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FOREWORD.

By the President of the Northwest Steam Society.

I hope all our steamboaters and future steamboating members will find these guidelines interesting and useful. The guidelines are in no way intended to be "Rules and Regulations". They are what the title states, guidelines, meant to help us all to enjoy our hobby in a safe and knowledgeable manner. Rules and Regulations alone don't make anything safe, it is up to the individual to be aware of what is safe and good practice at all times.

To the many members who have contributed to the contents of this booklet, my most sincere Thank-you.

Wolfgang Schlager, President, NWSS. February, 2004

The Northwest Steam Society is not responsible for the accuracy of the information contained herein nor can we control the conditions under which it is used. We therefore disclaim any expressed or implied liability.

PREFACE.

Hobby steamboating is an activity which is unusual by being on the one hand individualistic, while on the other being cooperative and sociable. At first glance it might seem odd for the NWSS to produce Guidelines for Operating Safety in our Hobby - with the implication of uniformity which that might seem to imply. In fact there are two good reasons for these Guidelines, and uniformity is NOT one of them.

First, one of the primarily goals of the NWSS is to provide information and guidance to members that they may better enjoy the hobby. This is fulfilled in part by the Steam Gauge, our Annual Meet, and the other mini meets and workshops throughout the year. By compiling these suggested Guidelines we hope to bring together in one small booklet the expertise of our members in areas vital to the safe operation of a hobby steamboat, thereby increasing the knowledge readily available.

Second - and this reason is forward-looking - like it or not both the boating world and the world of hobby steam are becoming increasingly regulated. There is a growing risk of hobby steamboating becoming subject to unsuitable regulations made by people who don't understand its nature or scale. Because of the duration of its existence and expertise of its members, the NWSS has the opportunity to demonstrate that we take seriously those matters which potential regulators may believe require attention. Hopefully this proactive stance will allow us input in any future discussions of proposed "regulations".

With the above two reasons in mind, these Guidelines - which are intended to be good, well proven, and safe practice - have been compiled. They are NOT "standards" with all that word would imply; they aim to provide a sound foundation on which individuals may build, improve and innovate. There are ample sources elsewhere of design information for steam plant and hulls, including relevant standards. Where there are matters affecting safety, these are clearly stated. However, while what is stated will often not be the only possible way of achieving the necessary safe result, great care should be taken to ensure that the alternatives adequately meet ALL safety requirements of each case. Ultimately, safe operation is YOUR responsibility.

Ron Fossum, G.O.S.H. Editor, February 2004

ACKNOWLEDGEMENTS.

Several members of the NWSS have contributed to these Guidelines:

Robert Dessert, Everett Engineering:
Boiler Piping, Valves & Fittings.
John C. Nessett, Captain:
Steam Plant Operation. Taken in part from the operating manual for SL Zebedee as approved by the US Coast Guard.
Thomas Ray, former Connecticut State Fire Marshal:
Fuels - Types, Handling & Storage.
William R. Larson, Captain (retired):
Safe Steamboat Handling.
Gordon Sullivan:
Appendices D through G and technical advice.
Robert Hull, Licensed Chief Engineer, Steam and Diesel (retired);
LeRoy Mietzner, US Navy Shipyard (retired);
Frank Orr;
Al Rustad, ME, LPE;
Don Thompson, Marine & Stationary Engineer, Steam, 4th Class:
General technical expertise and advice.
Ron Fossum:
Editing and bringing it all together in a coherent pamphlet.

Additional resources used:

Commander Bob's Website
http://www.commanderbob.com/homepage.html
National Board of Boiler and Pressure Vessel Inspectors
1055 Crupper Avenue
Columbus, OH 43229-1183
Steamboats and Modern Steam Launches
Boat House
6744 S.E. 36th Avenue
Portland, OR 97202
Steamboater's Handbook
International Steamboat Society
Route 1, Box 262
Middlebourne, WV 26149

1. BOILER DESIGN & CONSTRUCTION.

1.1. What is a code boiler?

The ASME (American Society of Mechanical Engineers) adopted a boiler code using specific language, methods, materials, record keeping and insurance because many boilers in the early days of steam would self-destruct - with a consequent loss of life and property - due to material or structural defects and construction deficiencies. As with any code, the ASME Fired Pressure Vessel Code is a "minimum standard". That is to say, there are basic MINIMUM requirements and it is the inspector's job to verify that the construction materials are as specified and that proper assembly procedures have been followed.

1.2. Must I have a code boiler?

If you operate ONLY on the navigable waterways of the United States, you fall under the USCG regulations (46CFR, Chapter I, part 50 - see Appendix A) which state that any vessel forty (40) feet in length and under does not need design approval or inspection of its steam plant. If you operate on any other waterway you MAY be subject to your local state requirements. Currently Washington and Oregon do not require design approval and inspection of steamboats under their jurisdiction, but it is best to check with your local boiler inspection department.

1.3. Can I design and build my own boiler?

If you operate only under USCG jurisdiction - and are not over forty feet - you may, but unless you are a licensed engineer AND a certified pressure vessel welder, it is NOT recommended. If the boiler should malfunction and injure others, YOU will be liable for any damages. NWSS insurance at our Annual Meet ONLY protects the NWSS; it does NOT cover individual boats and owners. There are many firms that build ASME code boilers and, although the initial cost will be greater, you and the hobby have too much to lose by cutting corners.

You may be able to buy a set of plans that conform to ASME code requirements and have the unit built by a competent welder - but unless it is built in a shop that has the ASME "S" stamp, it is NOT a code boiler!

2. BOILER PIPING, VALVES & FITTINGS.

Although as important as the boiler, the piping, valves and fittings attached to the boiler frequently receive less attention and many people reduce expenses by installing that "old used valve from the scrap bin". ANYTHING under boiler pressure should be treated with as much care and respect as the boiler itself. If a pipe or fitting bursts can you close the valve fast enough that you or a passenger are not seriously injured? Probably not! The following are suggested MINIMUM standards:

2.1. Piping.

2.1.1. All pipe or fittings screwed into the pressure vessel must be a MINIMUM of schedule 80 and NOT be "close" nipples.

2.1.2. If piping is run long distances it should have adequate bracing to prevent unnecessary loading and vibration fatigue.

2.1.3 There shall be NO galvanized fittings or pipe on steam service lines. Galvanized fittings and pipe, if used, should be on water suction lines ONLY.

2.1.4. All boilers must have at LEAST TWO INDEPENDENT ways of being supplied with feed water, one of which may be a hand pump

2.1.5. The piping for a self-regulating boiler feedwater system should have a means to manually bypass it in case of failure.

2.1.6. The boiler should have blow down capabilities with TWO valves in the blow down line - one high temperature valve at the boiler and one regular valve at the through-hull fitting. If the blow down discharges below the water line it is recommended that a "check" valve be fitted - between the two above noted valves - to prevent sea water being sucked back into the boiler.

2.1.7. All piping should be kept as short as possible to accomplish its purpose.

2.1.8. Unions should be used to ease disassembly of piping.

2.1.9. The boiler and all steam lines should be WELL insulated to prevent burns.

2.1.10. "Never Seize" or an equivalent pipe thread compound should be used on all threaded pipe connections.

2.2. Valves.

2.2.1. All entry/exit points of the pressure vessel - EXCEPT the safety valve - should have readily accessible boiler stop valves, located as close to the boiler as possible and whose primary function is to stop pressure from escaping the boiler. A throttle valve is NOT a boiler stop valve.

2.2.2. All pressure valves should be rated for at LEAST the pressure setting of the safety valve - noted on the valve body by the initials WSP to indicate "Working Steam Pressure".

2.2.3. All pressure valves should be of union bonnet type.

2.2.4. "Ball" valves may be used as long as they are rated for the boiler's working STEAM pressure. It is recommended that they NOT be used as throttle valves as the ball and/or seal will wear rapidly and the valve not fully close.

2.2.5. Check valves should be fitted to all boiler feedwater lines as close to the boiler stop valve as practicable.

2.3. Water Level Gauge Glass.

2.3.1. A "reflex" gauge glass is recommended over a tubular gauge glass.

2.3.2. If the boiler is fitted with a tubular gauge glass it should have a guard around it sufficient to prevent accidental breakage and to deflect steam and water in the event of glass breakage.

