518	548	578	610	643	676	710	745	781	818
157.5	164	180	198	216	236	256	277	298	321	344	368	393	419	446	473	501	530	560	591	622	655	688	722	757	792
160	159	175	192	210	228	248	268	289	311	333	357	381	406	432	458	486	514	543	573	603	634	667	699	733	768
162.5	154	170	186	203	221	240	260	280	301	323	346	369	394	419	444	471	498	526	555	585	615	646	678	711	744
165	149	164	180	197	215	233	252	272	292	314	336	358	382	406	431	457	483	510	538	567	597	627	658	689	722
167.5	145	160	175	191	208	226	245	264	284	304	326	348	371	394	418	443	469	495	522	550	579	608	638	669	700
170	141	155	170	186	202	220	237	256	275	295	316	338	360	383	406	430	455	481	507	534	562	590	620	649	680
172.5	136	150	165	180	197	213	231	249	267	287	307	328	349	372	394	418	442	467	493	519	546	573	602	631	660
175	133	146	160	175	191	207	224	242	260	279	298	319	339	361	383	406	430	454	479	504	530	557	585	613	642
177.5	129	142	156	170	186	201	218	235	253	271	290	310	330	351	372	395	418	441	465	490	516	542	568	596	624
180	125	138	152	166	180	196	212	228	246	263	282	301	321	341	362	384	406	429	452	477	501	527	553	579	607

$$S = 51,700 \text{ kPa}$$

$$P = \text{MAWP kPa}$$

$$P = \frac{\pi \left[\frac{d}{2} \right]^2 S}{p^2}$$

$$p = \text{staybolt spacing, mm}$$

$$d = \text{Minimum diameter of corroded staybolt, mm}$$

Table S2.10.4.1.a [Metric Units]

Maximum Allowable Working Pressure Based on the Load Carrying Capacity of a Single Corroded Iron Staybolt

Staybolt Spacing, in.	Actual Diameter of Corroded Steel Staybolts, in.																						
	0.35	0.375	0.4	0.425	0.45	0.475	0.5	0.525	0.55	0.575	0.6	0.625	0.65	0.675	0.7	0.725	0.75	0.775	0.8	0.825	0.85	0.875	0.9
3.5	81	93	105	119	133	149	165	182	199	218	237	257	278	300	323	346	370	396	422	448	476	504	533
3.625	75	86	98	111	124	139	153	169	186	203	221	240	259	280	301	323	345	369	393	418	444	470	497
3.75	70	81	92	104	116	129	143	158	174	190	207	224	242	261	281	302	323	345	367	390	415	439	465
3.875	66	76	86	97	109	121	134	148	163	178	193	210	227	245	263	282	302	323	344	366	388	411	435
4	62	71	81	91	102	114	126	139	153	167	182	197	213	230	247	265	284	303	323	343	364	386	408
4.125	58	67	76	86	96	107	119	131	143	157	171	185	200	216	232	249	267	285	303	323	343	363	384
4.25	55	63	71	81	90	101	112	123	135	148	161	174	189	204	219	235	251	268	286	304	323	342	362
4.375	52	59	67	76	85	95	105	116	128	139	152	165	178	192	207	222	237	253	270	287	305	323	341
4.5	49	56	64	72	81	90	100	110	121	132	143	156	168	182	195	209	224	239	255	271	288	305	323
4.625	46	53	60	68	76	85	94	104	114	125	136	147	159	172	185	198	212	227	241	257	273	289	306
4.75	44	50	57	65	72	81	89	99	108	118	129	140	151	163	175	188	201	215	229	243	258	274	290
4.875	42	48	54	61	69	77	85	94	103	112	122	133	143	155	166	178	191	204	217	231	245	260	275
5	40	45	52	58	65	73	81	89	98	107	116	126	136	147	158	170	182	194	207	220	233	247	261
5.125	38	43	49	55	62	69	77	85	93	102	111	120	130	140	151	161	173	184	197	209	222	235	249
5.25	36	41	47	53	59	66	73	81	89	97	105	114	124	133	143	154	165	176	187	199	211	224	237
5.375	34	39	45	50	57	63	70	77	84	92	101	109	118	127	137	147	157	168	179	190	202	214	226
5.5	33	38	43	48	54	60	67	74	81	88	96	104	113	122	131	140	150	160	171	182	193	204	216
5.625	31	36	41	46	52	58	64	70	77	84	92	100	108	116	125	134	143	153	163	174	184	195	207
5.75	30	34	39	44	49	55	61	67	74	81	88	95	103	111	120	128	137	147	156	166	176	187	198
5.875	29	33	37	42	47	53	58	64	71	77	84	91	99	107	115	123	131	140	150	159	169	179	189
6	27	32	36	40	45	51	56	62	68	74	81	88	95	102	110	118	126	135	143	153	162	172	182
6.125	26	30	34	39	44	49	54	59	65	71	77	84	91	98	105	113	121	129	138	146	155	165	174
6.25	25	29	33	37	42	47	52	57	62	68	74	81	87	94	101	109	116	124	132	141	149	158	167
6.375	24	28	32	36	40	45	50	55	60	66	71	78	84	90	97	104	112	119	127	135	143	152	161
6.5	23	27	31	34	39	43	48	53	58	63	69	75	81	87	94	100	107	115	122	130	138	146	155
6.625	23	26	29	33	37	41	46	51	56	61	66	72	78	84	90	97	103	110	118	125	133	141	149
6.75	22	25	28	32	36	40	44	49	54	59	64	69	75	81	87	93	100	106	113	121	128	136	143
6.875	21	24	27	31	35	39	43	47	52	56	61	67	72	78	84	90	96	103	109	116	123	131	138
7	20	23	26	30	33	37	41	45	50	54	59	64	70	75	81	87	93	99	105	112	119	126	133

S = 11,300 psi
P = MAWP psi

$$P = \frac{\pi \left[\frac{d}{2} \right]^2 S}{1.1 \times p^2}$$

d = Minimum diameter of corroded staybolt, in.
P = staybolt spacing, in.

