Transport HeritageNSW

3801 Update

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Repairs to Boiler 3819

On 13 September 2016 it was announced by THNSW that Goulburn based company K & H Ainsworth Engineering Pty Ltd had been appointed to repair boiler 3819, as the result of an extensive competitive tendering process.

The boiler was transported from Chullora to Goulburn on Thursday 22 September and work commenced immediately to remove the inner firebox.

In order to remove the firebox, it was necessary to first cut out all the foundations ring rivets, all the rigid and flexible wall stays, all the crown stays (rigid and flexible) and cut the connection between the inner and outer firehole sleeve. To provide easy access inside the firebox, the five 3" diameter arch tubes were cut out. The majority of stays were cut out with oxy-acetylene and some drilled out; although foundation ring rivets were successfully pushed out with a small hydraulic press. The crown stay nuts on the outer casing were cut with either oxy or abrasive disc and the stays unscrewed from inside the box with an air-powered impact wrench.

This all sounds fairly straightforward, but when you consider the quantities, you start to gain an idea of the work involved. There are some 200 $^{7}/_{8}$" diameter foundation ring rivets and another 14 $^{7}/_{8}$" diameter corner studs that have to come out first, followed by 1,300 rigid wall stays, 490 flexible wall stays. On the outer casing, there are also 336 rigid crown stays and 42 flexible crown stays to remove.

The initial stage of this work was performed with the boiler in the upright position as delivered, but as the job progressed, it was convenient to rotate the boiler on its side to remove the crown stays.

With all the connections cut, the boiler was again rotated upside-down to lift out the inner firebox. Two cranes were positioned and chained to opposite corners of the foundation ring.

It really was no surprise (!) that a little bit of chasing around the foundation ring was necessary to ensure all traces of rivets and corner studs had been removed before the box popped out.

Boilers for class C.38 were specifically designed to allow the firebox to be lifted out. Many years ago when

Locomotive 3801's boiler (boiler 3819) is lifted for loading onto a truck for road transport to Goulburn.

Boiler 3819 departing Chullora Boiler Shop.

State Member for Goulburn, the Hon. Prue Goward MP and Ken Ainsworth, Managing Director of K & H Ainsworth Engineering Pty. Ltd.

I was a Mechanical Engineering undergraduate, I was introduced to Mr. W. A. Thompson, who designed the firebox for these engines and I clearly remember what he told me, "When we designed the D.57 class in the late 1920s, we never anticipated having to remove an all-steel firebox completely. When we came to design the C.38, the Chief Mechanical Engineer Harold Young was adamant the firebox be designed so it was removable."

The process of removing the box involves lifting and rotating the box to allow the combustion chamber to withdraw from the barrel. This operation was successfully achieved on 20 October and this was the first time the box had been removed since the mid-1980s.

The immediate opinion was the condition of the box vindicated the decision to remove it. The next step was to sand-blast the firebox to make it easier to inspect.

The firebox tube plate has significant stress-corrosion cracking around the flange on the (water) side and the same type of cracking has commenced down the flanged sides of the throatplate. There is widespread cracking around stay holes in all areas. The backhead indicates a number of weaknesses, in particular where the plate has thinned dramatically around the stay holes, leaving an insufficient number of threads. The bottom back corners of the firebox have been replaced (a typical repair), but these have 'pulled' other areas of plate and cracking and distortion is evident. The original static investigation made it obvious that the tubeplate and the throatplate needed to be replaced and this has always formed part of the scope of repair. Independent investigation has revealed the full extent of damage and it has been decided to replace the entire inner firebox, completely.

Boiler 3819 undergoing initial removal of wall stays and foundation ring rivets.

Thus, a new wrapper sheet will be required (i.e. the sides and crown of the inner box) as well as a flanged inner backhead plate. This will require additional design and castings for flanging dies.

The same independent investigation has confirmed the need to replace the smokebox tubeplate and work will soon commence to procure this item.