2.3.3. If the boiler is fitted with a tubular gauge glass it should also have try cocks in case the glass is broken.

2.3.4. It is recommended that ALL water level gauge glass valves have safety balls, if they are manufactured/available.

2.3.5. All water level gauge glasses MUST have the capability of being blown down.

2.3.6. The water level gauge glass must have sufficient bracing - if remotely plumbed - to prevent separation of the glass from the valves and to prevent any stress on the glass.

2.4. Safety Valves.

2.4.1. The safety valve(s) should be sized to the output capacity of the boiler - too large is as bad as too small.

2.4.2. The safety valve(s) should have an escape pipe to direct blow-off away from the operator and passengers, preferably up the after side of the stack and the size should be not less than that of the pipe from the boiler to the valve.

2.4.3. The safety valve(s) should have an intact seal clearly noting inspectection/certification by an AUTHORIZED service facility.

2.4.4. Piping from the boiler to the safety valve should be as SHORT as possible with NO fittings.

2.4.5. There must be NO valve(s) between the boiler and the safety valve.

2.5. Pressure Gauges.

2.5.1. Pressure gauges should be suitable for the type of service (i.e., steam, water) and the pressure range should be AT LEAST 1-1/2 times the maximum pressure to be applied.

2.5.2 All pressure gauges must have a stop valve, and gauges handling steam must have a siphon.

2.5.3. The boiler pressure gauge should be tested annually.

3. BOILER INSPECTION, MAINTENANCE & LAYUP.

The boiler of a hobby steamboat is certainly one of the most expensive - in labor and/or materials - parts of the vessel. A reasonably well designed, constructed, maintained and operated boiler can have a lifespan of 30+ years in service. Yet because the "innards" of the boiler, unlike the engine, are hidden from the eye it is frequently NOT given the attention and preventative maintenance it should have to prolong its life and safety.

3.1. Boiler Water Treatment.

Because most of us live in the Pacific Northwest, which has some of the best boiler water around, we frequently ignore this VERY important aspect of boiler maintenance. Boiler water treatment fights deposits of scale on boiler surfaces; concentration of dissolved solids; and corrosion eating into the metal of the boiler.

Appendices D through G contain much good information on the "care and treatment" of boiler water, as well as the problems which WILL occur should this vital part of boiler maintenance be ignored.

3.2. Fireside Deposits.

What with the many fuels and boiler types it is difficult to give full instructions for fireside cleaning. However, if your fireside heat exchange surfaces are sooty or have other deposits, you would be well advised to clean them. Even thin accumulations can reduce boiler efficiency by a surprising amount. And in a marine environment those deposits will absorb water from the air, creating a sulphuric acid solution which will attack the fireside metal of your boiler.

While there are a number of products which are sold to reduce deposits "on the go", maintaining an efficient fire - best judged by a proper color flame and near smokeless ("efficiency haze") exhaust from the stack - will keep the fireside cleaner and make cleaning it easier.

At least annually - in preparation for winter layup - the fireside surfaces should be thoroughly cleaned. Fire tube boilers clean best with a flue brush of the correct size; brush all flat surfaces and finish with a

vacuuming. Water tube boilers clean best with a steam lance or a compressed air blower, finished with a vacuuming. And don't forget to vacuum the firebox to remove all particulates.

3.3. Waterside Deposits.

These are a MAJOR cause of boiler failure. Build up of deposits on the water side of a boiler can dramatically reduce heat transfer from the fire to the water. The tubes overheat and ultimately result in tube failure - sometimes with FATAL consequences. Proper boiler water treatment, as well as removal of oil from the feedwater, will go a long way towards reducing these deposits. See Appendices D through G.

Whether you have a firetube or water tube boiler the basics are the same. Drain the boiler and open every hole in the boiler that you can, top, middle, bottom. Visually examine, using an extension mirror and flashlight, all the watersides of the shell, mudring/mud drum(s), tubes, steam drum, etc. If the surfaces are clean, or just lightly scaled, you're fine. If a little rust or crud is evident in the mudring/drum(s), clean it out. If there is a lot of rust or scale consult someone who knows how to remove it. There are products that will chemically remove it, but before using any product talk with the manufacturer's technical representative.

3.4. Hydro Test.

Spring Startup is probably the best time to perform this ANNUAL TEST - although you may want to do it in the autumn and correct any problems over those lazy winter months. The boiler should be clean and the casing removed so that all areas may be readily inspected for leaks. If another steamboater is available, have him/her witness the test.

There has been much discussion as to what constitutes a proper hydro test. To correct any misconceptions:

- The ASME Code for hydrostatic testing applies **ONLY** to new construction (see Appendix B);

- The NBIC (National Boiler Inspection Code) applies to repairs and periodic testing (see Appendix C).

If your boiler is a code boiler (i.e., it has the ASME "S" stamp) then it should be tested in accordance with Appendix C.

If your boiler does not carry the ASME "S" stamp there is no "official" testing policy. However, certain procedures should be observed:

- Keep water temperature between 60ºF (15.6ºC) and 120ºF (49ºC);
- Do not test in excess of 1-1/2 times MAWP (Maximum Allowable Working Pressure) and maintain this pressure for 10 minutes;
- Drop the pressure to 90% of MAWP for close inspection.

Remove the safety valve from the boiler to prevent the possibility of the safety being damaged by hydraulic lifting during the test. Leave the hole/pipe unplugged until the boiler is filled to this level. Close all boiler stop valves INCLUDING the water level gauge glass valves, but not the feedwater supply valve or the boiler pressure gauge valve. Fill the boiler with water - observing the temperature range noted above and adding extra boiler water treatment - to the level of the safety valve; plug/cap the safety valve opening and, using the hand feedwater pump, raise the pressure to the determined amount. Close the water supply valve and wait for a few minutes. The pressure will drop (due to the air dissolved in the water fed to the boiler). Open the water supply valve; pump water to bring the pressure up and close the valve again. Over the next ten minutes the pressure should not drop appreciably. Reduce the pressure to 90% of the MAWP and visually inspect the boiler for any leaks or "weepage". One frequent cause of pressure drop is leaking valves. Examine all the outflow areas of the valves for valve leakage by removing associated piping (that's one reason for those unions noted earlier). Make a note of any problems and correct them.

Drain the boiler to the normal operating level, install the safety valve, build a fire and slowly raise the pressure until the safety "lifts". It should open and close positively. Note the pressure at which it lifted. If this is in excess of the MAWP or if the safety valve is otherwise not working properly have it repaired by an authorized repair facility.

3.5. Winter Layup.

Start your fire and build the pressure to approximately 25psi. This will cause any sediment to become suspended. Shut down the fire and blow

down the boiler, leaving some water. DO NOT completely blow down a hot boiler! After the boiler has cooled, remove any remaining water by using a small newspaper fire.

When laying up the boiler the primary purpose is to remove ALL moisture so that no rust is able to form on the inside surfaces and no acidic corrosion can occur. Pull several plugs or devices off the boiler so that air can circulate through the boiler during layup. A light bulb in a protective cage and inserted into the firebox will aid in keeping the boiler dry during layup season - particularly in our "damp" Pacific NW.

While water left in the piping can encourage rust, the biggest problem comes from water freezing in the pipes during winter layup. If the temperature drops below 30ºF for more than 24 hours, the pipe or fitting may burst! So the safest thing to do is to disconnect the piping (remember those unions?) and blow it dry with compressed air. An alternative is to COMPLETELY fill the boiler, piping and pumps with an antifreeze solution.. The best solution contains alcohol - denatured or methanol - in proportions of 1 gallon alcohol to 1 gallon water. It leaves no residual film in the boiler and, in the event that the boiler has not been thoroughly flushed, will simply evaporate with the water when heated. Automotive antifreeze should be avoided as it contains glycol and/or similar substances and, unless completely flushed, will cause problems similar to oil in the boiler water. See Appendix D.

And don't forget the keel condenser if one is fitted! A small brass pipe plug fitted at the lowest part of the condenser will allow any residual water to be drained.

3.6. Spring Startup.

If an antifreeze solution has been used, THOROUGHLY flush the boiler and any piping which has contained it! If you laid up the boiler dry, ascertain that no "critters" have made it a home during layup. Perform the annual hydro test and safety valve check as noted above. Re-assemble all disconnected piping - and don't forget the keel condenser drain plug if fitted. Gradually bring working pressure on the boiler, noting fittings that need to be tightened to correct leaks. NEVER EVER tighten a fitting with boiler pressure on it! Remove pressure from the boiler, tighten the fitting and test again.