Table S2.10.4.1.b [US Customary Units]
Maximum Allowable Working Pressure Based on the Load Carrying Capacity of a Single Corroded Steel Staybolt

Staybolt Spacing, mm	Actual Diameter of Corroded Steel Staybolts, mm																								
	10	10.5	11	11.5	12	12.5	13	13.5	14	14.5	15	15.5	16	16.5	17	17.5	18	18.5	19	19.5	20	20.5	21	21.5	22
90	688	758	832	909	990	1074	1162	1253	1348	1446	1547	1652	1760	1872	1987	2106	2228	2353	2482	2614	2750	2889	3032	3178	3328
92.5	651	718	788	861	937	1017	1100	1186	1276	1368	1465	1564	1666	1772	1881	1993	2109	2228	2350	2475	2604	2735	2870	3009	3150
95	617	680	747	816	889	964	1043	1125	1209	1297	1388	1483	1580	1680	1783	1890	1999	2112	2228	2346	2468	2593	2721	2852	2987
97.5	586	646	709	775	844	915	990	1068	1148	1232	1318	1407	1500	1595	1693	1794	1898	2005	2115	2228	2343	2462	2584	2708	2835
100	557	614	674	737	802	870	941	1015	1092	1171	1253	1338	1426	1516	1609	1706	1804	1905	2010	2118	2228	2340	2456	2574	2695
102.5	530	584	641	701	763	828	896	966	1039	1114	1193	1274	1357	1443	1532	1623	1717	1814	1914	2016	2120	2228	2338	2450	2566
105	505	557	611	668	727	789	854	921	990	1062	1137	1214	1293	1375	1460	1547	1637	1729	1824	1921	2021	2123	2228	2335	2445
107.5	482	531	583	637	694	753	814	878	945	1013	1084	1158	1234	1312	1393	1476	1561	1649	1740	1833	1928	2025	2125	2228	2332
110	460	507	557	609	663	719	778	839	902	968	1036	1106	1178	1253	1330	1410	1491	1575	1662	1750	1841	1934	2030	2128	2228
112.5	440	485	532	582	634	688	744	802	862	925	990	1057	1126	1198	1272	1348	1426	1506	1589	1673	1760	1849	1941	2034	2130
115	421	464	510	557	606	658	712	767	825	885	947	1012	1078	1146	1217	1290	1364	1441	1520	1601	1684	1770	1857	1947	2038
117.5	403	445	488	533	581	630	682	735	791	848	908	969	1033	1098	1166	1235	1307	1381	1456	1534	1614	1695	1779	1865	1952
120	387	426	468	511	557	604	654	705	758	813	870	929	990	1053	1118	1184	1253	1324	1396	1471	1547	1625	1706	1788	1872
122.5	371	409	449	491	534	580	627	676	727	780	835	892	950	1010	1073	1137	1202	1270	1340	1411	1484	1560	1637	1716	1796
125	356	393	431	471	513	557	602	650	699	749	802	856	912	970	1030	1092	1155	1220	1287	1355	1426	1498	1572	1648	1725
127.5	343	378	415	453	493	535	579	624	671	720	771	823	877	933	990	1049	1110	1173	1237	1303	1370	1440	1511	1584	1658
130	330	363	399	436	475	515	557	601	646	693	741	792	844	897	952	1009	1068	1128	1190	1253	1318	1385	1453	1523	1595
132.5	317	350	384	420	457	496	536	578	622	667	714	762	812	864	917	971	1028	1086	1145	1206	1269	1333	1399	1466	1535
135	306	337	370	404	440	477	516	557	599	642	688	734	782	832	883	936	990	1046	1103	1162	1222	1284	1348	1413	1479
137.5	295	325	356	390	424	460	498	537	577	619	663	708	754	802	851	902	954	1008	1063	1120	1178	1238	1299	1362	1426
140	284	313	344	376	409	444	480	518	557	597	639	683	727	774	821	870	921	972	1026	1080	1137	1194	1253	1313	1375
142.5	274	302	332	363	395	429	463	500	538	577	617	659	702	747	793	840	889	939	990	1043	1097	1153	1209	1268	1327
145	265	292	321	350	381	414	448	483	519	557	596	636	678	721	766	811	858	907	956	1007	1060	1113	1168	1224	1282
147.5	256	282	310	339	369	400	433	467	502	538	576	615	655	697	740	784	829	876	924	973	1024	1076	1129	1183	1239
150	248	273	299	327	356	387	418	451	485	520	557	595	634	674	715	758	802	847	894	941	990	1040	1092	1144	1198
152.5	239	264	290	317	345	374	405	436	469	503	539	575	613	652	692	733	776	820	864	911	958	1006	1056	1107	1159
155	232	256	280	307	334	362	392	422	454	487	522	557	593	631	670	710	751	793	837	881	927	974	1022	1072	1122
157.5	225	248	272	297	323	351	379	409	440	472	505	539	575	611	649	688	727	768	810	854	898	943	990	1038	1087
160	218	240	263	288	313	340	368	396	426	457	489	523	557	592	629	666	705	745	785	827	870	914	959	1006	1053
162.5	211	233	255	279	304	330	356	384	413	443	475	507	540	574	610	646	683	722	761	802	844	886	930	975	1021
165	205	226	248	271	295	320	346	373	401	430	460	491	524	557	591	626	663	700	738	778	818	860	902	946	990
167.5	199	219	240	263	286	310	335	361	389	417	447	477	508	540	574	608	643	679	717	755	794	834	875	918	961
170	193	212	233	255	277	301	326	351	378	405	434	463	493	525	557	590	624	660	696	733	771	810	850	891	933
172.5	187	206	226	248	270	292	316	341	367	394	421	450	479	510	541	573	606	641	676	712	749	787	825	865	906
175	182	200	220	240	262	284	307	331	356	382	409	437	466	495	526	557	589	622	656	691	727	764	802	841	880
177.5	177	195	214	234	255	276	299	322	346	372	398	425	453	481	511	541	573	605	638	672	707	743	780	817	856
180	172	190	208	227	248	269	290	313	337	361	387	413	440	468	497	526	557	588	621	654	688	722	758	795	832

