Steam Locomotive 3801

Inner Firebox Assessment Report
Carried out at Maitland, December 15th 2006

Assessed by Puffing Billy Railway Rolling Stock Branch

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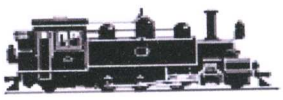


Executive Summary

E1 General comments

It is critical to understand that the conditions under which a main line steam locomotive must be operated in today's modern environment, differ considerably from those prevailing in the 'steam era'. The infrastructure needed to support such operations is now largely non-existant and suitable arrangements for watering, refuelling, de-ashing etc. must often be put in place by the operator for the particular tour undertaken. Small issues that can occur in day to day operations can potentially lead to a steam locomotive failing during running. Therefore, as well as being based on engineering terms the condition assessment is also addresses some of the items that affect the ability of the locomotive to be reliable and safe in operation. Typical factors causing a steam locomotive to fail may include:-

- Component failure – either catastrophic or minor.
- Loss of boiler water.
- Condition of boiler water.
- Type of coal used.
- Fire prevention equipment.

Consideration of these factors by the authors have identified some concerns for the operation of 3801.

E1.1 Condition of the Boiler

Within the time constraint associated with the locomotive needing to be available for traffic in early March 2007, it was, as previously indicated to Rail Corp, not possible to carry out a full assessment of the boiler; this work will requiring full dismantling, i.e., removal of tubes and flues to obtain access to the boiler interior. Such work needs to be planned to have the replacement tubes and flues to hand ready for installation, some months lead time being necessary, to minimise the down time required.

It may also be found during such assessment that further repairs may be necessary, the extent of which cannot be currently determined, but it should be kept in mind that they may require the boiler to be removed from the locomotive.

With the preliminary brief given to the Puffing Billy engineering team and subsequent investigation, the inner firebox area was noted as an area of initial focus. As far as practically could be ascertained and with consultation with the Boiler Inspector Mr Clyde Harrison and contract NDE technicians, it was found to be in general terms in a reasonable condition, subject however, to the defects found during the boiler inspection being satisfactorily completed before it is returned to service in 2007. However, and typically of this type of construction, there is some deterioration of the general plate work on the inner fire box area. Some superheater flues, small tubes, waterwall stays, and foundation ring rivets are leaking and there is cracking in one corner in particular that will need repairs immediately.

After the initial boiler inspection the Puffing Billy team carried out further investigations revealing that at least two of the five arch tubes that run on the inside of the fire box will also need repairs immediately. It should be noted that the Boiler Inspector did not identify these issues.

Recent anecdotal reports of poor steaming by the locomotive, (these having been largely attributed to the coal quality) have probably been largely caused by the defective smokebox door found during inspection of the locomotive at Maitland. The need to keep the smokebox of a steam locomotive airtight is of fundamental importance to steam locomotive operation. The door was found to be open by approximately 6mm at the bottom, and was not contacting on the sealing face for more than 50 percent of its circumference. This major defect should have been identified and repaired long before the date of inspection at Maitland, and would have caused a significant impairment of the locomotives performance.

In summary, and subject to the boiler inspection being completed satisfactorily after the identified repairs have been carried out, subsequent to the locomotives transfer to Thirlmere, (and subject to no further defects being found at the Thirlmere inspection), the boiler will probably be certificated for 12 months of operation.

E1.2 Running gear condition

A preliminary visual inspection revealed the running gear (wheels, motion, cylinders etc) to be in reasonable condition. Further investigation by the Puffing Billy engineering team did raise some areas of concern as noted below:-

- The front bogie on the locomotive was recently re-tyred by 3801 Ltd and the retaining method used is an area of concern. The traditional method of attachment of the tyre was not used and at the very least a metallurgical opinion should be sought as to the suitability of the method used, and its possible effect on the integrity of the tyres.

- Although requested, no documentary evidence was forwarded regarding the recording of fits and tolerances of all the running gear. This evidence should be made available to RTM as a priority in order to establish the integrity of these safety critical components. Evidence should include tolerance of fits, and of any non-destructive testing of mechanical components. If such information is not made available, RTM will most likely need to dismantle certain items to allow them to sign off to comply with their accreditation requirements.

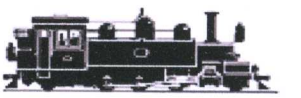
- The fire prevention equipment e.g. the ash pan, was found to be generally sound, but was not completely tight, some holes being found that require repair as ash dropping through them could potentially start fires during the high fire summer season. In fact, when the authors were guests of 3801 Ltd on its last trip, a fire was started on the sleepers at one location. Puffing Billy staff made some remedial repairs, however, this will need further attention by RTM.

