Notes on Meeting between Chris Newman and David Wardale
Beijing – 23rd Oct 2003

[Edited version covering Water Treatment topics only]

Q: What is the history of usage of Porta treatment (PT)? Where do the facts about it come from?

> **A:** Early work must have been done on the Rio Turbio line when Porta worked there in the late 50s, because from DW's memory, Porta's 1969 I.Mech.E paper refers to the cleanliness of the tube and length of tube life achieved there. However it must have been further developed when he worked for Argentine Railways, when he conducted the trials that are referred to in his PT paper.
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> DW's own experience with PT was limited to 3450 (it was not used on 2644), and his use of it gave mixed results. He certainly recorded extremely clean boiler conditions (notwithstanding, SAR regulations still required 3450's boiler to be washed out every 30 days), but he was never able to achieve a TDS over about 10,000 ppm without major foaming problems. Regular SAR antifoam was supplied in the form of an emulsion which tended to separate in storage, and DW could never be sure that the emulsion had been properly mixed before it was dosed into the locomotive's tender.
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> Nevertheless his suspicion is that there are many different formulations of the same chemical (diesteariletildiamide), just as there are many formulations of hydrocarbons (petrol, diesel, kerosene etc) all of which have different properties. Porta used a powdered formulation and he once sent a sample to DW with a note saying "this will solve all your problems", however DW never had an opportunity to try it out. DW strongly recommends obtaining the recommendations of antifoam suppliers in selecting an appropriate formulation, though he warns that suppliers are likely to baulk at the idea of controlling the foam in a boiler with 50,000 ppm of TDS (as recommended by Porta) since it is likely to be quite outside their experience. Industrial boilers with which they will be familiar, do not operate at such high TDS levels.
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> DW warns that whilst it may be possible to control foaming by overdosing with antifoams, the cost of doing so is likely to be high, and no-one has undertaken any tests to determine whether so doing is likely to have any detrimental effects on the boiler.
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> DW does not know who (if anyone) has claimed a 30-year life from boiler tubes using PT.

Q: Why do small boiler leaks reduce alkalinity? And if small leaks are a problem, is it not a contradiction to suggest the use of a continuous blow-down device (as Porta does)?

> **A:** If water leaks from a boiler it carries TDS with it, and is replaced by water with a low TDS from the tender. Therefore the leak results in a lowering of TDS, which is another way of saying that it results in a lowering of alkalinity (since TDS is a measure of alkalinity).
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> So too will a continuous blow-down device reduce TDS and alkalinity. The difference is that a continuous blow-down device allows control of the leakage rate and can be set to ensure that a desired level of TDS is maintained in the boiler. (Normally the leakage rate would be much lower than from general uncontrolled leakage). If TDS

is low (e.g. after a wash-out) then the blow-down device should be turned off. If it gets so high that antifoams cannot control priming, then a continuous blow-down device would help to maintain a lower level. DW has never used a continuous blow-down device.

Q: Does the steam from a boiler with high TDS carry with it any alkalinity? If not, does one have to worry about alkaline reaction in brass/bronze cylinder glands etc?

A: Provided the antifoam is working properly and preventing priming, the steam coming from the boiler should be 99.999% pure. Levels of impurity that have been measured are insignificant (~ 1 ppm). The only concerns relate to fittings below the water level, such as the bottom gauge glass fittings, boiler washout plugs, blow-down valves and fusible plugs. SAR used an alloy which DW does not know the composition of, but which did not seem to be subject to alkaline attack from 3450's boiler contents. 3450's fusible plugs were protected successfully by having them electroplated with copper. DW recommends consulting a metallurgist before making any decisions on remedies or precautions.

Q: What about alkalinity in all-rivetted boilers? John Bancroft expresses concerns.

A: The problem here is that where tiny boiler leaks occur, the water evaporates rapidly leaving alkaline salts in very high concentration around the leaking joint. This alkalinity can (and does) result in caustic embrittlement, which can in turn cause cracking and premature boiler failure. This was a major problem in the US in the 1940s when they began using caustic water treatments. In view of the fact that such small leaks from lagged boilers are very hard to detect, let alone monitor, it has to be concluded that Porta's treatment is not really suitable for rivetted boilers that are in regular or continuous operation. There is no such problem with all-welded boilers such as the one proposed for the 5AT.