$$S = 78,000 \text{ kPa}$$

$$P = MAWP \text{ kPa}$$

$$P = \frac{\pi \left[\frac{d}{2} \right]^2 S}{1.1 \times p^2}$$

$$d = \text{Minimum diameter of corroded staybolt, mm}$$

$$p = \text{staybolt spacing, mm}$$

Table S2.10.4.1.b [Metric Units]

Maximum Allowable Working Pressure Based on the Load Carrying Capacity of a Single Corroded Steel Staybolt

Subject: 2010 Edition, Part 2, Supplement 2, S2.10.2 – Define Deteriorated Rivet Heads

File Number: NB11-1603

Prop. Page: 133

Proposal: Update text in S2.10.2 to include guidelines for decayed rivets.

Current Wording:

S2.10.2 RIVETS

When the diameter of the rivet holes in the longitudinal joints of a boiler is not known, the diameter of rivets, after driving, may be ascertained from the Table S2.10.2.

Proposed Wording:

S2.10.2 Rivets and Rivet Heads

When the diameter of the rivet holes in the longitudinal joint of a boiler is not known, the diameter of the rivets, after driving, may be ascertained from Table S2.10.2.

Thickness of Place, inches (mm)	Diameter of Rivet after Driving, inches (mm)
1/4 (6)	11/16 (17)
9/32 (7)	11/16 (17)
5/16 (8)	3/4 (19)
11/32 (9)	3/4 (19)
3/8 (10)	13/16 (21)
13/32 (10)	13/16 (21)
7/16 (11)	15/16 (24)
15/32 (12)	15/16 (24)
1/2 (13)	15/16 (24)
9/16 (14)	1-1/16 (27)
5/8 (16)	1-1/16 (27)

Rivet Head Types

Finished rivet heads are shown in NBIC Part 3, Figure S2.13.13.4.

Note that a riveted seam may have more than one type of rivet to, for example, provide necessary clearance during operation, or for provision for equipment assembly and maintenance.

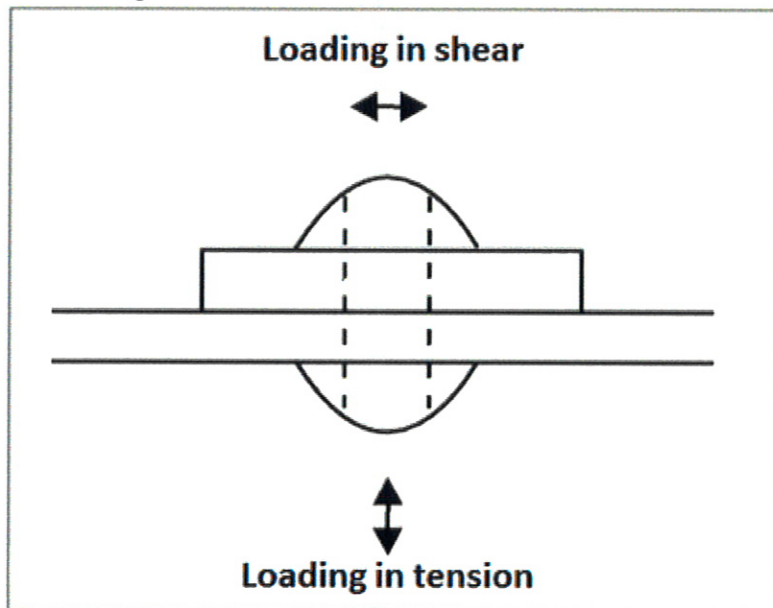
S2.10.2.1 Inspection of Corroded Rivets

A riveted seam or joint is very redundant by design. Therefore, the following guidelines apply when generalized corrosion is present and consistent on a group of adjacent rivets (typically 4 or more), and not to individual rivets. The inspector must consider the frequency and consistency of corroded rivet heads, and condition, location, and type of riveted joint (and how it may fail) in determining allowable corrosion.