4. STEAM PLANT OPERATION.

As noted earlier, each hobby steamboat is individualistic. The guidelines suggested below are general in nature, but encompass safe operation. Although not necessary to safe operation, the keeping of an "engine room log book" (a spiral notebook will do) can go a long way towards ensuring pleasant, trouble free operation. Every time the boiler is steamed there should be an entry in the log book. Date, duration of time under steam, condition of fire and feedwater, fuel consumed, and any problems should be noted. This will greatly aid future problem solving and help prevent those embarrassing breakdowns.

4.1. Testing ("blowing down") the Boiler Water Level Gauge Glass.

The water level in the boiler is a MOST important thing at ALL times. If a malfunction of the gauge glass is suspected, immediately blow down the gauge glass using the procedure below. If the malfunction continues, immediately shut down the fire and inspect the gauge glass before further steaming is attempted. The glass itself will not last forever. This is particularly true of a tubular gauge glass due to the wear from the action of minute particles of abrasive material present in the boiler as well as the glass being slowly "dissolved" by the hot water, especially with too high pH. Periodically the glass should be replaced or it will burst. ALWAYS carry a spare gauge glass on board.

The following is the suggested procedure to blow down the boiler water level gauge glass:

4.1.1. Close the top and bottom gauge glass valves and open the drain valve.

4.1.2. Open the top valve. Steam should flow freely from the drain. You now know the top valve is not obstructed.

4.1.3. Close the drain valve. This pressurizes the glass. Should it break you will be exposed only to steam instead of the scalding water that would issue if the bottom valve were opened first.

4.1.4. Open the bottom valve. The water should rise rapidly to the correct level. If it rises slowly, the bottom passage may be

partially obstructed. Close the top valve; quickly open and then close the drain valve; open the top valve and observe the rise in water level. If the water level still does not respond properly, the fire should be shut down, pressure removed from the boiler, and the offending valve(s) examined/removed. The boiler should NOT be fired again until the deficiencies are corrected.

4.1.5. If try cocks are fitted to the boiler these should next be tested. When the water level gauge is operating correctly it is much easier to judge if it is water or steam that is escaping when a try cock is opened, making it easier to interpret discharge at a later date. SLIGHTLY open each try cock and observe the discharge. If the cock is opened too much, pressure drop in the surrounding area inside the boiler may cause the water directly below to "lift", giving a false reading.

4.2. Start Up.

The following steps will vary from steamboat to steamboat (we're individualistic, remember). Some may not be required and the sequence may change depending on whether the boat is in the water or on a trailer. The MOST important step is to verify that the water level gauge glass on the boiler is working and that the water level is correct.

4.2.1. Make sure the reserve water tank(s) are full. Take on fuel (if solid) or fill fuel oil tank(s). Do not fill tank(s) to capacity as overflows, or spillage when trailering, may result. Keep the load balanced. NEVER overfill propane tanks (80% is correct).

4.2.2. Remove the cover from stack!

4.2.3 Check the log book for any previous problems.

4.2.4. Move all valves to the start position.

4.2.5. Fill the hotwell to operating level.

4.2.6. Briefly open and close the drain valve of the water level gauge glass. Verify that water level in the boiler is at the proper

level - usually 1/3 to 1/2 way up the glass. If the water level is low, fill the boiler to the proper level using the hand pump.

4.2.7. Fill all engine oilers and fill the hand oiler.

4.2.8. Oil all engine components with the hand oiler.

4.2.9. Move the engine reversing lever to mid-position.

4.2.10. Open the cylinder drain valves and turn the engine over by hand - using a "barring lever" for larger engines - to verify it is free and the propeller is not fouled.

4.2.11. Light fire, increasing slowly so boiler is heated evenly.

4.2.12. When pressure first shows on the steam pressure gauge, open the whistle valve and whistle drain valve to expel any air.

4.2.13. When pressure reaches 30 psi, blow down gauge glass.

4.2.14. Once boiler pressure reaches about 50 psi, make sure the cylinder drain valves are FULLY open. Open the oilers on the engine. If cylinder oil is used, pump a stroke. Slowly open the engine steam stop valve on boiler and partially open the throttle valve. Work the reversing lever back and forth to completely expel all condensate from engine (with smaller engines with a flywheel, turn the engine over "by hand" until it runs). When steam begins to issue from the cylinder drain valves, close them until they are open about 25%.

4.2.15. Start turning the engine over slowly with the feedwater valve in the bypass position to remove any air (if a float controlled hotwell is used, the automatic bypass may remove any air). Adjust the feedwater bypass valve to ensure the pump is feeding water to boiler and that the water level shows in the correct position on gauge glass.

4.2.16. Allow the engine to warm thoroughly at the dock. Close the cylinder drain valves.

4.3. Underway.

4.3.1. Watch the water level in the boiler and hotwell - adding water to the hotwell as needed. Adjust the feedwater bypass as needed. If in rough seas, do not overfill the boiler as water may be carried over into the steam line and the engine. If this occurs the engine will "knock". Immediately open the cylinder drain valves to remove the water. If the water level in the boiler drops and you are unable to bring it up to the correct level, IMMEDIATELY shut off the fire until the problem is corrected!

4.3.2. Adjust the fire as needed. Anticipate any maneuvering and lower the boiler pressure accordingly to avoid unnecessary "lifting" of the safety valve.

4.3.3. Periodically top up the oil in the engine oilers. Hand oil as needed.

4.3.4. When reversing underway it is best to slow the engine then move the reversing lever to the reverse position. Quickly moving the reversing lever from ahead to astern with the throttle fully open can cause SERIOUS damage to the engine and/or propeller shaft and should only be done in an EMERGENCY.

4.4. Shutting Down.

4.4.1. Anticipate the distance to the dock and shut off the fire accordingly, keeping in mind a solid fuel fire takes longer to die.

4.4.2. If used, pump a stroke of cylinder oil into the engine.

4.4.3. When stopping the engine and tying up to the dock, move the reversing lever to mid-position and close the throttle valve. Close the engine steam stop valve at the boiler. Open the engine cylinder drain valves. Close the engine oiler valves.

4.4.4. Blow the boiler down for 3 to 4 seconds to remove any scale and sludge deposits. Do this while it is still "hot" (30psi) and any sediment is still in solution.

4.4.5. Make sure all boiler feedwater stop valves are closed. As the boiler cools a partial vacuum will be formed in the boiler and, if the boiler feedwater stop valves are left open, the boiler will suck water from the hotwell until the boiler is full or the hotwell empty.

4.4.6. When the boiler has cooled replace the stack cover! Rainwater or moisture can enter an open stack, collect on the fire side of the boiler tubes/flues, and cause boiler corrosion.

4.4.7. Make entries in the engine room log book indicating any problems. Also note fuel consumption, water use. etc.

4.5. General Do's and Don'ts.

4.5.1. If you must use internal steam cylinder oil, use the correct type, sparingly. Chevron 460 for condensing and 460X for noncondensing engines are recommended.

4.5.2. Oil all external engine bearing surfaces with external reciprocating steam engine oil. Other types of oils do not have the "stickiness" to properly adhere to the surfaces under steam and water conditions. Chevron 150X is suggested for up to 350 rpm.

4.5.3. When opening valves fully, turn the valve handle back about 1/8 of a turn from the fully open position. This will prevent the valve from becoming "locked" in the fully open position as it "heats up".

4.5.4. When "laying up" for long periods:

- Remove the cylinder covers and/or valve chest covers and squirt some WD-40 onto the valve seats/faces and the cylinder walls. Turn the engine over by hand several times to distribute it over these areas. This will prevent "seizing" of the engine by rust.
- Apply external reciprocating steam engine oil to all outside moving/bearing surfaces: rods, eccentrics, crossheads, valve gear, etc. to reduce occurence of rust.

5. FUELS - TYPES, HANDLING & STORAGE.

One BTU is the amount of heat required to raise 1 lb. of water 1 deg. F.

There are four types of fuel in general use on hobby steamboats:

1. Wood;
2. Coal;
3. Liquid;
4. Gaseous.

Selection of a particular fuel is (and has been) dictated by personal choice, availabilty and cost. ALL fuels have the potential to be dangerous if handled incorrectly! An improperly managed wood fire can destroy a steamboat as readily as a leaky propane fitting.

