Centurion Society of Model Engineers

Boiler Handbook

A guide to building your boiler to satisfy the Boiler code

BOILER HANDBOOK (To be read in conjunction with the Boiler Code)

Everyone contemplating the construction of a model boiler to be operated on the premises of the above Society should be familiar with the contents of the BOILER CODE and this HANDBOOK. In general, the Code deals with those items which the Society regards as non-negotiable and this handbook deals with those that are desirable, and in addition endeavours to provide further help to builders. The overall objective of both documents is to ensure, as far as possible that;

1. The boilers are safe to operate - (remember, in addition to concerns about public safety, you will be sitting close to it).
2. The standard of safety is maintained throughout the life of the boiler.
3. You have proof that the boiler is safe to operate.
4. Boilers covered are detailed in the Code.

THE INSPECTORS.

The boiler inspectors are appointed by the Committee and are considered by them to be competent to do the job. They will consult with each other where necessary. In the case of a boiler being rejected by an inspector, the aggrieved person may approach the Committee who will appoint one or more persons other than the inspectors to adjudicate. Their decision will be final.
IT IS MOST IMPORTANT THAT THE YOU CONSULT WITH THE SOCIETY'S INSPECTOR(S) BEFORE COMMENCING A NEW BOILER. It can only be your own fault if the boiler is rejected due to something which could have been corrected by a chat with the inspector at an early stage - he is not there to catch you out, but to ensure you have a boiler which meets the Society's requirements.

DESIGN CONSIDERATIONS.

Published designs for boilers by well-known and reputable model engineers or designers, and designs by persons accustomed to pressure vessel/boiler design are acceptable. Design to be discussed with at least one inspector before work commences.
Where no published design is available or the builder is converting from copper boiler design to a steel boiler design, or building from scratch, or without drawings, the project

must be discussed with at least one of the Society's inspectors and preferably two, before construction commences. This may save later and more difficult and/or expensive modifications. You may be asked to produce drawings and or calculations to verify that the strength is adequate.

CONSTRUCTION

The design drawings would normally indicate the method of construction. If you wish to deviate from the drawing, or are unsure of the procedure, you are advised to consult with the Society's boiler inspector(s). The materials of construction, joining materials, etc., are to be stated on the boiler test certificate.
You are advised to ensure that the inspector(s) see all the parts to be joined and that you discuss with them the method and materials to be used. During construction, you should arrange for the inspector(s) to visually examine those joints which cannot be seen after completion of the boiler.

STEEL BOILERS

Types of welds to be discussed with at least one inspector before commencing. Parts to be passed by boiler inspector after preparation, before welding. It is recommended that all joints are chamfered at 45 degree angle to a total depth of 40% of the material thickness for welds on both sides, and 80% of the thickness
for welds on one side only.
The Inspector needs to know competency of welder. You are to supply inspector with the necessary information re welder's experience, record, etc., and the inspector may, at his discretion check the information and/or call for samples which you must obtain.
Fire tubes, of thick walled copper to be expanded in and to be left protruding from the tube plates a distance of one and a half times wall thickness for beading over at the firebox end.
The barrel, of seamless hot finished tubing, or rolled and welded plate, should have a wall thickness of adequate strength to suit the design pressure, plus a factor of safety and the usual allowances for corrosion. You may be called upon to produce calculations. In a traction engine, attention must be paid to the fact that the boiler is also a structural member.
Recommendations for fire tubes of solid (hard?) drawn copper, minimum wall thicknesses are, 18g up to 5/8" (16mm) o/d and 16g over 5/8" o/d.
It is recommended that a fusible plug is fitted in the boiler crown.

COPPER BOILERS

Copper sheet or tube of acceptable quality should have a minimum wall thickness of not less than 3 mm. This is not "written in stone" and may be dependent on the size of the boiler. Discuss with the inspector.

For fire tubes of solid drawn copper, minimum wall thicknesses recommended are, 18g up to 5/8" (l6mm) old and 16g over 5/8" old.
It is recommended that a fusible plug is fitted in the firebox crown.
Suitable and adequate precautions must be taken to ensure that the firebox crown will not distort under pressure.
It is recommended that the boiler be pickled after each stage of the soldering process and you are advised, particularly if the boiler is your first, to practice absolute cleanliness, have an abundance of heat and good fits between components to be silver soldered.