- a. Visually identify all connections containing rivets which show signs of significant corrosion.
- b. Categorize each connection as the type which loads the rivets in one of three possible modes (pure shear, pure tension, or combined shear and tension). Refer to Figure S2.10.2.
- c. A leak around a rivet head may be indicative of a rivet which is loose, broken, or otherwise failing to provide adequate clamping force and will require further inspection.
 - i. A rivet shall be deemed loose if it can be felt to move after being struck on the side of the head in a direction approximately perpendicular to its shank with a 40oz. engineer's hammer.
 - ii. NBIC Part 3, S2.13.13 defines procedures to address a leak around a rivet head.
- d. Allowable corrosion:
 - i. For rivets in pure shear load, the amount of measured head deterioration shall not exceed 80% of its total head volume. Where rivets have countersunk heads, the head diameter must be equal or greater than 65% of the original head diameter. Severe head corrosion will require further evaluation of the condition and thickness of the plate at the joint.
 - ii. For rivets in pure tension, the amount of measured head deterioration shall not exceed 35% of its total head volume. Where rivets have countersunk heads, the head diameter must be equal or greater than 85% of original head diameter. Application of this value shall take into consideration the consistency and frequency of adjacent rivets showing excessive corrosion.

- iii. For connections subjected to combined shear and tension loads, the amount of measured head deterioration shall not exceed 60% of its total head volume. Where rivets have countersunk heads, the head diameter must be equal or greater than 75% of original head diameter. Application of this value shall take into consideration the consistency and frequency of adjacent rivets showing excessive corrosion.

Figure S2.10.2



The condition of the plate surrounding the rivets including general wastage, pitting, and the condition of the caulking edge, must be considered.

Explanation

Supplement 1 (Locomotives) has a guideline for deteriorated rivet head acceptance/rejection [5]. Supplement 2 (Historical Boilers) does not have such a guideline. This report itemizes concerns and errors in Supplement 1 guidelines, and proposes a new Supplement 2 guideline.

Supplement 1 Errors & Omissions

- 1.) No guidelines for rivets in shear.
- 2.) S1.4.2.1.L wording is unclear / self-contradictory. The first sentence discusses wastage, and the 2nd sentence discusses remaining height at shank diameter, both using 0.25D.

Discussion

[1, 9] state “U.S. Navy rules require the repair or replacement of rivets when head thickness has been reduced by 25% for 40.8lb [1-inch thick] plate and smaller and by 20% in plate over this weight.”

[8] is heavily referenced, and states that current practice is to replace all rivets in connections subject to tensile or tensile-shear loading that have heads corroded to the point of losing 50% or more of their projection beyond the shank. An original copy of this publication could not be sourced, but this wording is consistent among all papers referencing this work.

[2] performs FEA on a 7/8” button head rivet, and recommends that the measured amount of head deterioration shall not exceed 35% of its total head volume.

Caveats:

- [2] assumes A502 grade rivets, other reports do not appear to specify the grade of rivet. Historical boilers are using A-31 grade rivets.
- All referenced work assumes no change to the load of the rivets. NBIC is unique where the standard will degrade MAWP based on boiler condition, thus changing the load imposed on the rivet. However, FEA in [2] shows a rather sharp increase in stress when deterioration surpasses 35%. This increase is far greater than the reduction due to change in MAWP. The paper reports that measurements have shown rivet clamping force approaches yield load of the rivet.
- Where mentioned, only button head rivet designs are discussed in reference materials.

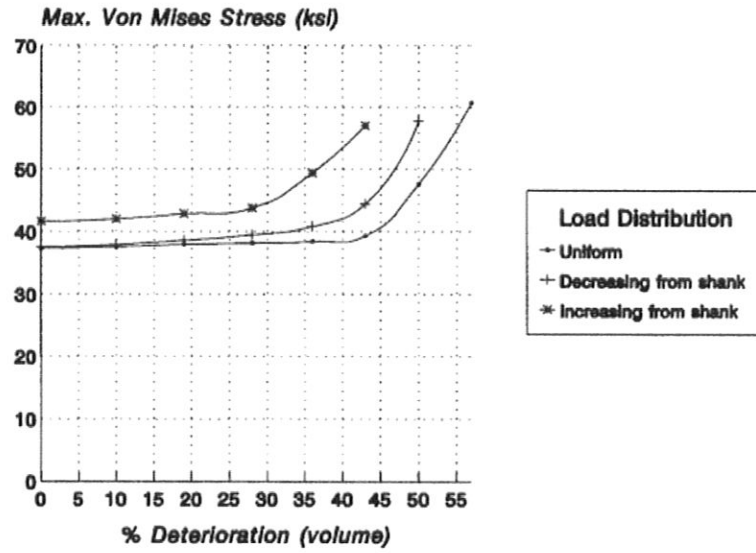


Figure 12 - Max. Stress Vs. Loss of Head Volume (Uniform Model)