5.1. Wood.

Wood has been the most common fuel in the United States from colonial times onward. Early American railroads, unlike their British cousins, tried charcoal, but soon changed to wood. The very early steamboats also used wood. It is cheap, available in most areas, and easy to handle. Its disadvantages are: content, space and time.

5.1.1. Content.

Content covers several things: moisture, resin and BTUs. BTU content of various woods are: Alder, 6,500; Ash, 6,397; Beech, 6,889; Birch, 6,889; Douglas Fir, 6,445; Elm, 6,389; Hemlock, 6,406; Maple, 6,395; Oak, 6,380; Pine, 6,395. All are expressed per pound of dry wood. But remember, there can be a great difference between woods in volume per pound - for instance, Oak takes up 15% less space per BTU than Douglas Fir.

Wood has to be reasonably dry. Too high a moisture content means that the sap, with its attendant sugar content, will produce poor combustion, lower heat transfer, and deposit a sticky, sooty covering on all fireside surfaces. If this creosote is allowed to collect on the stack and flues, you may end up with a stack fire that could do serious damage to your boat. The other down side

is a coating/plugging of tubes and flues, resulting in poor heat transfer and loss of steam pressure.

5.1.2. Space.

Wood, for a given cubic foot - or pound, has far fewer BTUs than any other fuel. Substantially less space is available for passengers than with any other fuel.

5.1.3. Time.

Although this may not mean much to the hobbyist, it does take more time to haul the amount of wood necessary for "x" hours of steaming down the dock than the equivalent quantity of any other fuel. And, of course, there is the emptying of ash etc.

5.2. Coal.

The first coals discovered were anthracite or "hard" coal, first found in Eastern Pennsylvania. The further east the coal fields, the harder the coal. Far Eastern Pennsylvania anthracite burns with the ease of slate! Unlike our British cousins, who had good Welsh coal (some of the finest steam coal in the world) we were stuck with hard coal until after the Civil War. It required long, narrow fireboxes and limited steam production. Better than wood, but still not the answer.

The discovery of good bituminous or "soft" coal set the industry on its collective ear. The harder kinds, such as Pocahontas (used by many eastern railroads), has good BTU content, low ash, low clinker, low moisture and burns very hot and easily. It requires a wider firebox and is suited to larger grates, combustion areas and higher horsepower.

Its disadvantages are soot and smoke. Smaller fire tubes will plug more quickly with a mix of soot and ash than with hard coal, but not as badly as with wet or resinous wood.

5.2.1. Content.

BTUs vary among the different types of coal. Anthracite coal - if you can get it to burn - has a heat content of 13,300 BTUs per

pound. Colorado Bituminous contains 13,700 BTUs per pound. And Washington's King County is at 9,970 BTUs per pound.

5.2.2. Space.

The ubiquitous "five gallon plastic bucket" of good coal will hold an afternoon's steaming as opposed to several armloads of wood.

5.2.3. Time.

You still have to clean the fire ("trimming" it's called with coal), haul away the ash, and carry in the coal and kindling to start it. Always use a steel bucket to carry your coal so that you have a fire proof container to haul away the ashes.

5.3. Liquid.

Liquid steamboat fuel, for our purposes, falls into three categories:
1. kerosene.
2. #2 fuel oil (diesel, home heat).
3. waste oils/biodiesel.

FLAMMABLE vs. COMBUSTIBLE. In our boats, we should avoid "Flammable Liquids" as opposed to "Combustible Liquids". The difference in the definitions occurs at 100ºF. Anything with a flash point of 100ºF or higher is a Combustible, anything with a flashpoint of 99ºF or lower is Flammable liquid.

Just for discussion, kerosene is a Flammable liquid while #2 and waste oils or biodiesel are Combustible liquids. Combustibles are inherently safer than Flammables.

There are several types of oil burners available or readily buildable (for those so inclined and talented). Many steamboats burning oil use a steam-atomizing burner. Steam atomizing burners have both positive and negative points. Discussions with those who have them will guide one in this choice. Vaporizing burners lend an absolute simplicity but seem to work best over a limited flame size (fuel consumption) and fuel type - generally kerosene. Several members are experimenting with

vaporizing burners that will burn #2 or waste oils/biodiesel. Pot burners either have to use a lighter fuel such as kerosene or require a forced air supply (either electrical or steam) to burn heavier distillates. There are now manufactured 12 volt d.c. pressurized oil burners and several of our members employ these. Turn "on" the switch and there is fire. Turn it "off" and no fire. This type of burner can be controlled manually or, to make it fully automatic, a "pressurestat" may be used.

No.2 fuel oil and waste oils (unless there is a lot of solvent present) or biodiesel are inherently safe. They will NOT burn until they are turned into a vapor. That is the function of the steam atomizer, vapoizer (a "pot burner" is a form of vaporizing burner) or high pressure oil burner nozzle. You can put out a match in a can of #2. If you have a spill or leak in your boat, you have oil in the bilge - not a fire or explosion as with Flammable liquids. It should be noted that the use of "crankcase drainings" may cause the fuel tank(s) to prematurely fail due to the "waste products" mixing with the water (ever present in a marine fuel tank), creating an acid solution which rapidly corrodes the tank.

5.3.1. Content.

One pound of #2 fuel oil contains a theoretical 19,500 BTUs. The equivalent for Pocahontas coal is 14,520 BTUs. Coals available on the West Coast such as Washington State's King County and Grand Ridge District come in at 9,970 BTUs per pound.

5.3.2. Space.

A fuel tank 15 -3/4" x 26" x 13-1/2" will hold 18 gallons or 2.5 million BTUs and will weigh (fuel only) 126 pounds. The equivalent in good Pocahontas will weigh 171 pounds while western coal would weigh 250 pounds.

5.3.3. Time.

No ashes to shovel or haul away. No shovel, chain saw, splitting maul or splitter necessary. But, unless you live next to a marina that sells diesel, you will have to carry - in approved containers - your diesel or waste oil to your boat.

5.4. Gaseous.

So far, propane (LP Gas, Tank Gas, Liquefied Petroleum Gas) is the only practical gas fuel. There are many dealers in all areas; the tanks are readily available; and the 20 and 30 pounders are not too difficult for one person to handle.

At about 91,500 BTUs per gallon, propane is - volume wise - some where between fuel oil and coal. A propane tank can be SAFELY filled to ONLY 80% of its capacity. So the size of the tank is larger than its capacity. In an oil tank, you can fill right up to the vent. A nominal 30 gallon tank of oil will hold close to 30 gallons. A 30 gallon propane tank can ONLY hold 24 gallons. The 20% difference is to take care of expansion and to hold the vapor that the liquid gives off.

A gallon of propane contains 60,000 BTUs less than a gallon of fuel oil. As a gallon of propane weighs 4.2 pounds, it has 21,785 BTUs per pound while Pocahontas coal has 14,690 BTUs per pound.

Propane has several disadvantages - the most dangerous being that it is in vapor form. Propane is heavier than air. In the event of a leak it heads for the bottom of the bilge. If propane bubbles up through water, the "stink" goes away and the definitive smell is no longer present. If it is suspected that there is propane vapor in a boat, an explosion proof fan should be used to remove it. The firing rate of the boiler is strictly dependent upon the size and vaporization area of the fuel supply tank. The greater the firing rate, the larger in size and/or greater in number the fuel tank(s) must be. It is EXTREMELY UNSAFE to heat the tank in which the propane is stored to avoid "icing" the tank - and thereby increase the amount of propane vapor which it will make available. At the very least the pressure relief valve on the tank will lift, releasing propane vapor. And unless there is a proper vent line fitted to discharge overboard this propane will end up in bilge. It is also possible that the tank may rupture and the resultant fire/explosion could be FATAL.

5.4.1. Content.

Less than fuel oil and waste oil, but much more than wood. Better than Eastern coal and much better than Western coal.

5.4.2. Space.

Propane loses some of its space advantage due to the necessity of building gas tight cabinets that MUST be vented - over the side or through the side - so that any gas leak or venting by the tank relief valve does not get into the boat. Propane tanks are built to the Unfired Pressure Vessel section of the ASME Code. As such, they MUST be periodically tested at a service facility.

5.4.3. Time.

No cleaning and/or shoveling of grate and ash pit but, like fuel oil, lugging of empty tanks out and full tanks back (a 20 lb. capacity propane tank, empty or full, will weight approximately the same as a comparable tank of #2 fuel oil). Loss of time having to open cabinet, disconnect tank, lift empty tank out, put full tank in, reconnect and LEAK TEST the connection(s).