The outer casing crown sheet (seen in the some of the photos) was the subject of investigation when the original scope was being developed. The plate itself has corroded and thinned significantly on the rear third of the plate and many of the rivets at the crown-backhead joint have wasted away. Our intention was to cut away the thin section of plate and butt-weld in a replacement section. After further consideration, we believe that it is a better option to replace the entire crown. Although this means a larger plate, a greater amount of welding and drilling, reaming and tapping additional crown stay holes, doing the job this way (and combined with a new inner firebox crown) brings about a number of advantages. The complete plate is actually easier to form and is simpler to fit and graft onto the existing casing. The fact that we are working with all new sized crown stay holes means that instead of having to manufacture a range of different sized stays to suit a range of hole sizes, all the stays can be of a single 'new' size and one set of tooling of a single size is required. We feel that these advantages will go some way towards negating some costs of the additional work.

Flanging dies for inner firebox throatplate and outer casing backhead

In the previous *Roundhouse*, mention was made of the design work to develop flanging dies for the inner throatplate and outer backhead. At time of writing, we are about to commission castings for the dies. The dies will be cast in spheroidal graphite (S.G.) iron from single use polystyrene patterns. The patterns themselves will be C.N.C. cut from an assembly of polystyrene blocks. The solid model design for the dies has been produced by a specialist CAD designer under supervision by THNSW. The graphic image accompanying this article shows a design mock-up of the backhead dies located in the flanging press. You will notice the 'flanged' plate shown in red. The press (located in a factory in Victoria) has a rated capacity of 850 tons, although somewhat less than this is required to successfully flange the plates. The plates (of boiler plate quality) are heated to

around 950-1,000 degrees centigrade to soften them. To give an idea of scale, the columns of the press are 200mm diameter each and the major opening between them is 3.2m. In the case of the backhead, each of the finished and machined dies weighs approximately 5.8 tonnes. The dies for the throat plate, although similar, are larger and more complex. The female die weighs around 7 tonnes and the corresponding male about 6.2 tonnes. These of course are the finished, machined weights of the completed dies and a somewhat greater mass of metal is required to produce sound castings (risers, feeders etc). The press has a stroke of 48" (1.2m) and this is just sufficient for pressing a C.38 class throat plate.

The plate material is of boiler quality to Australian Standards and 12mm plate is required for the throatplate and 16mm plate for the throatplate. Each of the plates must be marked out and the 'developed' shape of the plate profile cut from the parent plate. It is only this developed shape which is heated and flanged.

The design of these dies has been a very interesting exercise. There are no known drawings of these dies, and certainly there are no official NSW railways drawings because this part of the work was undertaken by the contractor (as everyone knows, Clyde Engineering). It's been necessary to go back to the original railway drawings of the boiler plates and to apply some first principles engineering to develop the form and shapes of the dies. Yes, they certainly are a large investment in time, effort and cost, but we will have in our possession tooling which will allow us to more cheaply manufacture firebox and boiler plates and repair other C.38 class boilers in the future.

New staff at the 3801 Workshop Chullora

We are very pleased to announce the appointment of two new full-time staff members on fixed-term contract to assist us to get 3801 back into steam.

Mark Brophy has been appointed to the position of 3801 Workshop Foreman. Mark started as a railway mechanical apprentice at Eveleigh Loco Works in December 1967. Later during the apprenticeship, Mark spent time at Water Supply, Chullora Loco Works, and Eveleigh Carriage Works, Eveleigh. His last stint as an apprentice was spent at Casino working on Goodwin-Alco 44 and 48 class locomotives. As acting tradesman, Mark spent seven years in No.1 bogie shop at Elcar, followed by seven more years at DELEC.

Mark had a career change in 1985, leaving the then SRA and going into business for himself, firstly operating a sand and soil delivery service, and then started excavation and demolition work. He owned and operated a sand-and-soil yard for a few years. He has driven trucks for Linfox Transport and spent 12 months at MAN working on overhaul of XPT engine and marine engine components (covering a territory which extended from Antarctica to Hawaii). Mark returned to RailCorp in 2005 and was stationed at Flemington Maintenance Centre, initially as a fitter and then progressed to Team Leader responsible for general

With the wall stays removed, the boiler is turned on its side to facilitate withdrawal of crown stays. As well, the sleeve connecting the inner and outer firebox is severed. There are 14 crown stays in each row. The first three rows are flexible stays, the remainder are rigid type, in total 378. The nuts were cut away with oxy-acetylene and ground smooth to the plate. Some of the stays screw up through into the safety valve and steam manifold seatings.