E1.3 Appropriate qualifications and skills required to maintain steam locomotives

Although both staff from RTM and 3801 Ltd are very dedicated to the preservation of 3801 and locomotives in general, it has been identified, that through no fault of their own, the heritage sector is drastically starved of effective senior strategic engineering input and sound technical input into processes and practices that impact on safety and operational management.

Decisions tend to be made at trade level, and such decisions may prove inappropriate for satisfactory management of risk. There is no system evident of auditable engineering process. In modern contemporary railways, a tradesman cannot make any changes to engineering drawings or standards without consultation or consideration by suitably professionally qualified engineers. One example could perhaps be the selection of an inappropriate choice of material or process for a repair or replacement component. The choice of a modern material, to replace a previously used but no longer available grade, can require significant engineering investigation in some cases. If no professional engineering or metallurgical advice is sought (or perhaps even considered,) in the process of maintenance/rebuild, the potential for failure, either minor or catastrophic, although not intentional, is very real. This type of scenario should be considered within the preservation/heritage area, as budget constraints are always prevalent and ultimately can compromise safety. Commercial expediency should never be allowed to override the engineering requirements of the machine.

For Rail Heritage to be sustainable into the future with safety and reliability, a resource must be made available regarding management and engineering of such matters.



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1 Purpose of report

This report has been prepared at the request of Railcorp N.S.W., Office of Rail Heritage, to assist the process of establishing the condition of the boiler of steam locomotive 3801, with a view to attempting to predict future heavy maintenance requirements for the boiler.

2 Limitations to the assessment

It should be understood that predicting the service life remaining in a locomotive boiler is not an easy task. Boiler inspections are carried out at yearly intervals, this mandated frequency being necessary because of the possible rapid deterioration of boilers if the appropriate operating conditions are not maintained, and such inspections do not attempt to predict longer than 12 months from the date of inspection.

This assessment report must be read taking into account that any estimates of remaining service life may be severely conditioned by the unknowns to which the boiler is subjected whilst in service, (including periods of storage) and that the ultimate life of components, and the subsequent repairs found necessary, will be in practice, and of necessity, determined by the Boiler Inspector(s) at the annual inspections.

3 Scope of the report

This report is limited to the inner firebox, front tubeplate and various lap joints that were accessible around the boiler barrel area. The barrel and outer firebox do not form part of this assessment as adequate access to their interior was not possible at this time.

There are some areas of the outer firebox and barrel that have previous repairs, and certain other areas such as the rear backsheet have historically been prone to problems. This assessment cannot give any opinion of such areas, but they should be properly inspected as the Boiler Inspector deems necessary.

The boiler installed in steam locomotive 3801 is identified as boiler number 3819.

4 Inspection

The locomotive was located at the Hunter Valley Training Company site at Maitland during the inspections and assessments that form the subject of this report.

The boiler was prepared for inspection by staff of the Puffing Billy Railway (PBR) together with staff from Rail Transport Museum (RTM), Thirlmere. All washout plugs were removed, the fire grate dismantled, and the cast iron protection plates covering the foundation ring rivets removed. The firebricks were removed from between two arch tubes, to give access to the combustion chamber and tubeplate area. Dismantling of smokebox spark arrestor grids, plates etc was carried out to give access to the front tubeplate and it's washout plugs. Some casing sheets were removed to access the Belpaire plate at the firebox top. Plugs were removed from some arch tubes.

The boiler was washed out. The PBR representative noted considerable quantities of boiler scale being flushed out during the washout.

The boiler was inspected on 15 December.2006 by Mr Clyde Harrison, of C.G.Harrison Pty. Ltd., Associated Boiler Inspectors. Mr Harrison has been the inspector used by '3801 Ltd' during the past few years.

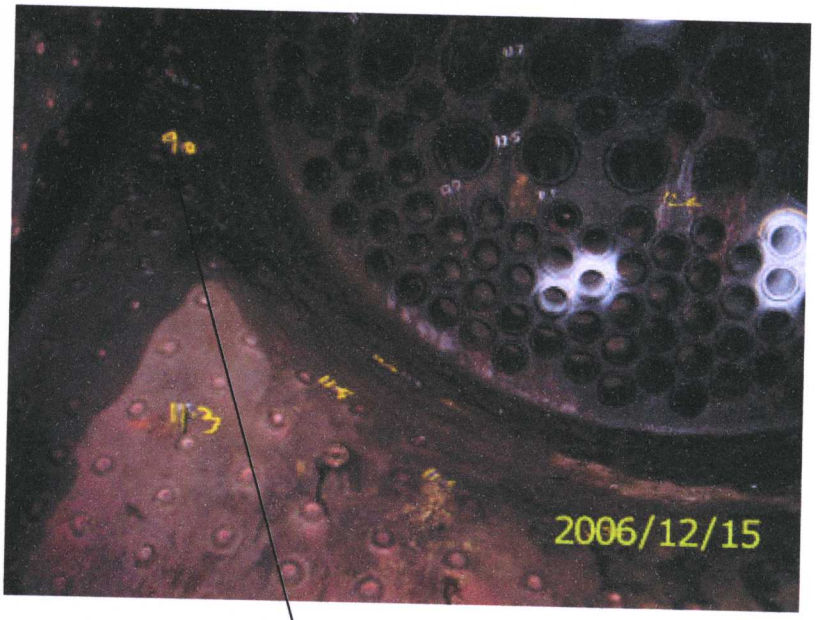
Non Destructive Examination (NDE) was carried out on 15.December 2006 to the boiler inspector's requirements by HVT Inspection Services, of Smithfield, N.S.W. HVT have been used previously to perform NDE on this boiler. Ultrasonic thickness testing and Magnetic Particle crack testing were performed to both the boiler inspector's and PBR requirements.