(Note: DW commented that Porta was not deterred by such concerns and had a solution for almost every problem. In the case of stopping small boiler leaks, his solution was to empty a drum of sawdust into the tender and let it find its way into the leaks to seal them.)

In the case of heritage steam, DW noted that with the limited amount of use that heritage locomotives get, it is probable that problems would not arise between a boiler's 7 yearly (or 10 yearly) check.

Q: What is the difference between TDS and sludge? Why doesn't sludge turn into TDS?

A: The two things are quite distinct and separate. TDS is dissolved solids; sludge is suspended solids. Alkaline TDS is created by the addition of **Sodium Carbonate** – the alkalinity providing corrosion protection to the boiler. (Note – TDS also includes dissolved salts that come out of solution at relatively low concentrations to form scale.) DW couldn't off-hand recall the origin of sludge, however its function is quite different: it prevents scale formation by virtue of the fact that scale deposits preferentially on the sludge particles rather than on the metal surfaces of the boiler. This is how the boiler is kept clean.

DW went on to explain that **tannin** is added as part of the water treatment for the purpose of keeping the sludge mobile, since it is important that sludge not be allowed to form a paste. As with antifoams, the quality or formulation of tannins seems to vary from country to country, and the tannins available for use on 3450 were called “wattle tannin” and came from local vegetation.   These worked successfully, but Porta had access to better tannins in Argentina, called Quebracho tannin.

Both sludge and TDS share in having a detrimental effect by causing foaming - hence the need for **antifoams**.

A fourth chemical – **sodium hexametaphosphate** - makes up the complete Porta Treatment. Its function is to inhibit scale formation on components in the hot water-feed system, including injectors, feedwater heaters etc from the (low TDS) feed water.

These four chemicals are all that is required for the implementation of PT.

Q: What pH should be aimed for with PT?

A: DW does not know. He was never involved with the chemical testing of 3450’s boiler water, and simply left it to the regular testers to check and report on the boiler’s quality.

Q: What happens at the start of treatment and after washouts etc during the build-up of TDS? Is priming likely in the build-up period?

A: Ideally one would fill the boiler with water containing high TDS. In practice this does not happen, so one has to do what is possible to build up the TDS and sludge as fast as possible, for instance by increasing the tender dosage rates after refilling the boiler and ensuring that no blow-downs are allowed (eg by blanking off the blow-down valve) until the TDS value reaches a satisfactory level.

DW added that if the treatment is successfully carried out, it is not necessary to wash out the boiler every 30 days, because there should be no scale formation. Firebox inspections are, however, still needed at 30-day intervals to check for signs of cracks. The locomotive therefore still needs to be cooled for these inspections to be done. (SAR regulations still required 3450’s boiler to be washed out every 30 days even though it wasn’t needed).

In conclusion, DW commented that in the case of the 5AT, a specialist chemist will be engaged to provide advice on the implementation of the water treatment.

Review of Porta's Water Treatment Paper:

I didn't go through Porta's paper item by item. DW considers it unnecessarily complicated document which describes a very simple technique.

- DW explained that there are four ingredients (as explained above), each of which performs a special function:

  1. **Sodium carbonate** is added to create alkalinity in the boiler water. Some of the carbonate reacts with the water to form sodium hydroxide. These chemicals form the alkaline TDS in the water and create the alkalinity which is needed to prevent corrosion of the metal surfaces in the boiler.
  2. **Tannin** is added solely for the purpose of ensuring that the sludge remains mobile and does not form a sticky semi-solid cake at the bottom of the boiler and heat transfer surfaces.
  3. **Antifoam** is added to control foam formation on the surface of the water in the boiler. TDS and mobile sludge combine to cause massive foaming to occur, and it was only the introduction of highly efficient antifoams that allowed successful "high TDS/high sludge" chemical treatment of boiler water.
  4. **Sodium Hexametaphosphate** is added to prevent scale formation of components exposed to hot feed water (before it enters the boiler) – e.g. injectors, feedwater heaters etc.