6. SAFE STEAMBOAT HANDLING.

Steamboats are eye-catchers! As a result, it is important for us to maintain and operate our steamboats in ways which reflect our care for the boat; for safety standards; and for the classic, traditional reasons. Safety in hobby steamboating is not limited to just design, construction and operation of the steam plant. Safe boat handling is as important - and not just because of our high visibility.

6.1. Rules and Regulations.

For most of us the International Rules, as administered by the US Coast Guard, apply. And where the Inland Rules may apply, they are similar enough in most instances that following the International Rules will not create problems.

Generally speaking, if you follow the "right of way" provisions of automotive safe driving you will be OK, but there are differences! For that reason it is highly recommended that the hobby steamboat operator take a course in safe small boat operation (the State of Oregon will, by 2009, have phased in regulations that require ALL operators of power boats of 10 HP or over to have a "Boater Education Card" which requires, in part, completion of such a course). The US Coast Guard Auxiliary and the US Power Squadron both offer these courses at times and places convenient for most people, and for nominal fees. For schedules contact their local offices, or visit their websites:

US Coast Guard Auxiliary: http://www.cgaux.org/
US Power Squadron: http://www.usps.org/

Whether you take one of the above courses or not, it is suggested that you carry a copy of your state's small craft safety regulations. It is usually in booklet form and lists what safety equipment is required for vessel sizes; indicates what navigation lights are required; shows buoys, markers and their meanings; and illustrates correct passing and meeting procedures. It can usually be obtained at marinas, USCG Auxiliary locations, or directly from state offices - and it's FREE!

6.2. Personal Flotation Devices.

Otherwise known as PFDs or "life jackets". There should ALWAYS be enough that EVERY person aboard has one of PROPER size. While requirements of wear vary from jurisdiction to jurisdiction, it is recommended that ALL passengers should wear them while aboard. Accidents usually happen SUDDENLY and without warning. EIGHTY PERCENT (80%) of boating fatalities result from NOT wearing a PFD! The boat owner/operator may be held liable in resulting legal actions. A Type IV Approved Throwable Device is also REQUIRED.

6.3. Fire Extingusihers and FIRE.

Probably the most important item to have aboard after PFDs is a fire extinguisher - most particularly since our boats contain a FIRE. US Coast Guard regulations REQUIRE that every motorboat (except outboards) under 26 feet in length carry one B-I type USCG approved extinguisher. Keep in mind that the minimum US Coast Guard requirements for fire extinguishers are **barely the absolute minimum!**

6.3.1. Types.

Type A. Combustible solids (wood or coal);
Type B. Flammable liquids;
Type C. Electrical;
Type D. Magnesium

For our purposes an extinguisher that will handle type A & B fires is adequate. Although a dry chemical is generally recommended for most boats, FOAM may be better for hobby steamboating. But, as we are all friendly in this hobby, keep in mind that another boater may need YOUR fire extingusiher.

6.3.2. Size.

Size I. The smallest required. Has about a 9 SECOND capacity. Is it enough - probably NOT!

Size II. May be adequate for our needs. Size III may be too large for many of our boats, so carry TWO Type II to be safe.

6.3.3. Location.

Should be located NEAR any potential source of fire - but not at the potential source - and MOUNTED in an approved bracket.

6.3.4. Boat Fire Fighting Tips.

- Notify someone immediately of your situation and location!
- If you can't fight the fire within TWO minutes, **GET OUT!**
- If you are unsure if you can contain the fire, **GET OUT!**
- ONLY fight the fire if you have the correct extinguisher!
- If applicable, shut off any fuel supply.
- Orient the boat so that the fire is downwind; i.e., if the fire is aft, put the bow into the wind.
- Make sure your exit is to your back.
- Aim at the base of the fire from about 6 feet away.
- If fiberglass is burning, **GET OUT!** Burning fiberglass is very hot and gives off noxious fumes.

The above is not a comprehensive list. **If in doubt, you and any passengers should GO OVERBOARD!** Your boat can be replaced, a human life cannot!

6.3.5. Maintenance.

- Inspect your extinguishers once a month, more often if exposed to weather. Make sure that the nozzle is not choked with debris or spider webs!
- Have the extingusiher checked once a year (winter layup).
- Recharge or replace after each use.
- Never partially discharge a unit to check it.

Not enough can be said about fire saftey afloat. A fire in a confined space will always cause a panic, particularly among passengers. This is a good reason to have EVERYONE aboard wear a PFD at all times.

(Editor's Note: Please don't say: "It can't happen to me - I'm very careful". I remember an instance of a boat owner who was VERY careful about a possible fire aboard. His boat is gone and so is he!)

6.4. Whistle Signals.

It is a rare steamboat that has no whistle. Most have more than one. And while we usually blow them for fun, their PRIMARY purpose is as a safety signalling device. With that in mind, listed below are some of the International Rules, Whistle and Bell Signals (COLREGS 72).

RULE 34. Narrow Channels.

Maneuvers / Warnings:

"Altering course to starboard" __

"Altering course to port" __ __

"Operating Astern" __ __ __

Overtaking:

"I'll overtake you on your starboard side" _____ _____

"I'll overtake you on your port side" _____ _____ __

"I agree" _____ __ _____ __

(5 or more) " Danger" __ __ __ __ __

RULE 35. Sound Signals in Restricted Visibility.

Underway:

Power vessel making way: _____

Power vessel stopped, making no way: _____ _____
Repeated at not more than two minutes.

Sailing vessels, fishing, towing, those constrained, restricted, or not under command: _____ __ __
Repeated at not more than two minutes.

At Anchor:

Ring Bell rapidly for 5 seconds each minute.
May also sound: __ _____ __

Aground:

3 Bell strikes before and after rapid ringing.
May also sound: ___ _____ ___

Here you see the main use of the bell aboard a vessel; to indicate your position when anchored or aground in a fog (with no pressure on the boiler). The longer lines above indicate a “prolonged” blast (4 to 6 seconds) and the shorter lines indicate a “short” blast (1 to 2 seconds).

Note that these signals are used under both International and Inland Rules. Caution should ALWAYS be the byword as many boaters do not understand these signals.

6.5. Lights.

The International Rules, paralleling the Inland Rules, also stipulate that boats under 7 M in length (23 feet) and traveling under 7 knots, need only fulfill a rather simple requirement as to running lights: only an all around white light (360°), with no red/green sidelights, is required. But those gorgeous, brass running lights shouldn't be left on the shelf!

6.6. Auxilliary Power.

Although our steam plants are usually fairly reliable once "settled in", unforseen events do happen. If your boat is open it is a good idea to carry a couple of paddles or oars aboard. No, they're not useful to complete a long journey, but they can get you safely to the dock in marina or other small enclosed area

7. TRAILER SAFETY.

Most of our steamboats sit on trailers much of the year and, while great attention is given to our boats to prepare them for the coming steamboating season, our trailers are often forgotten or neglected. This lack of attention can result in some rather unpleasant surprises (and serious accidents) traveling to a meet with boat and trailer in tow.

As most NWSS members do some steaming in seawater (which is very corrosive), it is almost compulsory to properly maintain your boat trailer. The following check list should help you to trailer, launch and retrieve your steamboat with a minimum of problems.

7.1. Advice for Beginners - and Experienced.

- Call your insurance agent and make sure your auto and/or boat policies cover your **liability** while pulling your boat trailer, as well as covering damage to your car, boat and trailer.
- Make certain your tow vehicle has the horsepower to do the job. If it doesn't have an oil cooling system adequate to keep the transmission from overheating, put one in. Burning-out a transmission or jeopardizing safety is not a good trade-off for a reliable towing vehicle, even if you have to spend a little more.
- Consider the size, weight, and length of your boat and capacity of the trailer when you're shopping for a tow vehicle. And remember - a rear drive vehicle is superior to a front wheel drive vehicle when it comes to getting your boat in and out of a slippery boat ramp. If you have 4 X 4, better yet.
- Check the metal or plastic certification label attached by the trailer manufacturer to the left forward side of your trailer. It may show the maximum load-carrying capacity of the trailer. It is required to show the Gross Vehicle Weight Rating (GVWR), which is the load-carrying capacity PLUS the weight of the trailer itself. Be sure that the total weight of your boat, engine, gear, and trailer do not exceed the GVWR.
- There are good trailor hitches and dangerous ones. A bumper hitch should never be used and is illegal for towing in many states. And make sure that the coupler, hitch and hitch ball are all matched in size.