5 Defects

Various defects were noted during the inspections, and those in the inner firebox area are now detailed:-

5.1 Damage by thermal cracking to some flue and generating tubes at the firebox tubeplate, these tubes to be replaced as per the boiler inspector's report. Further NDE is required to be carried out on tube ends after the locomotive is transferred to RTM Thirlmere, as the technicians did not have the appropriate probe available at Maitland.

5.2 Some plate thinning was shown during the Ultrasonic testing and this thickness reduction, whilst still acceptable, seems excessive for the amount of steaming that this boiler has had, and points to inadequate water treatment (see later comments re water treatment). Photo 1.



Note thinning at this point

Photo 1. Combustion chamber & tubeplate, LHS

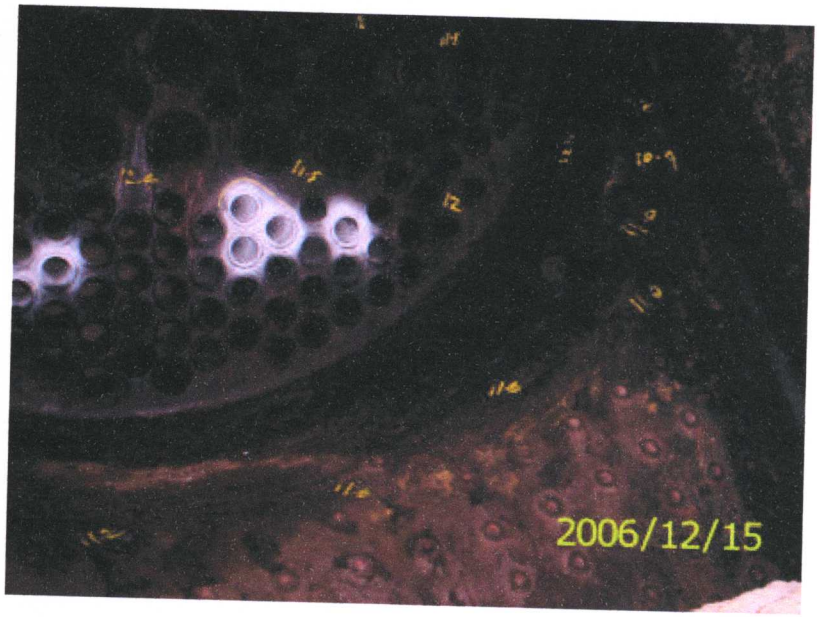


Photo 2. **Combustion chamber and tubeplate, RHS**

5.3 Leaking rivets and consequent fire side corrosion in the front corners of the foundation ring. Photo 3.

Photo 3. **RH front corner of firebox**

5.4 A plate crack between rivet holes, and leaking rivets in the rear left hand side corner. These were located in a previously fitted corner patch, this patch showing thickness of 12 mm at top but 9mm in crack zone. Photo 4.

Photo 4. LH rear corner of firebox

5.5 The right side rear corner has a previously repaired (pad welded) area in a generally similar zone to that of the other corner defects. Photo 5