The following is a reference list of some of the formulae available in published works from the PMES library intended to help designers. It is not an exhaustive list.

C2 Greenly's Model Steam Locomotives-Design and spec Greenly 1952
C4 Boiler Construction N. Foley 1889
C5 Manual of Model Stream Locomotive Construction Evans 1972
C19 Model Locomotive boilers Evans 1973
C20 Model Boilers and Boiler Making Harris 1974
C29 Steam Engines and Boilers Molloy

BOILER FITTINGS

Mountings for fittings on a copper boiler and fittings in contact with steam should be in phosphor bronze. If brass is used, de-zincification of the material can occur with subsequent possible failure.
All screw operated valves will be checked to ensure that the spindles cannot be screwed out whilst under pressure.
Pressure gauges to have the working pressure marked with a thin red line, preferably on the inside of the glass.

INSPECTION PROCEDURE

When you present your new boiler for inspection and testing, the Inspector will be looking for the following (amongst other things):

Copper boilers.

During the heating process threads in bushings may be scorched/burnt. Suggest you drill the bushes tapping size and put in starter threads for final threading after completion of the hot work.

Firebox crowns must be adequately stayed and full penetration of silver solder is necessary, otherwise the crown may bulge under test pressure, possibly resulting in rejection.
Full penetration of silver solder in all joints will be checked. Mountings for water gauges should be parallel to each other so that no undue pressure is placed on the glass during assembly.

Steel Boilers.

If checks have been made by the inspectors during construction, the inspectors will probably make a visual inspection and run the test procedure under the code.
Re-test of steel boilers.
The inspector will conduct inspection tests for corrosion as carefully as he can. If no access has been provided for interior examination he may call for holes to be appropriately drilled to check thickness of plates. He will look for leaks at joints and stays.
Traction engine boilers will be examined for stress cracks particularly between the smoke box and the boiler barrel joint with the outer firebox. The inspector may call for cladding to be removed to facilitate inspection at his discretion.
The fusible plug will be examined and the inspector may call for its replacement if any fault can impede its operation e.g., scale.
Boilers which have been passed and certificated early in the construction of a model and not used before the valid period runs out shall be put into service and the period of validity recommenced after consultation with the inspector, although the latter may call for a test at the re-test pressure at his option.
The safe operation of any boiler depends a lot on constant care and vigilance by the owner and particularly in the case of steel boilers, correct procedures in the treatment of the water and the boiler to minimize corrosion.
We intend to produce an addition to this handbook on boiler care and treatment.

MAY YOU ENJOY MANY YEARS OF HAPPY AND SAFE STEAMING!

April 2006

BOILER CODE

PREAMBLE

Model boilers in South Africa do not come under the Government Health and Safety Act if they comply with the requirement where the volume in litres times the pressure in bar is less than 150.

At a meeting in Centurion in 2005, of the Chairmen of most of the societies, it was resolved that a boiler code should be developed and at the same time the above formula altered to allow for bigger boilers, for discussion with government representatives. The responsibility to put the resolution into effect was placed with the Chairman of the CSME.

It will inevitably be sometime before the above becomes a reality, but it is incumbent upon individual societies for reasons which have been well documented, to put forward its own controls over boiler construction and testing, which is why this document has been put together.

MINIATURE BOILER CODE

a. This code puts together those items in the building and testing of a boiler which the Society regards as non-negotiable. In conjunction with this code, a handbook has been prepared which covers items which the Society regards as desirable and also contains useful tips for Inspectors and builders. It should be read at the planning stage.
b. All boilers operated on the Society's track site must have a boiler certificate - those outside the Occupational Health and Safety Act to have a certificate issued by the PMES appointed inspectors or by any other recognized model engineering society.
c. Those falling under the Act to have an official boiler test certificate or an exemption certificate issued by the Health and Safety Authority, or issued by a recognized insuring authority. A copy of certificates not issued by the PMES should be taken.