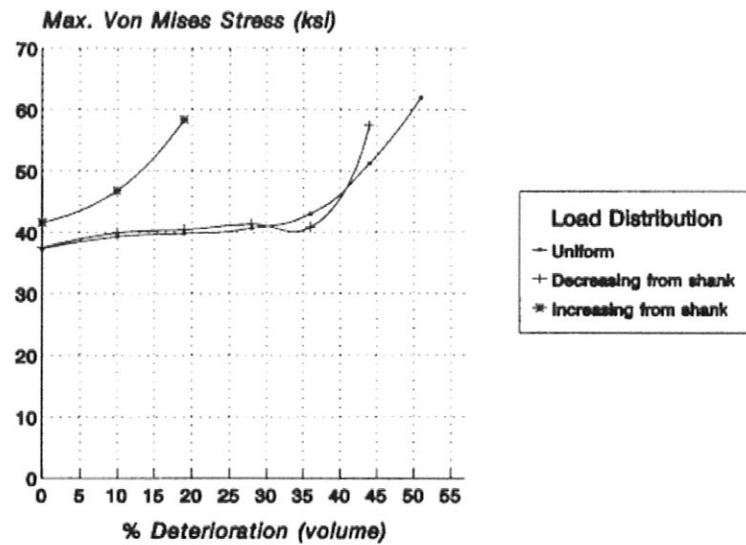
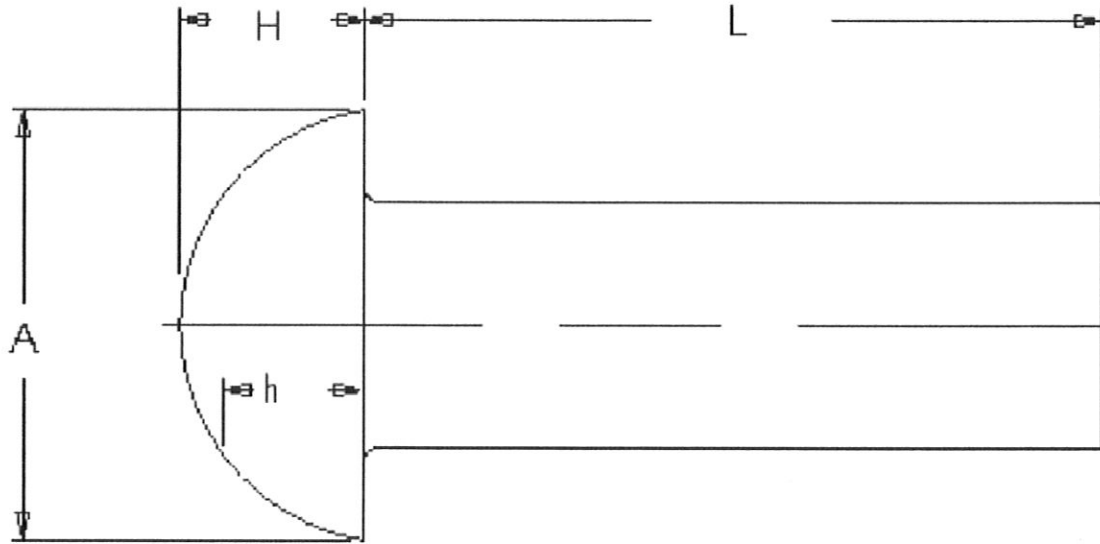


Figure 13 - Max. Stress Vs. Loss of Head Volume (Non-Uniform Model)

New Button Head Rivet Dimensions

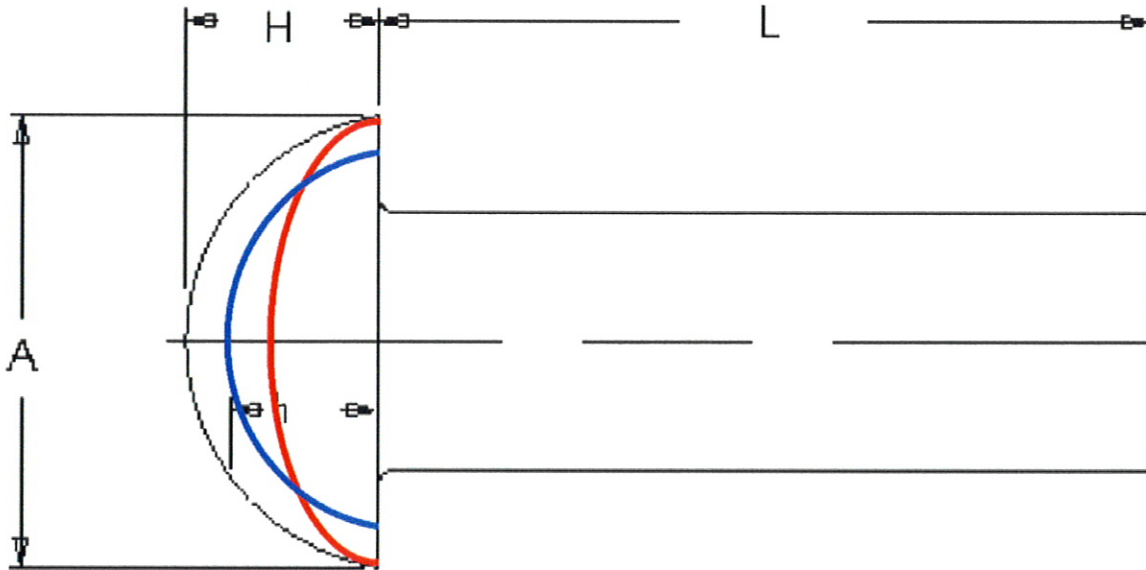
Values are taken from [6]. Calculated values below are based on equations from [7].