  All ingredients are added to the tender water. Dosage rates are not critical – adding too much appears to have no harmful effect except in terms of increasing costs. Once a satisfactory level of TDS and sludge has developed in a boiler, dosage rates can be reduced to maintain those levels steady.

  Boiler water should be sampled and tested daily or whenever the locomotive is on-shed, and dosage rates adjusted to suit the readings obtained.

  PT is as simple as that, however expert advice should be sought with respect to the selection of antifoams and tannins that are used. DW suggests contacting a reputable chemical supplier such as ICI for advice on water treatment generally.

- DW explained the principles associated with the "tender feeder" illustrated in Porta's paper (see diagram overleaf). He believes that the plugs and the adjustable hose provide alternative means of dosing the tender water. The chemicals (briquettes) are placed inside the mesh basket which is located inside

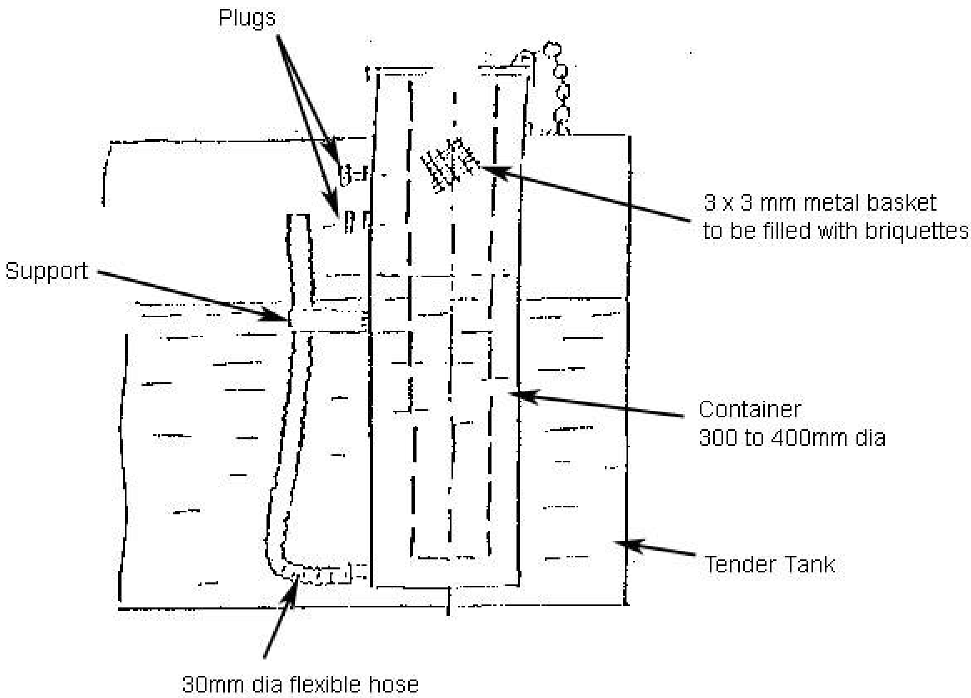


Fig 6: Tender Feeder (derived from British Railways' design)
The flexible hose permits the filling of the container mainly from the bottom so as to avoid the formation of sticky deposits.

a sealed container with the hose connected at the bottom and plugs at the side. When the tender is filled with water, the sealed container is filled with water either through the hose and/or through one of the plug-holes. A highly concentrated chemical solution is thus formed inside the container, a proportion of which then drains out into the tender through the hose (or plug hole) as the tender water falls (the amount being governed by the height of the hose outlet or plug opening. However only a certain amount of the solution can drain back into the tender, thereby providing the selected dosage. By this means, the basket need only be filled once per week (perhaps) rather than every time the tender is filled.

- DW commented on the illustration of the flexible stay bolts in Porta's paper (see over). He warned against taking too literal interpretation of things that appear in Porta's papers, since very often they are simply expressions of ideas, and may not have been tried in practice. He thinks it is likely that the flexible stay diagram is one such example. Nevertheless, he understands the idea behind it – namely to reduce the width of the water chamber surrounding the firebox whilst retaining the length of stay needed to allow for differential movement. Reducing the width of water chamber allows the firebox width (and volume) to be increased, and also reduces the weight of water in the boiler (and hence the weight of the locomotive).