1. **Boilers covered by this document.**
   a. Boilers complying with the following formula: The product of design pressure in bars and the volume in litres is less than 150, where the figure exceeds 150, the boiler comes under the Occupational Health and Safety Act 1993 (Act 85 of 1993) and will

not be certified by the Society's inspectors. The 'design pressure' is the maximum allowable steam pressure at which the boiler is designed to operate. The 'working pressure' is the pressure to which the boiler is certificated by the inspector. Working pressure must not exceed the design pressure.

b. Boilers constructed from low carbon steel hot rolled plate, boiler plate and/or seamless tubes with steel or copper fire tubes.
c. Boilers constructed from copper sheet and/or seamless tubes with copper fire tubes.
d. Stainless steel boilers will not be accepted.
e. Maximum design or working pressure covered by this code is 120 p.s.i (830 kpa). Higher pressures to be the subject of discussion with the Society's inspectors.

2. **Designs**
   a. The Society's inspectors do not take responsibility for the successful performance of a boiler to any design, but simply to ensure that the design and manufacture produces a boiler which conforms to the code.
   b. See Boiler Handbook for further comments on design.

3. **Manufacture**
   a. Copper Boilers
      i. No person involved in the inspection and testing of a boiler shall take part in the construction of it except for giving advice.
      ii. Any joints which, in the opinion of the inspector, are defective shall be remade.
      iii. See the Handbook for further notes on construction.
   b. Steel Boilers
      i. No person involved in the inspection and testing of a boiler shall weld, or prepare for welding that boiler.
      ii. Any welding which in the opinion of the inspector is defective, shall be ground out to the satisfaction of the inspector before re-welding.
      iii. See the Handbook for further notes on construction.

BOILER TESTING - STANDARD PROCEDURE

1. All boilers to be operated under steam on the Society's premises must have a boiler test certificate issued by a Model Engineering Society or other recognized body.
2. The owner SHALL determine the volume of the boiler to establish whether it falls within the Occupational Health and Safety Act 1993. If so, a Letter of Exemption and/or a test certificate SHALL be obtained from the appropriate authority and no test will be carried out by the Society's inspector(s). A boiler test certificate issued by a professional body

as recognized by the Society's inspectors will exempt the boiler from any examination/testing by the Society's inspector(s).

3. A boiler examination/test SHALL be carried out by one or more of the Society's approved inspectors and a witness, none of whom shall be the designer, builder or the owner of the boiler.
4. The designer and/or the builder SHALL satisfy the inspector that the design, materials, construction, and jointing materials and methods are suitable for a safe boiler.
5. Reference SHALL be made to the designer/builder to establish the working pressure and consequently the initial and re-test hydraulic pressure which SHALL be entered on the test certificate.
6. When the boiler is presented for the initial examination/testing, all the apertures shall be blanked off and a test connection supplied to suit the Society's pressure testing equipment.
7. **Initial test**
    a. The boiler, out of the frames and unclad shall be closely examined by the inspector prior to the hydraulic test.
    b. The initial hydraulic test shall be twice the working pressure.
    c. The initial test pressure shall be applied slowly and steadily with pauses for examination being made as the pressure increases above working pressure.
    d. On reaching test pressure an examination shall be made for signs of distortion, leakage, or evidence of joint failures.
    e. On successful completion of the INITIAL test, the boiler shall be stamped by the Society's inspector(s) with the test and working pressures in PSI (pounds per square inch) or kPa (kilopascals), the boiler test number and the date, in a position where it can be easily seen.
    f. The original boiler certificate, recording all the relevant details completed by the owner, and signed by the Society's inspector(s) and the witness, shall be handed to the owner and a copy filed in the Society's Register of Boiler Tests.
    g. All boiler certificates will be issued on the understanding that the owner will practice good boiler management.
8. **Re-Test**
    a. Copper Boilers
        i. No further testing in the life of a copper boiler will be required UNLESS there have been any repairs or replacement of any of the bushes, or any alterations.
    b. Steel Boilers
        i. Subject to a ten year re-test period UNLESS there has been any repairs or replacements during the ten years.

ii. All re-testing shall be to one and a half times the working pressure, and the boiler re-certificated.

9. The Society cannot be held responsible for the failure of any boiler during the above tests, or for any other reason.

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