Shank Diameter	A Head Diameter	H Head Height	h Height at Shank Circumference (new)	Head Volume
0.500	0.875	0.375	0.298	0.140
0.625	1.094	0.469	0.372	0.274
0.750	1.312	0.562	0.446	0.473
0.875	1.531	0.656	0.521	0.752
1.000	1.750	0.750	0.595	1.123
1.125	1.969	0.844	0.670	1.600
1.250	2.188	0.938	0.745	2.200
1.375	2.406	1.031	0.818	2.918
1.500	2.625	1.125	0.893	3.790
1.625	2.844	1.219	0.968	4.820
1.750	3.062	1.312	1.041	6.013

Deteriorated Button Head Rivet Dimensions

We will consider two types of generalized deterioration. All red values will represent even deterioration at the crown of the head, where the base of the rivet head remains intact. All blue values represent equal deterioration around the rivet head.



NBIC S1.4.2.1: minimum $h = 0.25 * \text{shank diameter}$

Assuming even deterioration at the rivet head crown, but no deterioration at the edge of the rivet head (red line), **60%** of rivet head material is removed before the rivet must be replaced.

Assuming even deterioration (blue line) throughout the rivet head, **52.5%** of material is removed before the rivet must be replaced.

US Navy [1, 9]: minimum $H = 0.75 * \text{original } H$

Assuming even deterioration at the rivet head crown, but no deterioration at the edge of the rivet head (red line), **31.5%** of rivet head material is removed before the rivet must be replaced.

Assuming even deterioration throughout the rivet head, **55%** of material is removed before the rivet must be replaced.

[8] is calculated in the same manner, except **$H = 0.5 * \text{original } H$** . Assuming even deterioration at the rivet head crown, but no deterioration at the edge of the rivet head (red line), **57.5%** of rivet head material is removed before the rivet must be replaced. However, assuming even deterioration throughout the rivet head, deterioration enters the rivet shank so these values are not considered. Given this result, [8] will not be further considered until a copy is attained to determine how to interpret its guidelines.

US Army [2]: minimum head volume = $0.65 * \text{original head volume}$

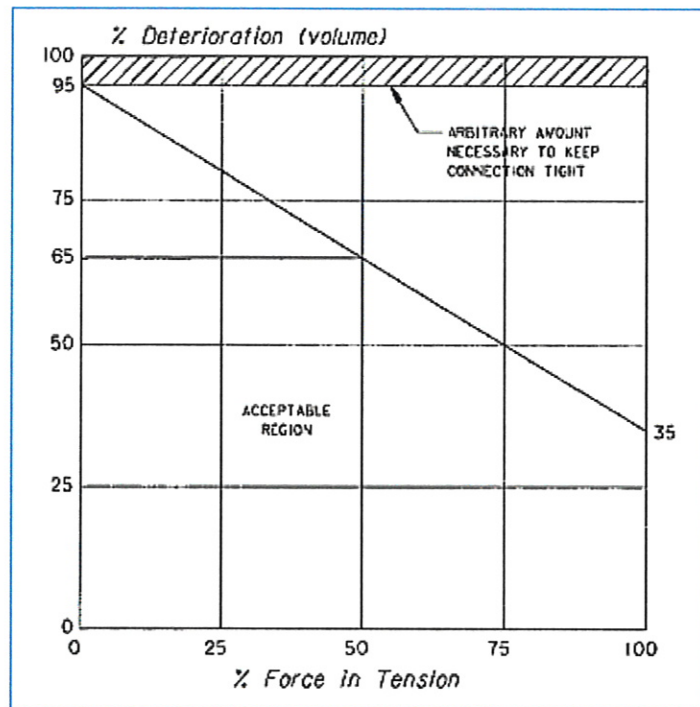
Assuming even deterioration at the rivet head crown, but no deterioration at the edge of the rivet head (red line), to obtain 35% removal of head volume, 'h' must only reduce by **20%** of its original height. Using NBIC S1.4.2.1 metrics, 'h' must be **40%** or greater than shank diameter.

Assuming even deterioration throughout the rivet head, to obtain **35%** removal of head volume, 'h' must only reduce by **17.5%** of its original height. Using NBIC S1.4.2.1 metrics, 'h' must be **46%** or greater than shank diameter.

Discussion

The FEA results [2] assumed even corrosion around the entire rivet head. These conclusions (35% volume removal) are similar to the rule-of-thumb U.S. Navy guidelines [1, 9] (31.5%) when corrosion is maximum at the crown of the rivet head. Given this consistency, this draft targets a maximum 35% volume removal threshold for rivets in pure tension.

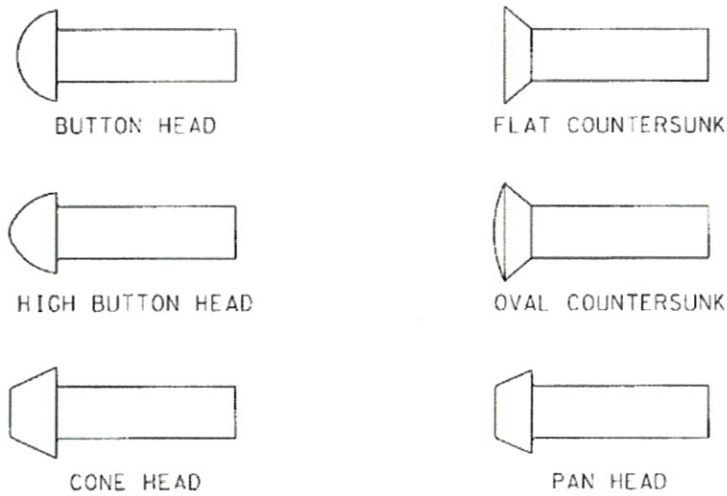
[2] also suggested that for rivets in pure shear, rivets do not need to be replaced as long as the corrosion has not extended into the shank and that the rivet is not loose. Furthermore, the ratio of total head volume removed may linearly scale from 35% (for 100% tension) to 95% (for 100% shear). Refer to below figure from [2].