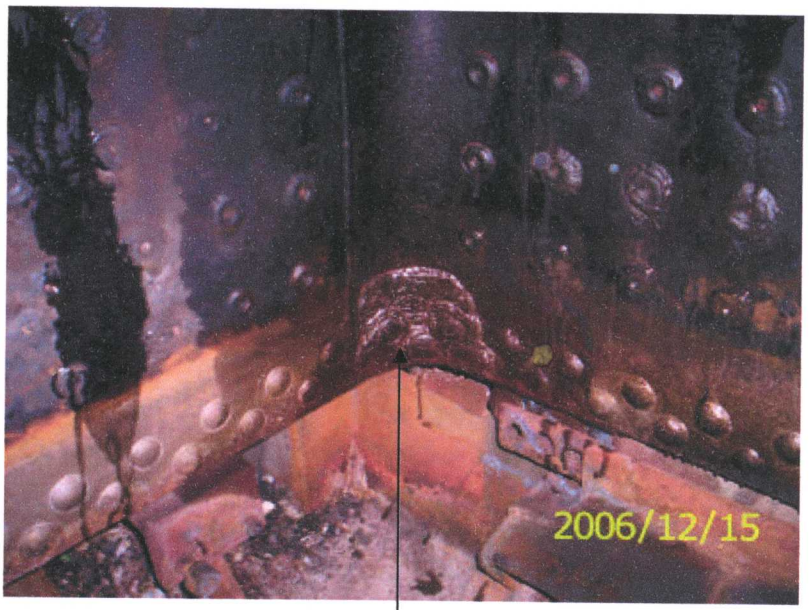


Photo 5. Firebox RH rear corner

5.6 A number of leaking waterspace stays were noted, together with some thermal cracking and fire wear on stay heads. Photo 6 is typical.

Photo 6. **Firebox front plate showing various leaking stays**

5.7 One stay broken (leaking from tell-tale hole) on front sheet RH side.
5.8 The LH arch tube leaking at the expansion into the door plate. Photo 7.

Photo7. **Leaking arch tube expansion (LH tube rear end)**

5.9 The centre arch tube pin hole leak on tube bottom about 700mm from throat plate end. Photo 8.

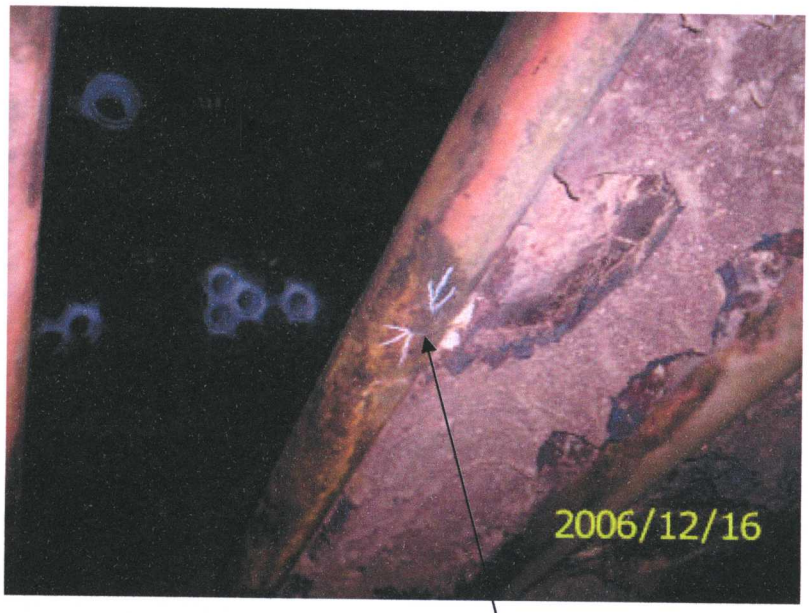


Photo 8. **Centre arch tube, location of pin hole leak**

5.10 Arch tube holes at the tubeplate end showed significant bell mouthing, but no leaks were evident.

Other defects noted:-

5.11 Leak on caulk line between the smokebox tubeplate and barrel angle ring, RH side between rivets Nos 7 to 9 counted from top centreline of barrel. Photo 9.

Location of leak on caulking

Photo 9 **Barrel angle ring/ smokebox tubeplate RHS**

5.12 Corrosion of plate at LH blowdown valve seating.
5.13 A couple of locations on the joint between the Belpaire ring and firebox outer wrapper were suspected of having leaked at some time, but no leaks showed under hydrostatic testing, although this was only carried out at mains pressure of approximately 80 psig at Maitland. Photos 10 and 11 show the locations in question.

Photo 10. **Top of Belpaire ring and firebox wrapper**

Photo 11. **Top of Belpaire ring and firebox wrapper**

5.14 Some wave like irregularities noted on the inner firebox plates, RHS, towards the top of sheet near firebox/combustion chamber margin.

6 Water Treatment

To extend the possible service life of this boiler, it is imperative that a good water treatment regime is put in place to reduce or prevent further corrosion.

There are treatments available that can properly control both corrosion and scale but they must involve the correct application of chemicals, and the ongoing regular testing of the boiler water to ensure that the correct levels of chemical are maintained. Simply adding chemicals and then not measuring the results, as has been practiced in the past, will not be adequate, as the current state of the boiler internals starkly demonstrates (photo 12).