7.2. Using the Trailer Winch.

High forces are created when using a hand-cranked or electric winch, creating potential safety hazards. NEVER allow children or anyone unfamiliar with the operation of the winch to use it.

- Check for proper operation of the winch on each use. If damaged, don't use it - have it fixed!
- Maintain a firm grip on the winch handle at ALL TIMES! NEVER release the handle when the rachet is in the unlocked position and a load is on the winch. The handle will spin violently, and may cause severe injury.
- Never use the winch handle for pulling or maneuvering the entire trailer.
- Don't exceed the capacity of the winch. Excess loads may cause premature failure and result in serious personal injury.
- Never apply load on the winch with the line fully extended. Keep at least three full turns of line on the winch drum.
- Secure the load properly. After completing the winching operation, don't depend on the winch to support the load.
- Using a winch line or hook that is worn or damaged can result in serious personal injury to you and/or damage to your boat.

7.3. Before You "Hit the Road".

- Keep a fire extinguisher in the tow vehicle or on the winch stem when trailering. Many things can happen to put it to good use: a bearing catching fire, someone throwing a cigarette into or onto your boat when you're stopped for lunch - use your imagination.
- Check structural parts of the trailer for areas of excessive corrosion and for cracks in the welds - and tighten any bolts that may have worked loose.
- Take the time to attach the trailer to the tow properly. Make sure the ball is correctly engaged and locked on the hitch and that the safety chains are the right length and are crossed under the hitch. The chains should be attached with bolts, not "S" hooks as these can S-T-R-E-T-C-H under severe strain.
- Make sure the hitch on the tongue is not seized up - and that the tongue jack is not seized up.

- Make sure the electrical connections to the trailer lights are correct and the trailer lights operate. Carry one set of bulbs or a complete light unit. An extra light may be required at the stern of your boat if it protrudes far beyond the after end of the trailer.
- If the trailer is fitted with brakes, make sure they properly adjusted and working.
- Hook up the wire for the emergency brake.
- Make sure that 5 to 7 percent of the total weight of the tow is on the tongue of the trailer. More, and the tow will handle poorly; less, and the trailer will tend to fishtail.
- Inspect wheel bearings to make sure they are well greased and the bearing protectors ("bearing buddies") are tightly fitted. During road stops, check wheel hubs for excessive warmth. It is advisable to carry a spare wheel bearing.
- Make sure the tires are correctly inflated. Carry a spare tire and a tire jack which will fit properly beneath the lifting points of the trailer. Your car jack may not be suitable.
- Make sure the trailer wheel lug nuts are properly tightened and that you have a lug nut wrench that fits them. Your vehicle lug wrench may not be correct.
- Check that your boat is securely tied down to the trailer with straps and a chain from the bow to the winch post (the winch line is NOT a tie down). Make sure that it cannot slide forward on the trailer.
- If the boat exceeds 8 feet in width, a special towing permit may be required.

7.4. Before Launching.

- When you get to the launch ramp, take your time getting the boat squared away before launching. Those minutes you spend making sure your boat and it's equipment are ready will give your wheels and bearings a chance to cool. If they're hot when you dip them into that cold water, you're taking a risk of seizing the bearings.
- Disconnect the electric cable to the trailer and, if possible, remove the trailer lights and keep them above the water surface. This will save bulbs and reduce corrosion.
- Remove the securing straps and bow chain. Unhook the line from the trailer winch to the boat. Make sure there is a line from the boat to the adjacent shore or dock.

- Always stay in your vehicle while you launch your boat. No driver, no access to the brake pedal - which activates the brakes on all four wheels. The parking or hand brake only sets the rear wheels.
- If possible, wash down the trailer with freshwater after the boat has been launched.

7.5. After hauling out.

- Make sure the trailer lights are working properly.
- Make sure the boat is properly secured to the trailer.
- Check wheel bearings and tongue jack. Re-grease if necessary - seawater is very aggressive.
- Before leaving the launch ramp, open a can of pop and take a leisurely stroll around the trailer and the tow vehicle. Make sure everything is hooked up properly, locked, strapped down, secure, and if your trailer has a spare tire, make sure it's fully inflated.
- If possible, thoroughly wash down the trailer and boat hull with fresh water to remove traces of salt, dirt and weeds. Otherwise do it immediately when arriving home!

APPENDIX A.

[Code of Federal Regulations]
[Title 46, Volume 2]
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[Page 111]

TITLE 46--SHIPPING
CHAPTER I--COAST GUARD, DEPARTMENT OF HOMELAND SECURITY (CONTINUED)

PART 50_GENERAL PROVISIONS--Table of Contents

Subpart 50.05_Application

Sec. 50.05-15 Vessels subject to regulations in this subchapter.

(a) Passenger vessels, tank vessels, cargo and miscellaneous vessels, nautical schoolships, mobile offshore drilling units, and oceanographic vessels are subject to the regulations in this subchapter to the extent prescribed by various laws and regulations as described in Sec. 50.01-1. The applicable provisions in this subchapter shall apply to all such U.S. flag vessels, and to all such foreign vessels which carry passengers from any port in the United States except as follows:

...

(3) Any vessel operating exclusively on inland waters which are not navigable waters of the United States.

...

[CGFR 68-82, 33 FR 18808, Dec. 18, 1968, as amended by CGD 73-251, 43 FR 56799, Dec. 4, 1978; CGD 80-161, 48 FR 15472, Apr. 11, l983; CGD 90-008, 55 FR 30660, July 26, 1990; CGD 95-012, 60 FR 48049, Sept. 18, 1995]

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TITLE 46--SHIPPING

CHAPTER I--COAST GUARD, DEPARTMENT OF HOMELAND SECURITY (CONTINUED)

PART 50_GENERAL PROVISIONS--Table of Contents

Subpart 50.05_Application

Sec. 50.05-20 Steam-propelled motorboats.

(a) The requirements covering design of the propelling engine, boiler, and the auxiliary machinery, and the inspection thereof on all motor boats which are more than 40 feet in length and which are propelled by machinery driven by steam shall be in accordance with the applicable provisions of this subchapter.

(b) If the engines, boilers, and auxiliary machinery are found to be in safe operating condition at the initial or subsequent periodical inspection, the

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Officer in Charge, Marine Inspection, shall issue a letter to that effect. Such letter shall be posted on the vessel under glass. The letter will be valid for a specified period of time, as determined by the Officer in Charge, Marine Inspection. The owner, within 30 days prior to its expiration, shall make application to the nearest Officer in Charge, Marine Inspection for a renewal thereof.

Editor's Note. By their ommission, there are no provisions for the design and inspection of steam-propelled motorboats 40 feet and under in length.

APPENDIX B.

Note: The ASME test procedure cited below is for new construction only. The NBIC (National Board Inspection Code) is used for testing repairs (Part RC) and for periodic testing (Part RB). See Appendix C.

ASME 2001 Edition, Section I, 2003 Addenda

PG-99 HYDROSTATIC TEST (amended in 2003 Addenda)

Hydrostatic testing of the completed boiler unit shall be conducted in accordance with the following requirements:

After a boiler has been completed (see PG-104), it shall be subjected to pressure tests using water at no less than ambient temperature, but in no case less than 70ºF (21ºC). Where required, test pressures are specified in this paragraph; whether minimum or maximum pressures, they apply to the highest point of the boiler system. At no time during the hydrostatic test shall any part of the boiler be subjected to a general primary membrane stress greater than 90% of its yield strength (0.2% offset) at test temperature...

PG-99.1 Hydrostatic pressure tests shall be applied by raising the pressure gradually to 1-1/2 times the maximum allowable working pressure as shown on the data report to be stamped on the boiler. The pressure shall be under proper control at all times so that the required test pressure is never exceeded by more than 6%. Close visual inspection for leakage is not required during this stage.

PG-99.2 The hydrostatic test pressure may then be reduced to the maximum allowable working pressure, as shown on the Data Report, to be stamped on the boiler and maintained at this pressure while the boiler is carefully examined. The metal temperature shall not exceed 120ºF (49ºC) during the close examination...

APPENDIX C.