Since no decision could be made regarding the future of either the inner or outer firebox crown sheets until the box was removed, it was necessary to perform this work in a manner to minimise damage to the plate or stay holes. The simplest way was to remove the nuts as in the previous image and wind the stays out with an air-powered impact wrench.

The growing pile of crown stays. In excess of 1 tonne of crown stays was removed from the boiler.

inspection and running repairs of electric rolling stock, managing multi-skilled teams consisting of between a dozen to 20 workers.

Sean Clarke has been appointed to the position of 3801 Workshop Tradesman. Sean served his apprenticeship as a fitter/machinist with the Zig Zag Railway at Lithgow, before moving to Plasser Australia after the closure of Zig Zag. At Zig Zag, he was Members and Volunteers Co-ordinator for two years, and held direct responsibility for locomotive boilers, liaising with independent specialists and contractors. A key element of boiler work was to implement a new regime of boiler water treatment and management. He has also worked as a

Mark Brophy (left), 3801 Workshop Foreman and Sean Clarke (right), 3801 Workshop Tradesman.

The mobile crane slinging the boiler and up-ending it for firebox withdrawal.

locomotive and rolling stock maintenance employee at Zig Zag Railway for four years with locomotive experience ranging from running repairs to major overhauls. At Plasser he has gained experience working in the pneumatic, hydraulic and mechanical sections, with exposure to design work. Most recently, Sean has been developing his skills as an air-brake specialist and also has acted in a relieving manager's role in a number of sections of the company.

NSWGR locomotive boilers: Numbering and naming

Confusion sometimes occurs when referring to one or other locomotive boiler and the boiler removed from locomotive 3801 is a perfect example. Back in NSWGR days, all locomotive boilers were given a 'registered

Two smaller cranes were then positioned and chains attached to the corners of the foundation ring.

number' which uniquely identified that boiler and which it carried for its entire service life until scrapping.

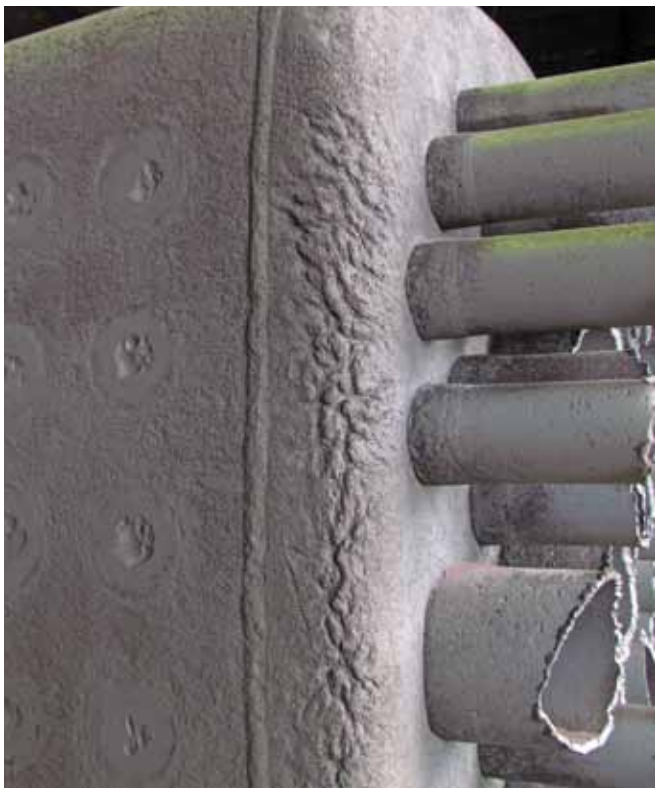
This system was employed from July, 1890 until the end of steam. It was outlined in a CME Circular Letter, No.226 of 1890 entitled 'System of Branding Locomotive Boilers' which read: *Locomotive boilers are to be numbered with and retain the number of the engine to which they originally belonged, if an engine is afterwards fitted with a new boiler, that boiler shall take the number of the engine to which it is fitted with the addition of the letter A. "A" denoting the first renewal, B the second and so on, all boilers to retain their original numbers no matter what changes are made.* (A few years later, instructions were given to use lower case letters for duplicate boilers thus: a, b, c, etc.)