Heavy scale on boiler tubes

Photo 12. Picture taken at Thirlmere by RTM boiler inspector viewed through flue hole whilst flue renewal in progress Jan 2007

Blowing down, or draining the boiler when not indicated by the water test results, simply removes the chemicals from the boiler and increases the difficulty of maintaining the correct levels. RTM are currently using a tannin and soda ash treatment supplied by the 'Tandex' company in Melbourne, and this treatment is also that used by Puffing Billy Railway, with considerable success. PBR treat their boilers (add the chemicals to the water tanks) on a daily basis, and test the water weekly, thus allowing the correct chemical dosages to be used, and to regulate the frequency of blowdown necessary to control the total dissolved solids. Control of corrosion is such that plate thicknesses, after 20 years of intensive use, are generally as new. Tubes recently removed from the boiler of our locomotive 12A after 10 years service, still showed the tube manufacturer's painted stencil on the tube surface. Compare this with the

photographs taken at Thirlmere recently (photo 10) during flue replacement on 3801, which show a boiler absolutely covered with heavy scale. Such scale causes a rise in the metal temperature of any plate or tube exposed to combustion, due to its insulating effect, and such temperature rise is the main cause of thermal fatigue (cracking) failures of tubes, flues, stay heads, and inner firebox plates, and is the main contributing cause of water space stay failure.

There is a widespread belief that the types of water that are used as feedwater are the cause of all this type of problem, but modern thinking on locomotive water treatment, e.g. Porta Treatment etc, is that the type of feedwater used is not really the issue, it is the *conditions maintained within the boiler* that determine the successful application of a water treatment regime.

6.1 De-scaling

The internal condition of this boiler, as demonstrated by the photograph (photo 10) mentioned, may well make it a candidate for a full internal chemical de-scaling treatment. Such a treatment was used, apparently successfully, some years ago by the Pitchi Ritchi Railway in South Australia, and is the subject of an article in 'Australian Welding', the journal of the Welding Technology Institute of Australia (WTIA), Vol 42, 4th quarter, 1997, pp 16,17, 28, entitled "Maintenance and restoration of Steam Locomotives".

7 Conclusions and Recommendations

- It is noted that the report from Mr Harrison recommends that the boiler be removed from the locomotive for heavy repairs. Ref p 1 of his report.

- It is imperative that the water treatment be improved, and also that the boiler should be de-scaled as soon as possible, to allow such water treatment to work. Continued operation in the current condition of heavy scaling will cause ongoing damage and deterioration, thus forcing the need for heavy maintenance and causing a drastically curtailed service life.
- The deterioration of the inner firebox plate thickness appears excessive for the amount of service that the locomotive has performed, but apart from isolated areas, it may be capable of giving several years of reliable use providing that the feedwater treatment is improved to halt the ongoing wastage of plate thickness. All four inner corners at the foundation ring level, either have, or have had, defects in either the plates or riveting, and it may be that four new corner patches may be needed in the next few years. These patches were a common repair in the steam era, as deterioration was caused by stressing due to the rigidity in this area, plate cracking occurring due to thermo-mechanical action. If leaking rivets in the corners are an ongoing problem possibly a light seal weld could be applied to them at installation, to obviate the corrosion damage that occurs if they eventually leak.
- Cracking of tube and flue welds and ends at the firebox tube plate can have several causes, thermal fatigue due to heavy scale build up being one of them, but the method of fitting the tubes and flues is also of great importance. Most railways using steel tubes and flues in steel firebox tube plates used a method involving the use of copper liners between the tube and tubeplate, and, after hydrostatic testing, seal welding *whilst the boiler was filled with warm water*, this last factor being vitally important for

success. We do not know if 3801 has such liners fitted, although a sketch showing the method appears in the appendix of the New South Wales Railways 'Boiler Maintenance Regulations". This method is well documented in the literature, PBR can if necessary supply many references. It is felt that such tube and flue installation should be considered, if it is not in fact already used.

- Many leaking stay heads were noted on the firebox end. Over the years, quite a number have been seal welded as leaks developed. The Victorian Railways introduced the practice of seal welding of the fireside end of all waterspace stays at installation, for boilers built during the post WW2 era. It is recommended this method be used on 3801.
- As stated earlier, (par 2 Limitations...), the life expectancy of this boiler can only be properly estimated after much more extensive investigations, involving significant dismantling, NDE, and prolonged down-time for the locomotive.

In conclusion, it is recommended that RTM in conjunction with their Boiler Inspector immediately carry out repairs to address the issues detailed in this report that must be repaired to ensure the availability of the locomotive to October 2007.

It is recognised the locomotive is in need of a major assessment and subsequent overhaul. The must be progressed in a timely manner to ensure that by June 2007 all planning processes associated with ensuring a sustainable operating and maintenance lifecycle for the locomotive are complete.