Part RB -- Inservice Inspection of Pressure Retaining Items

RB-3210 PRESSURE TESTING

During an inspection of a pressure-retaining item, there may be certain instances where inservice conditions have adversely afftected the tightness of the component or the inspection discloses unusual, hard to evaluate forms of deterioration that may affect the safety of the vessel. In these specific instances, a pressure test using air, water, or other suitable test medium should be discussed with the owner-user.

The Inspector is cautioned that a pressure test will not provide any indication of the amount of remaining service life, or the future reliability of a pressure retaining item. The pressure test in this instance only serves to determine if the pressure-retaining item contains defects which will not allow the item to retain pressure. In certain instances, pressure tests of inservice components may reduce the remaining service life of the component due to causing permanent deformation of the item. *(Editor's Note. Underlining is mine)*

a. The test pressure should not exceed 90 % of the set pressure of the lowest setting pressure relief device on the component to avoid damage to the pressure relief devices.

b. Test pressure should be selected or adjusted in agreement between the Inspector and the owner-user. When the original test pressure includes consideration of corrosion allowance, the test pressure may be further adjusted based upon the remaining corrosion allowance.

c. The metal temperature during a pressure test should not be less than 60ºF (16ºC) unless the owner-user provides information on the toughness characteristics of the vessel material to indicate the acceptability of a lower test temperature.

d. The metal temperature shall not be more than 120ºF (50ºC) unless the owner-user specifies the requirement for a higher test temperature...

Part RC -- Repairs and Alterations of Pressure Retaining Items

RC-2051 METHODS

Based on the nature and scope of the repair activity, one or a combination of the following examination and test methods shall be applied to repairs and replacement parts used in repairs.

a. Liquid Pressure Test
Pressure testing of repairs shall meet the following requirements:

1. Pressure tests shall be conducted using water or other liquid medium. The test pressure shall be the minimum required to verify the leak tightness integrity of the repair, but no more than 150% of the maximum allowable working pressure (MAWP) stamped on the pressure retaining items, as adjusted for temperature. When original test pressure included consideration of a corrosion allowance, the test pressure may be further adjusted based on the remaining corrosion allowance.

2. During a pressure test, where the test pressure will exceed 90% of the set pressure of the pressure relief device, the device shall be removed whenever possible. If not possible, a test gag may be used following the valve manufacturer's instructions and recommendations. Extreme caution should be employed to ensure only enough force is applied to contain pressure. Excessive mechanical force applied to a test gag may result in damage to the seat and / or spindle and may interfer with the proper operation of the valve. The test gag shall be removed following the test.

3. The metal temperature for the pressure test shall be in accordance with the original code of construction, but not less than 60ºF (15.6ºC) unless the owner provides information on the toughness characteristics of the material to indicate the acceptability of a lower test temperature. During close examination the metal temperature shall not exceed 120ºF (49ºC) unless the owner specified requirements for a higher test temperature and it is acceptable to the Inspector.

4. Hold-time for the pressure test shall be a minimum of 10 minutes prior to the examination by the Inspector. Where the test pressure exceeds the MAWP of the item, the test pressure shall be reduced to the MAWP for close examination by the Inspector. Hold-time for close examination shall be as necessary for the Inspector to conduct the examination.

Editor's Note. The National Board of Boiler and Pressure Vessel Inspectors suggests that the above method would be appropriate for testing "non-code" boilers such as those used in our hobby.

APPENDIX D.

Oil in Boiler Water.

Beware of oil in the marine steam boiler feed water system! As we all should know, a small quantity of oil introduced with the feedwater into a boiler can cause serious problems and possible boiler failure. What many may not know is how very small a quantity of oil it requires to achieve this dangerous situation.

The US Navy has determined that 1ppm of oil in the boiler water is the MAXIMUM allowable amount. Some would say that this is due to Navy boilers being fired harder than normal marine boilers. While this is true on full size marine boilers, our little boilers are frequently forced almost as hard. If one uses 100# of steam per hour and gives a stroke of cylinder oil every 4 hours (a good average) then - if there is no filtering - 2ppm of oil per hour will be introduced into the boiler water. As the oil does not evaporate and get carried over with the steam, in 8 hours of steaming 16ppm of oil will be in the boiler water. This approaches the MAXIMUM recommended amount for normal marine boilers

When oil is introduced into a boiler it first floats on the surface of the water, increasing surface tension and causing foaming. When normal boiler water alkalinity is maintained any animal fats will saponify, forming soap and causing more foaming. The oil floating on the surface eventually picks up enough solids from the boiler water to cause the oil to form globules and sink. The oil globules follow the natural water circulation, picking up more solids as they go, and when they can no longer hold any more solids they settle on the heating surfaces. There the heat quickly decomposes the animal fats, liberates any gases, and causes the oil and solids to form a foamy mass which insulates the heating surfaces. It won't be very long before parts of the boiler metal will fail to conduct heat; will deteriorate due to overheating (and you'll never see it because it's INSIDE the boiler) and the boiler will fail.

An oily ring inside the water gauge glass at the water level is a serious warning!

If you use cylinder oil in your engine, you'd better have good and clean filters in your hotwell AND use the cylinder oil sparingly!

APPENDIX E.

Minerals and Organic Subtstances in Boiler Water.

The mineral and organic substances present in natural water supplies vary greatly in their relative proportions, but are principally comprised of carbonates, sulphates, and chlorides of lime, magnesia and sodium, iron and aluminum salts, silicates, mineral and organic acids, and the gases oxygen and carbon dioxide.

Scale is formed from the carbonates and sulphates of lime and magnesia, and from the oxides of iron, aluminum and silicon and it will result in:

- Reduction in the boiler's efficiency because of the decreased rate of heat transfer;
- Overheating and burning of tubes resulting in tube failure.

A very thin layer of scale can cause tube failure due to overheating. Scale has about 2% of the heat conductivity of steel. A scale thickness of about 1 mm (0.04") can be sufficient to reduce the heat transfer to a danger point. When the water inside (or surrounding) the tube cannot receive and carry away the heat fast enough from the tube metal to keep its temperature below its fusion temperature, the tube will "burn out" and boiler failure WILL result.

APPENDIX F.

Heating Feedwater.

Feedwater heating has a number of advantages:

Using a feedwater heater BEFORE returning the condensate to the hotwell is the most effective, the cheapest and the most convenient system of de-aeration. The removal of oxygen and carbon dixoide from the feedwater will extend the life of the boiler. However, if the water in the hotwell becomes too "hot", the feedwater pump may not function properly due to the pump suction causing the water to "flash" to steam. A temperature of somewhat less than 160ºF is desireable.

Use of an additional feedwater heater AFTER the feedwater pump is also desireable. This may be done by either using exhaust steam or locating the heater in the path of the exhaust gases (it is then called an economiser), making sure that the flow of gases is not "choked". An economiser in the smokestack will scavange otherewise lost heat - exhaust gases usually run about 500ºF - and may raise the temperature an additional 100ºF. It is suggested that stainless steel tubing be used. It should be noted that heating by means of an economiser will NOT de-aerate the feedwater as the air has no place to go except into the boiler.

Heating feed water by means of exhaust steam effects a saving of about 1% of fuel for each 10.8ºF rise in the temperature of the feed water. Consequently, heating the water from 52°F to 160ºF saves about 10% fuel. And if you use the exhaust gases in the stack to heat the feedwater going directly to the boiler to 250ºF, then you have saved an additional 8% - for a total of 18%! Besides the fuel saving, heating the feed water increases the actual steaming capacity of the boiler.

Some other valuable advantages:

- Smaller temperature difference at the feed water inlet to the boiler reduces thermal stresses in the boiler material;
- Higher feed water temperature reduces the expansion and contraction of the water in the steam drum and simplifies water level control.

APPENDIX G.

Boiler Feedwater Treatment.

Boiler feedwater treatment fights on three fronts: against the deposit of scale on boiler surfaces; against the harmful concentration of dissolved solids; and against corrosion of the water side of the boiler. Boiler feedwater treatment can be purchased from chemical supply houses and some live steam hobby firms.

D.1. Scale.

There are two types of scale: "temporary hardness" (carbonate) and "permanent hardness" (calcium sulfate and silica). The scale forming potential is equivalent to the "hardness" of the water

D.1.1. Temporary hardness scale can easily be controlled by simple feedwater treatment and maintaining correct boiler water alkalinity. **Boiler water alkalinity should have a pH from 10.5 to 11.5**. This can be checked by using litmus paper strips purchased from any scientific or chemical supply house. Chemical feedwater treatment will cause the carbonate to precipitate out of the feedwater as a loose sludge. The water in your gauge glass should appear cloudy. If it is crystal clear you may not be properly controlling carbonate scale.