However, in practicality, one must expect the plate to deteriorate with the rivet head. For example, when a flat countersunk rivet head is 20% of its original volume, the adjoining plate is 33% of its original thickness. So, in practice, it is reasonable to expect a repair that replaces both plate and rivets when severe rivet head decay is present.

Regardless of the type of corrosion, NBIC S1.4.2.1 allows more corrosion than all other approaches for rivets in pure tension. Research and references to peer reviewed documents for NBIC S1.4.2.1 is unknown so cannot be considered. However, due to the difficulties in determining the ratio of shear/tension load on a specific rivet, this draft

adopts the rule to apply equal 50/50% shear/tension. Given the above text, allowable head corrosion for rivets in combined shear/tension is 60%; consistent with NBIC S1.4.2.1.



We assume equal allowable wastage regardless of rivet head type because all known construction codes assume equal allowable loading regardless of rivet head type.

References

- [1] "Atlantic Area Best Practices: Rivet Inspection Guidance", U.S. Department of Transportation, United States Coast Guard, 2000.
- [2] "Rivet Replacement Analysis", Erich Edward Reichle, U.S. Army Corps of Engineers, 1999.
- [3] "Inspection, Evaluation, and Repair of Hydraulic Steel Structures", U.S. Army Corps of Engineers, 2001.
- [4] "Guidelines for Assessing Condition of Riveted Spillway Gates", REMR Technical Note CS-ES-1.12, 1994
- [5] NBIC Supplement 1, Part 2, 2010.
- [6] ASME B18.1.2: American National Standard Large Rivets
- [7] http://en.wikipedia.org/wiki/Spherical_cap
- [8] "Rivet Replacement Criteria", Fazio, A.E., and R.N. Fazio, Second Bridge Engineering Conference. Washington, D.D. Transportation Research Board. Vol 1, TRR-950
- [9] "Procedures For Hull Inspection and Repair on Vessels Built of Riveted Construction", U.S. Department of Transportation, United States Coast Guard, 2001.

NB11-2101

The issue I want to address is the lack of inspection on propane tanks that have been out of service for a period of time, sometimes even 10 yrs or more, that are "rebuilt, refurbished or revitalized" and placed back into service without an internal inspection or hydrostatic testing. These tanks are purchased from anyone who has excess tanks in their possession. These tanks are in all manner of conditions. Some have had all the valves removed and stand open to the elements.

There are dozens of companies "refurbishing" tanks. Some have little or no experience in the propane industry and are nothing more than paint body shops. To my knowledge there are only two companies doing these types of "refurbs" that have their "R" stamp. The normal "refurb" service is sand blast, visual inspect the outside surface (if at all), paint and replace some valving.

There are a several issues that I think need to be addressed:

1. There is no way of knowing if these tanks were ever used in anhydrous ammonia service during their lifetime.
 - Changing a tank from propane service to anhydrous ammonia service has been a common practice in the past.
 - There have been multiple accidents involving fatalities from tanks being changed for one service to the other.
 - Stress corrosion cracking and odor fade can occur
 - In NFPA 58 2011 edition in 5.2.1.5 this conversion of service is no longer allowed.

2. Tanks have had their valves removed, allowing them to be susceptible to internal oxidation.
 - Oxidation is the primary cause of odor fade.
 - There have been documented cases where odor fade has been the cause in fatal accidents.
 - There was a national recall on old tanks that were converted from aboveground use to underground use.
 - These tanks were found to have had odor fade issues because of internal oxidation.
 - 11,000 units were involved

3. No one knows the integrity of the vessel.
 - 95% plus (estimate) of the tanks being sold as "refurb" never get hydrostatically tested.

1/3

Proposed Verbiage

S7.9 Special Consideration for LPG Tanks Being Renewed By a Commercial Source.

Since new LPG tanks have had major cost increases, "refurbished" LPG tanks have become more available on the commercial market. Because the history on some of these tanks is unknown special attention should be given to inspection and repair before returning any of these tanks back to service.

- 1) All tanks must have a name plate that is firmly attached and legible with an ASME Code symbol, U1A Data Report and a National Board and / or jurisdictional registration number, if required.
- 2) All coatings must be removed to clean bare steel.
- 3) All valves and gauges will be removed and inspected for signs of anhydrous ammonia use.
 - a. If the tank has been used for anhydrous ammonia service a distinctive blue-green corrosion will be present on the brass valves. There may also be an ammonia odor around the tank or valve area. If any of these signs are present the tank must not be returned to LPG service, under the guidelines of NFPA 58 5.2.1.5 and all valves and gauges must be discarded.
- 4) A complete external inspection should be completed under the guidelines of NBIC S7.6-8.5

If any defects are found beyond the limits the defect should be repaired under NBIC Part 3, Repairs and Alterations by qualified personnel or discarded.

The main reason for these additions to supplement 7 is "refurb" companies are popping up everywhere and most have no understanding of pressure vessels.

Proposed Verbiage

S7.9 Requirements for Special Consideration for LPG Tanks Either Used or Will Be Used in Different Service Conditions Being Renewed By a Commercial Source.