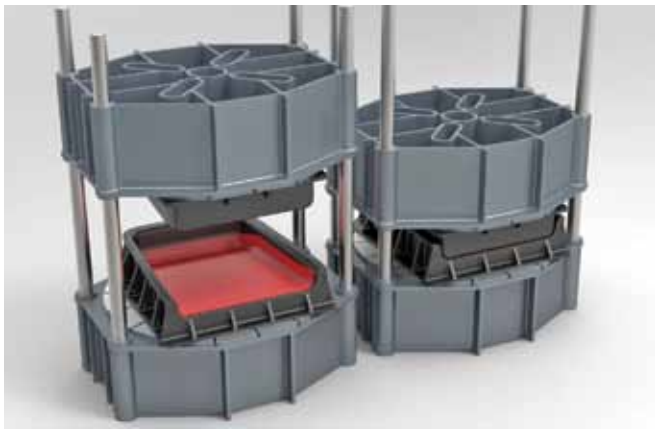
Removing a C.38 class inner firebox from the casing involves lifting and rotating the box to allow the combustion chamber to withdraw from the barrel. This is the first time this box has been removed from the boiler since it was installed in the 1980s. This particular box is a fully welded design. We will be reverting back to the original riveted construction.

Right: *A close-up view of the top flanged edge of the firebox tubeplate. The deep grooves caused by stress-corrosion can be clearly seen. This damage extends all around the flanged edge of the tubeplate and is also evident on the sides of the throatplate.*

Within a few days of removal the firebox was sand blasted on all surfaces to allow detailed visual and non-destructive examination. This view shows the box inside Ainsworth's workshop and also the foundation ring in the process of being cleaned up for inspection.

With the outer casing backhead and inner firebox removed, it is now possible to inspect the water side surfaces of the boiler shell or casing.





This graphic image shows the flanging dies (backhead) mounted in the press. The flanged plate can be seen (red) inside the female die in the fully formed condition. 3D modelling has made it easier to visualise the dies and the flanging process.

A stage in the design process included production of 1:20 scale 3D printed models of the dies. This was also a valuable means of checking the design and understanding the process of flanging. In the image at right, male (blue) and female (red) model dies can be seen. At left, a 1:20 scale model of the press (limited to the essential features) as assembled. Between these two, can be seen various attempts to press thin materials to simulate the flanging process. Ultimately, 0.5mm lead sheet gave the most useful results.

For some older classes of locomotives which were in service for many decades, it was quite possible for there to have been a, b, c, d, and even e series duplicate boilers fitted. Most of the larger, modern engines were not in service long enough for such circumstances to take place. A quick review of locomotive repair cards reveals boilers such as 3229d, 3274e, 1210d, 1246e etc.

In the case of locomotive 3801, the boiler first fitted to it at Clyde Engineering Company when it was being built during 1942 was numbered boiler '3801'. It is of great interest to note that this particular boiler is the one now fitted to Locomotive 3830. Note the distinction between boiler and locomotive.

Eventually, during major overhauls, the boiler will be removed and transferred to the Boiler Shop for repairs. Depending on boiler age and condition, this could involve relatively light work, or could include very heavy repairs, almost to the extent of being rebuilt.

Generally, to keep locomotive repair times to a minimum, it was desirable to have a stock of spare boilers for any particular class of engine. There were five spare C.38 class boilers manufactured by the Department of Railways at Chullora Boiler Shop.

Back to locomotive 3801. Throughout the course of its revenue service life, this engine underwent a number of boiler changes. It received a new, unused boiler in 1950, so in accordance with CME Circular No.226 of 1890, this boiler was numbered '3801a'. Later on, in 1955, Boiler No.3813 was fitted to Locomotive 3801. In 1958, the engine received Boiler 3810. In 1963, Boiler 3816 was fitted. Finally, in 1966 Boiler 3819 was installed and that boiler remained fitted to the engine until it was removed for rebuilding at the State Dockyard. This same boiler powered locomotive 3801 until it was withdrawn for repairs in 2008. It is this boiler – 3819 – that has been sent to K & H Ainsworth Engineering in Goulburn for repairs. Note that the act of repairing does not modify the number; this boiler when returned to Chullora and fitted to the engine will still be known as boiler 3819.