D.1.2. Permanent hardness scale is of two kinds: calcium sulfate and silica. Calcium sulfate is handled in the feedwater treatment with sodium phosphate and will produce a loose sludge. Silica is the most dangerous as it produces a "glasslike" scale which can only be removed with a hammer. Maintaining correct alkalinity of the boiler water will cause most of the silica to settle out as a loose sludge.

D.2. Dissolved Solids.

The total amount of suspended and dissolved solids in the boiler water must be limited to prevent foaming and priming. This is easily accomplished by blowing down the boiler and adding fresh water. The

main thing is to blow the boiler down regularly enough to prevent foaming and a buildup of sludge.

D.3. Corrosion.

There are two types of waterside corrosion: oxygen pitting and sheet corrosion. Oxygen pitting is one of the biggest causes of boiler failure!

D.3.1. Oxygen pitting is caused by free oxygen in the feedwater and results in lumps or carbuncles of rust like material. This causes pitting and degradation of the interior surface of the boiler, reulting in boiler failure. Heating the feedwater in the hotwell to 160ºF will drive off most of the free oxygen and adding an ounce or two of sodium SULFITE will cause the remaining oxygen to turn to sodium sulfate.

D.3.2. Sheet corrosion is a wasting of boiler metal over a large area. This is caused by the entrained carbon dioxide being dissolved and turning into carbonic acid. By maintaining the pH of the boiler water at 10.5 to 11.5 acids will not be able to form.

D.4. Oil.

As noted earlier, even a small amount of oil present in feedwater can cause serious problems in a boiler. There are no effective internal methods of treating oil. Therefore, the best way to eliminate oil from a boiler is to prevent it from entering. This can be accomplished by not using cylinder oil - or at least no more than is ABSOLUTELY necessary - and installing filter materials in the hotwell; changing or cleaning them FREQUENTLY.

Many methods of removing cylinder oil from feedwater are used, including oil absorbent bilge towels, human hair, loofah sponges, and "soda straws". Much depends on the size and configuration of the hotwell. And some steamboaters have installed an in-line filter between the condensate pump and the hotwell. Ask other steamboaters what they use - and don't settle for just one opinion.

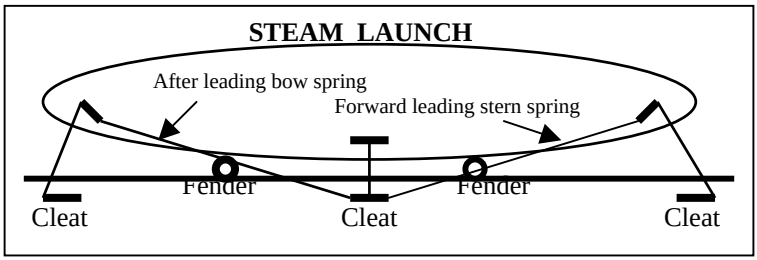
APPENDIX H.

Smart Docking, or "Spring Line Magic".

Handling a small vessel as it approaches a dock is often a frustrating experience, especially when dock space is limited or the available spot is little longer than the boat. How can you easily maneuver your craft in such situations - and how do you get out again when you wish to leave?

One solution which is easy to learn, can be quickly taught to any crew member and often looks like “magic” to onlookers (you know, the ones at NWSS meets) is the use of spring lines!

A spring line is a dock line arranged at a "steep" angle to the centerline of the vessel rather than nearly perpendicular (as most dock lines are rigged). A spring line can be rigged in such a way as to allow the vessel to swing toward or away from the side of a dock; either bow first or stern first; either arriving or departing; and it requires open dock space only slightly longer than the vessel to perform these feats of "magic".



Here's some terminology to help you. A line from the bow which leads aft is called an “after leading bow spring”. A line from the stern which leads forward is called a “forward leading stern spring”. These lines should be made-up quite a bit longer than the ones you use as breast lines. Some boaters like the spring lines to be almost as long as the boat. The after leading bow spring allows you to approach a dock and slip into a space only slightly longer than the boat.

To accomplish this place a plump fender a few feet aft of the bow of the boat. Toss the after leading bow spring to someone on the dock and ask them to fasten it to the dock well aft of the center of the boat. Then - with the engine running slowly forward and a bit of right rudder -

your boat will be stopped by the spring line; will rotate on the fender against the dock; and the stern will be brought nicely to the dock. The stern and bow breast lines may then be placed. This works for either side of the boat but should be done gently as the spring line will stretch if too much power is used and, like a rubber band, the return bounce will amaze you.

The reverse tactic can be used with a forward leading spring line. You are tied to a dock port side to and you wish to put out for a steam. Your passengers are aboard; steam is up and the engine is oiled and ready.

Set a fender a few feet forward of the after end of the boat. Secure a forward leading stern spring line to the dock well forward of the center of the boat. Cast off all other lines and gently put turns on the engine in reverse. Without moving forward on the dock, the bow of your boat will swing out away from the dock. Close the throttle; ask someone on the dock to toss you your now slackened spring line; and steam away. With a little practice - and noting the best position for the fenders - you'll be maneuvering with "spring line magic"! One caution about using spring lines - BE CAREFUL - they can easily foul your propeller if they fall in the water while maneuvering.

Most of us run our engine while tied to the dock, in part to amaze the dockside loungers but more importantly to get the engine warmed and ready. With spring lines rigged both fore and aft your launch will stay steady beside the dock - whether the engine is running forward or reverse. Such lines can be rigged in either of two ways. The lines can be fastened to a single cleat on the dock, near the center of the boat (as shown on the previous page), or rigged - as a single line - from the two dock cleats near the bow and stern with an eye made fast to a single cleat near the center of the boat. In a slip you use frequently this can be very handy, and you only need to cast off one line at the center of the boat. The long spring line stays on the dock ready for your return.

Steamboats are often operated on rivers, or in salt water areas where tidal currents may be encountered. Especially at dockside the flow of water can provide interesting examples of how the rudder - working with spring lines - can shift the boat close to or away from the dock, even without effort from the engine. Just as an airplane pilot wants to know the wind direction while preparing to take off or land, so the boat

handler should look closely for signs of moving current as the dock is approached.

Hobby steamboats are frequently stored ashore on trailers. Therefore, whenever you are afloat, you should take every opportunity to practice various maneuvers. Try landing port side and starboard side to; run through the Spring Line Magic stuff; learn the best positions for fenders in a number of situations; even get practice in towing another vessel. You should become competent in handling situations where there is a current. Use your steamboat in safety, with enjoyment and careful stewardship.

APPENDIX I.

Conversions - US / Metric

HEAT	
1 BTU (Britsh Thermal Unit)	0.25 KILO CALORIE
1 KILO CALORIE	4.00 BTU
WORK	
1 HP (Horsepower)	0.75 KW (Kilowatts)
1 KW	1.34 HP
PRESSURE	
1 PSI	0.068 BAR
1 BAR	14.504 PSI
WEIGHT	
1 LB. (Pound)	0.4536 KG (Kilograms)
1 KG	2.2046 LBS.
1 SHORT TON	2000 LBS. or 907 KG
1 METRIC TON	2195 LBS.
LIQUID	
1 US GAL. (Gallon)	3.78 LITER
1 LITER	0.264 US GAL.
1 BARREL	42 US GAL. or 159 LITERS
AREA	
1 SQUARE FOOT	0.093 SQUARE METERS
1 SQUARE METER	10.76 SQUARE FEET
VOLUME	
1 CUBIC FOOT	0.0283 CUBIC METERS
1 CUBIC METER	35.315 CUBIC FEET
LENGTH	
1 INCH	0.0254 METERS
1 FOOT	0.3048 METERS
1 METER	3.281 FEET
1 FATHOM	6 FEET or 1.83 METERS
1 ST.M. (Statuate Mile)	1.6093 KM (kilometers)
1 KILOMETER	0.6214 ST.M.
1 NAUTICAL MILE	1.15 ST.M. or 1.85 KM
TEMPERATURE	
Farenheit to Centigrade	(F - 32) x 5/9 = C
Centigrade to Farenheit	(C x 9/5) + 32 = F

N O T E S