Direct Chemical Treatment of Boiler Water Compared to Lineside Treatment

The problem of using impure feedwater in locomotive boilers have been generally appreciated from the very early days of locomotive operation. It is worthwhile to list the major problems at this point:

- **Fouling (scale and muds)** - Anything which adheres to boiler surfaces causing localised overheating and or disrupts water circulation. It must also be noted that in very bad water areas fouling also occurs in water tanks, pipework, valves, injectors, clacks etc;
- **Corrosion** – This take several forms. The principle forms of concern in locomotive boilers are galvanic corrosions, essentially, but not exclusively, caused by the use of different metals and oxidation corrosion caused by dissolved oxygen contained in feedwater. It must also be noted that in all water areas corrosions also occurs in water tanks, pipework, valves, injectors, clacks etc;
- **Caustic embrittlement** – Essentially this is the weakening of metals through the action of hydroxide ions. It is a complex problem which requires several causes to be present at the same time. It may be rare but must be guarded against;
- **Steam contamination** – The overlooked problem? In normal operation steam passing the throttle valve is far from pure. It will contain water droplets carried along in the "steam wind". These droplets contain dissolved and suspended solids. Such particles build up in passages, ports, valve and piston heads/rings, gland packings and similarly in auxiliaries. Contaminated steam leads, amongst other things, to oil contamination. The contaminated oil can act as a mild grinding paste with obvious detriment to the locomotive.

The solution to these problems have long been thought about and debated. It was, perhaps, thought by the 1940s the problems had, to a degree, been tackled and the way forward had been seen. Problems still existed but the general approach had been settled on. This was certainly the case amongst the experts in the treatment of boiler water – the French Railways, with certain North American firms not far behind.

This way forward was direct chemical treatment of boiler water (also known as internal treatment), that is treatment of the feedwater in the locomotive's tanks and thus in the boiler. It had been acknowledged that various forms of lineside treatments (also known as external treatments), such as reverse osmosis, were not effective at dealing with all of the above problems whereas direct chemical treatment was shown to be able to achieve the same results as lineside treatment but was also capable of attacking the problems left untreated.

In 1949 M. Louis Armand of SNCF wrote a paper entitled *"The Influence of the Treatment of Boiler Waters on the Maintenance and Utilisation of Steam Locomotives"* given at the Institution of Locomotive Engineers. This detailed the very considerable success achieved with the chemical treatment known as Traitement Integral Armand (TIA). It includes a very relevant and important statement:

> *"It was demonstrated that the result aimed at could not be obtained by the previous demineralisation of the water, either by the processes of the lime-soda type or by zeolites, for either the anti-scaling action was not sufficient, or corrosions appeared. It has been demonstrated in every instance that it is necessary to add various products to the boiler water."*

This statement has stood the test of time – it remains absolutely true to this day. No evidence has ever been presented to suggest lineside treatment alone in *railway locomotive boilers* is capable of dealing with all of the problems previously listed. However internal treatments can.

Lineside treatment is not totally ineffective. It can, but not always, provide the following benefits:

- A reduction in fouling;
- A degree of protection against caustic embrittlement.

Lineside treatment can not control:

- Corrosions;
- Steam contamination.

These two can be fully controlled with direct chemical treatment but so can fouling and caustic embrittlement. So why spend large sums of money on wayside treatment when inexpensive and more effective chemical treatments are available?

It is very instructive to record that despite full lineside treatment in North West Argentina boiler washouts were a weekly event, ongoing boiler repairs were very much the norm, heavy carryover was occurring within days of a washout and heavy boiler repairs were required ever two years. In other words the lineside treatment was ineffective. It was these problems which caused the Argentine Railways to ask Ing. L.D. Porta to develop a direct chemical treatment. This he did, building on the work of Armand's TIA. In doing so it was possible to permanently shut off the lineside treatment plants, extend washouts to once every six months, dispense with ongoing boiler repairs whilst heavy boiler repairs were extended to hitherto unheard of periods, measured in decades rather than years. And this is in bad water areas. In areas of good water washouts once a year are possible and the other advantages remain. It should be noted such periods between washouts and internal inspection are not unusual. Five months was achieved with in France, three months in the UK and six in Canada, to list just a couple of examples.

It is true in more recent times that the availability of Reverse Osmosis (RO) systems has made it possible to produce extremely pure water. Whilst this cuts the levels of fouling very considerably it still does not eliminate it or deal with any of the other problems listed. For these to be dealt with, again, it is necessary to add further chemicals to the treated water. It is also the case that for RO based solutions the limited results can only be achieved if ALL water used has been through RO. Thus whilst at a technical level RO still offers an incomplete solution at an economic level the cost benefit of such systems is highly suspect. Of course such cost benefit can only accurately be based on a comprehensive case by case analysis. It is important to remember that with RO systems up to 30% of the water fed in comes out as waste, the expensive filters have limited life, the equipment requires electricity to run and this equipment only has a limited life itself. For any large operation the economics of lineside treatments compared to direct internal treatments is going to be very cut and dried. As each watering point needs a RO plant, with all the associated expense, such a system will rapidly cost much more than an operation can justify. The more watering points the more the regime will cost. In contrast figures show for direct chemical treatments as the volume of chemical purchased rises the cost per volume of treated water actually falls.

In conclusion it can be stated that whilst an economic case needs to be built to select the best approach to water treatment, with the numbers generally going in favour of internal treatments, at a technical level external treatments are not really the answer. Where they can be made to work (economically or otherwise) the complexity the extra user intervention required involves is unnecessary with internal treatments.

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