The meeting of the Technical Panel at the Office of Rail Heritage, 6 February 2007, agreed that a full plans for an all steel welded boiler for the locomotive be drawn up. This will expedite future planning and provide guidance in areas related to firebox replacement and eventually boiler replacement

Appendices

1 **HVT Inspection Services reports**

Ultrasonic thickness test report. Report No H420/151201
Magnetic particle inspection report

2 **C.G.Harrison, Associated Boiler Inspectors report**

Boiler Inspection report dated 2nd January 2007

FORM NO. FPH 102

HVT INSPECTION SERVICES PTY LTD

Unit 3, 9-11 Cullen Place, Smithfield NSW 2164
P. O. Box 6390, Wetherill Park NSW 2164
Telephone: (02) 9725 1511
Fax: (02) 9725 4208
ABN 76 077 815 635

ULTRASONIC THICKNESS TEST REPORT

Correlation No: H420

Report No: H420/151201 (Pg 1 of 5)

Client: Hunter Valley Training Company Pty Ltd

Order No: 11743

Address: P O Box 559
MAITLAND NSW 2320

Job No: 3801

SUBJECT: Locomotive 3801

Date of Inspection: 15.12.06

Operator: P Ashby & S Woodward

Material: Carbon Steel

Accuracy: + or – 0.25mm

Test Spec: AS2452.3.2005

Instrument: Krautkramer USN-50 S/No.: 602531

Surface Condition: As formed

Probe Details: KK 0 deg. 5MHz T/C

Inspection Technique: Single spot – single measurement technique in nominated area.

RESULTS:

Fire Box.

Crown Plate –	13.2 to 14.0 mm	Minimum 13.2
Port Side Wall	12.6 to 13.5 mm	Minimum 12.6
Starboard Side Wall	12.9 to 13.2 mm	Minimum 12.9
Back Wall	10.0 to 12.0 mm	Minimum 10.0

Back wall between bottom row of stays

Between Stay		Between Stay		Between Stay	
1 – 2	10.3mm	2 – 3	10.5mm	3 – 4	10.0mm
4 – 5	10.0mm	5 – 6	10.0mm	6 – 7	10.2mm
7 – 8	10.4mm	8 – 9	11.0mm	9 – 10	10.0mm
10-11	10.2mm	11-12	10.4mm	12-13	10.3mm
13-14	10.2mm	14-15	10.2mm	15-16	10.2mm
16-17	10.2mm				

HVT Inspection Services Pty Ltd
Date of Issue: 09.01.07

P. ASHBY

This Laboratory is accredited by the National Association of Testing Authorities Australia. The tests(s) reported herein have been performed in accordance with its terms of accreditation. This document shall not be reproduced except in full. ACCREDITATION NUMBER 2602

FORM NO. FPH 102

NVT INSPECTION SERVICES PTY LTD

Unit 3, 9-11 Cullen Place, Smithfield NSW 2164
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Fax: (02) 9725 4208
ABN 76 077 815 635

ULTRASONIC THICKNESS TEST REPORT (Continuation)

Correlation No: H420

Firebox (continued)

Plates leading up to rear tubesheet.

Generally 10.9mm to 12.3mm, however one spot on port side corner where plates change angle (welded section) minimum thickness 9.0 mm (Refer rear tubesheet sketch for location)

Rear Tubesheet:

11.5mm to 12.5mm

Front Tubesheet:

16.0 mm, however one location at the 5 o'clock position (as viewed from front) between outer rivet and plug revealed a minimum thickness of 14.5mm.

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ABN 76 077 815 635

MAGNETIC PARTICLE INSPECTION REPORT

Correlation No: H420

Report No: H420/151201 (Pg 3 of 5)

Client: Hunter Valley Training Company Pty Ltd

Order No: 11743

Address: P O Box 559
MAITLAND NSW 2320

Job No: 3801

SUBJECT: Locomotive 3801

Material : Carbon Steel

Surface condition : As formed / welded

Nature of test : Magnetic Particle Crack Detection

Test spec. : AS1171.1998

Acceptance spec. : Record any surface cracking

Date of examination : 15.12.06

Inspector : P Ashby & S Woodward

Equipment : Magnaflux Y6 electromagnet (yoke type)

Inspection technique : A sustained, wet, magnetic flow method of magnetisation was applied in two directions 90 degrees opposed in conjunction with a fine fluorescent ink (Ardrox 8561) and Labino Black light. Demagnetisation not performed. A Burmah-Castrol Flux Density Indicator was used to ensure adequate field strength.

Examined:

All tubes to rear tubesheet welds
All corners and changes of section in firebox.

RESULTS:

5 off tubes in rear tubesheet welds revealed crack-like indications (Refer attached sketch)
Rear port side bottom corner of firebox revealed cracking extending from rivet
Rear port side bottom corner revealed linear indications around two rivets

All indications as marked and referred to client representative.