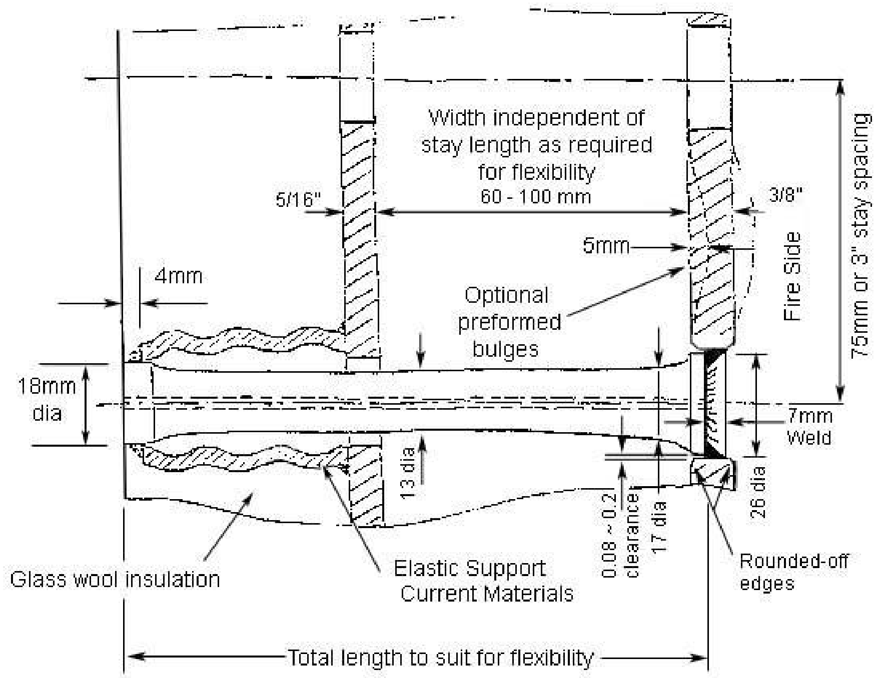
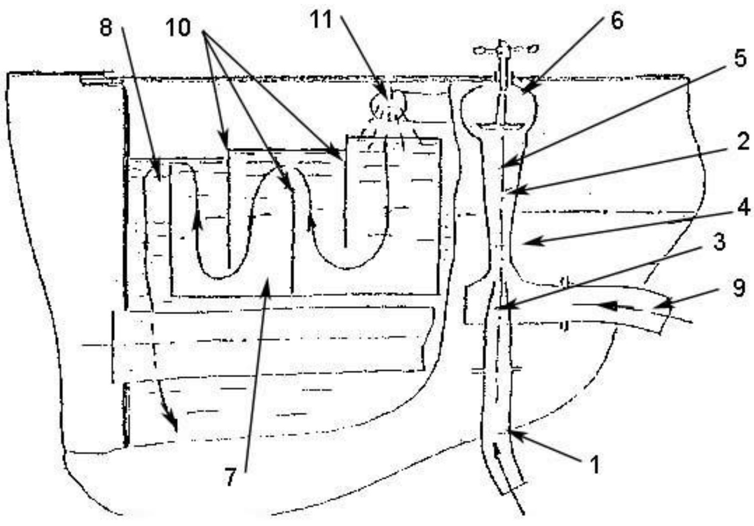


Fig 8: New proposed form of flexible staybolt design
Steam Pressure 30 bar (450 psig)

With respect to the Crystallizer diagram in the paper, DW offered the same warning – this is almost certainly no more than an untried idea. DW would not consider using it in the 5AT.



1 Feed Pipe
2 Ejector
3 Tuyère
4 Mixing Chamber
5 Diffuser
6 Non-Return Valve
7 Internal Pan
8 Perforated Plate
9 Boiler Water Pipe
10 Baffle
11 Perforated Pipe

Fig 10: Crystallyzer

CJEN 25 Oct 2003