Since new LPG tanks have had major cost increases, "refurbished" LPG tanks have become more available on the commercial market. Because the history on some of these tanks is unknown special attention should be given to inspection and repair before returning any of these tanks back to service.

The following requirements apply to LPG tanks that either have been used or will be used in service conditions other than LPG service.

- 1) All tanks must have a name plate that is firmly attached and legible with an ASME Code symbol, U1A Data Report and a National Board and/or jurisdictional registration number, if required.
- 2) All coatings must be removed to clean bare steel.
- 3) All valves and gauges will be removed and inspected for signs of anhydrous ammonia use.
 - a. If the tank has been used for anhydrous ammonia service a distinctive blue-green corrosion will be present on the brass valves. There may also be an ammonia odor around the tank or valve area. If any of these signs are present the tank must not be returned to LPG service, under the guidelines of NFPA 58 5.2.1.5 and all valves and gauges must be discarded.
- 4) A complete external inspection ~~shall~~ should be completed under the guidelines of the NBIC, Part 2, Supplement 7, NBIC-S7-6 and Supplement 8, -8.5 [gwg]

If any defects are found beyond the limits the defect should be repaired under NBIC Part 3, Repairs and Alterations by qualified personnel or discarded.

The main reason for these additions to supplement 7 is "refurb" companies are popping up everywhere and most have no understanding of pressure vessels.

NB12-0604

Request for Code Change

NBIC Part 2, Forms NB-6 and NB-7

Statement of Need: These forms need to be changed to become current with a majority of Jurisdictional Requirements

Make the following changes to forms NB-6 and NB-7

Owner-Change to Object Location
Owner Street Address Change to Object Street Address
Owner City Change to Object Location City

User Name Change to Mail Invoice
User Street Address to Invoice Street Address
User City to Invoice Address City

New Block:
Certificate Address
Certificate City
Certificate State and Zip Code

5.3.5 BOILER-FIRED PRESSURE VESSELS REPORT OF INSPECTION FORM (NB-6)

A11

FORM NB-6 BOILER-FIRED PRESSURE VESSEL
REPORT OF INSPECTION

Standard Form for Jurisdictions Operating Under the ASME Code

1	DATE INSPECTED MO DAY YEAR	CERT EXP DATE MO YEAR	CERTIFICATE POSTED <input type="checkbox"/> Yes <input type="checkbox"/> No	OWNER NO.	JURISDICTION NUMBER	NAT'L BD NO. <input type="checkbox"/>	OTHER NO. <input type="checkbox"/>
2	OWNER <u>Object Location</u>			NATURE OF BUSINESS	KIND OF INSPECTION <input type="checkbox"/> Int <input type="checkbox"/> Ext	CERTIFICATE INSPECTION <input type="checkbox"/> Yes <input type="checkbox"/> No	
	OWNER'S STREET ADDRESS <u>Object Street Address</u> NUMBER			OWNER'S CITY <u>Object Location City</u>	STATE	ZIP	
3	USER'S NAME <u>OBJECT LOCATION Mail Invoice:</u>			SPECIFIC LOCATION IN PLANT		OBJECT LOCATION - COUNTY	
	USER'S STREET ADDRESS <u>Invoice Street Address</u> NUMBER			OWNER'S CITY <u>Invoice Address</u> <u>City</u>	STATE	ZIP	
4	TYPE <input type="checkbox"/> FT <input type="checkbox"/> WT <input type="checkbox"/> CI <input type="checkbox"/> Other _____			YEAR BUILT	MANUFACTURER		
5	USE <input type="checkbox"/> Power <input type="checkbox"/> Process <input type="checkbox"/> Steam Htg <input type="checkbox"/> HWH <input type="checkbox"/> HWS <input type="checkbox"/> Other _____			FUEL	METHOD OF FIRING	PRESSURE GAGE TESTED <input type="checkbox"/> Yes <input type="checkbox"/> No	
6	PRESSURE ALLOWED MAWP _____ This Inspection _____ Prev. Inspection _____			SAFETY-RELIEF VALVES Set at _____ Total Capacity _____		HEATING SURFACE OR BTU (Input/Output)	
7	IS CONDITION OF OBJECT SUCH THAT A CERTIFICATE MAY BE ISSUED? <input type="checkbox"/> Yes <input type="checkbox"/> No (If no, explain fully under conditions)				PRESSURE TEST <input type="checkbox"/> Yes _____ psi Date _____ <input type="checkbox"/> No		
Certificate Address:							
Certificate City:				Certificate State, Zip:			
8	<p>CONDITIONS: With respect to the internal surface, describe and state location of any scale, oil or other deposits. Give location and extent of any corrosion and state whether active or inactive. State location and extent of any erosion, grooving, bulging, warping, cracking or similar condition. Report on any defective rivets, bowed, loose or broken stays. State condition of all tubes, tube ends, coils, nipples, etc. Describe any adverse conditions with respect to pressure gage, water column, gage glass, gage cocks, safety valves, etc. Report condition of setting, linings, baffles, supports, etc. Describe any major changes or repairs made since last inspection.</p> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>						
9	<p>REQUIREMENTS: (List Code Violations)</p> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>						
10	<p>NAME AND TITLE OF PERSON TO WHOM REQUIREMENTS WERE EXPLAINED:</p> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/> <hr/>						

I HEREBY CERTIFY THIS IS A TRUE REPORT OF MY INSPECTION

This form may be obtained from The National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Ave., Columbus, OH 43229

NB-6 Rev. 5

SECTION 5