P Ashby

HVT Inspection Services Pty Ltd.
Date of issue : 09.01.07

FORM NO. FPH 102

Unit 3, 9-11 Cullen Place, Smithfield NSW 2164
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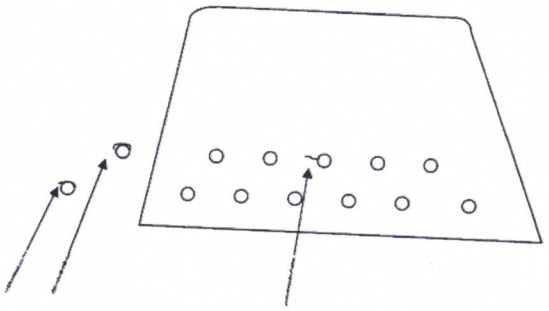
ABN 76 077 815 635

INSPECTION REPORT (Continued)

Correlation No: H420

Report No: H420/151201 (Pg 4 of 5)



Linear indication around rivets

Cracking 25mm long into plate coming from hole

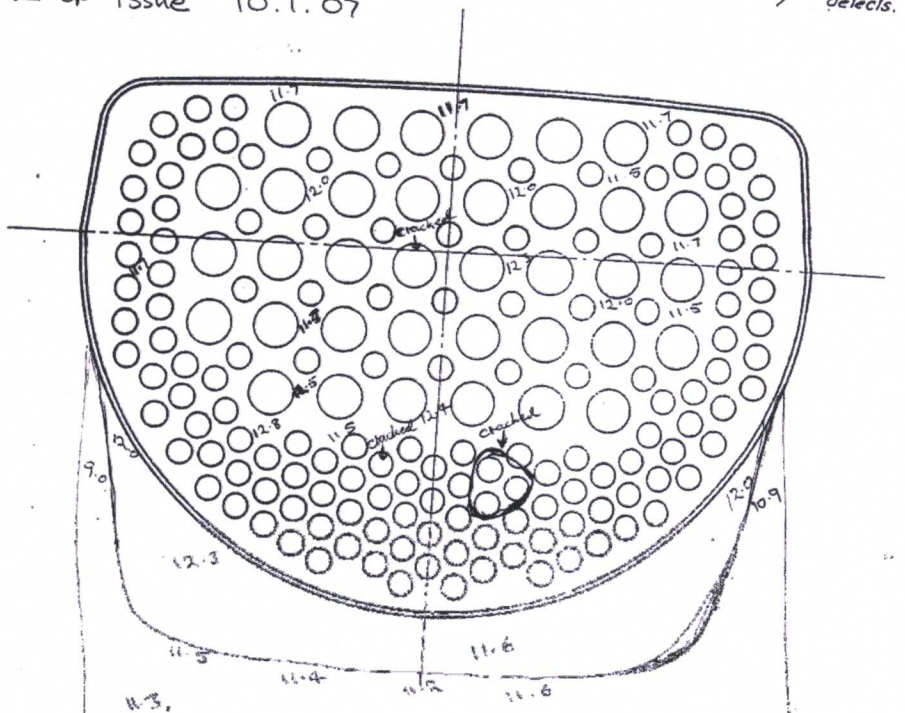
Rear Port Side Bottom Corner

Report No H420/151201 Page 5 of 5

BOILER N° ____ ENGINE N° 3801 CLASS C38

DATE EXAMINED 15.12.06 WHERE EXAMINED Telarah
EXAMINED BY P Ashby S Woodward
Date of Issue 10.1.07

} For reporting leakages or defects.



DATE ATTENTION GIVEN _____
NAME OF BOILERMAKER _____
WORK EXAMINED BY _____
DEPOT _____

} For reporting REPAIRS effected.

FIREBOX TUBE PLATE

DISTRICT LOCOMOTIVE ENGINEER

Note:— Indicate on diagram Stays and Ion Tubes

C.G. HARRISON PTY. LTD.
A.C.N. 002 104 707 A.B.N. 53 002 104 707
ASSOCIATED BOILER INSPECTORS
CONSULTING ENGINEERS
34 Ampleside Street, Wheeler Heights 2097. POSTAL ADDRESS: P.O. Box 516 Dee Why 2099
Telephone: (02) 9982 5429 Mobile: 0418 228 010 Facsimile: (02) 9982 2698

3801 Ltd.
Puffing Billy Railway
P O Box 451
Belgrave Victoria 3160
2nd January 2007

Attention Mr Alan Gardner

Report on condition of Boiler 3819 in 3801 locomotive.

This Boiler was manufactured in 1947 by the NSWGR and installed in the 3801 locomotive during the last major refurbishing at 1985.
The removal of the steam boiler from a locomotive was usually, in 10-year cycle, this allowed all the worn and wasted areas to be replaced or repaired to the original NSWGR standard for steam locomotives.

This Boiler 3819 was last removed from the locomotive frame at the last major refurbishing of the entire locomotive which is over twenty years ago. The service conditions for 3801 are very different from that of the normal steam locomotive operations as the 38-class type were in steam continuously, with a wash out of the boiler on weekly cycle. The 3801 are steamed only infrequently this will induce excessive thermal stress and strain to the locomotive boiler.
The quality of the feed water supplied to this steam boiler is now very poor and with its storage and distribution system contaminated this increases the stress and strain on this boiler. This Boiler should be removed from the main locomotive frame for a full assessment of all repairs necessary to return this boiler to the original standard and Specifications within the next inspection cycle.
When boilers are removed from the locomotive frame all the lagging and insulation material are removed, then a very thorough examination of the external surfaces is then possible. Internal inspection of the boiler is on an annual cycle, with very limited removal of external lagging and cladding. The removal is very costly and extensive in time, thus only removed in areas on known potential problems.
Conditions as found
The technicians who prepared this Boiler for the assessment were from the Puffing Billy Railway system.
1 All fire bars were removed
2 Centre line of fire bricks in main arch was removed
3 All washout Plugs were removed from this Boiler
4 External lagging was removed in area above main firebox section
5 the front smoke box door was opened and all the internal fittings were removed.
6 the HVT NDT company was used for ultra sonic thickness testing and magnetic particle crack testing.

C.G. HARRISON PTY. LTD
ASSOCIATED BOILER INSPECTORS
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34 Ambleside Street, Wheeler Heights 2097 POSTAL ADDRESS: P.O. Box 516 Dee Why 2099
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7 The Boiler was Hydrostatic tested after the inspection schedule

The General condition of this locomotive steam boiler is good for the service conditions. The ultra sonic thickness testing indicated only a small amount of wastage corrosion is evident in this Boiler, this fact was supplemented with visual inspection at all wash out plugs locations. An area was recorder at 9mm thickness in the throat area of front firebox tube sheet.
1 the magnetic particle test revealed some defects.
A Fire cracks in the tube projections on this boiler. One large flue tube and several of the generating tube were effected. The cracking extended along and into the tube expansion area. (Photo)

2 A section in the throat plate front firebox was recorder at 9.00 mm in plate thickness; this effected area was not previously recorder.
3 All flexible wall stays in the lower firebox with direct fire contact now have been seal welded.
4 The large Flue tubes have developed stress grooving in the tubes. This damaged tube area is behind the front tube sheet in the firebox. Three of the tubes have been replaced. Ultra sonic testing was requested to the entire flue tubes for assessment and monitoring. The technicians on site were without the required ultrasonic probe to perform this task. This NDT service is to be completed at this first available window.
5 Cracks were detected in the firebox at rear left side around a rivet and in the ligament.
6 The Boiler blown down valves were leaking and wastage to the Boiler support block has occurred and should be returned to full strength by pad welding?
7 The Boiler three safety valves are operating, but are very worn and require removing and sending to a valve service company for reconditioning. Note R S Simpson at Matraville has serviced this type of valve for both the 38 class locomotives.
8 The Hydrostatic test on this Boiler, a small leak was detected on the barrel riveted seam a slight weep at defect in rear of firebox.
9 The front smoke box wear on non-pressure parts was evident; these repairs would be normal maintenance. The front tube sheets the row rivets are wasting at rivet heads heavier at the base on the smoke box.
10 The waterside of this boiler has scale on the heating surfaces, while a water treatment program is used in this boiler; the poor quality of the raw feed water appears to be the problem.

Wall stays are all threaded on this Steam Boiler, on the firebox side walls the stays are all work hardened with the continuos caulking over the years of service. The last annual service many of the wall stays on fireside were seal welded. This internal firebox has been replaced and there is slight misalignment in threaded wall stays, this increases stress and strain on all the wall stays in this boiler. The replacement of wall stays would be very extensive and the parent metal that is wasted by leakage at the stay areas of the years of service should be returned to original strength by weld metal.

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Rivets on the foundation ring. Leakage on seams particularly in the corners of this boiler, would require replacement, as continually caulking has strained these rivets and now some of seams are seal welded. Any loss of parent metal would be replace by welding process. The firebox has other areas of wastage the rear base and the top
The Main steam control valve and internal steam lines should be removed and tested for any defect.

The immediate repairs are

1 The damaged flue and generating tubes to be replaced.
2 The extent of Stress Grooving in the flue tubes to be defined and damaged tubes to be replaced
3 The cracking in rivet area rear of firebox to be repaired and defective rivets replaced.
4 The Boiler Safety valves to be cleaned tested and any worn or defective parts replaced.
5 All broken flexible stays to be replaced.
6 The Quality of raw feed water should be improved for safe and efficient Boiler Control.
7 The steaming coal should be to Japan export quality.
8 All staff operating the locomotive should be experienced in Boiler operations. particularly the Fireman water/ tender.

This boiler will require extensive repairs to return to the original specifications for the steam locomotive boilers of the NSWGR system. It is essential that all the parameters Are completed to ensure reliable and safe operation of this locomotive for many years of service.

Yours Faithfully
Clyde G Harrison
Boiler Inspector