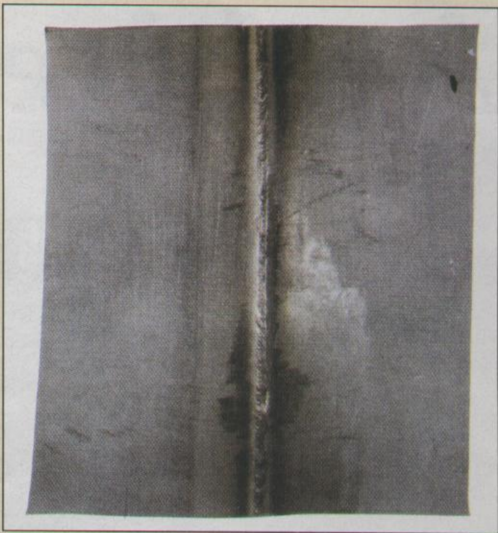
Often a pioneer in the use of novel materials, NAM was one of the first operating companies to make extensive use of 22Cr duplex stainless steel when that material was developed in the mid-70s. 22Cr duplex was originally a casting alloy but, once wrought products came on the market, NAM made use of the plate for vessels and both seamless and longitudinally welded pipe for flowline applications.



1

Acceptance criteria for oxidation of stainless steel weldments

by Liane Smith (Intetech Ltd, United Kingdom) and Max Klein (NAM, the Netherlands)

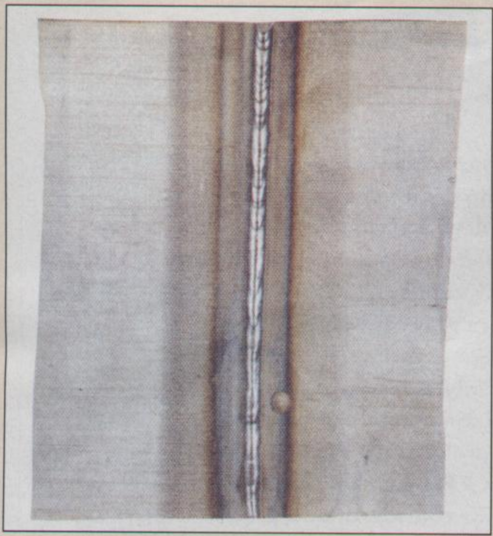
The material very quickly proved itself as highly suitable for resisting corrosion in the prevailing conditions of the projects at that time, i.e. in preventing CO_2 corrosion. Notwithstanding its overall success, the early applications of duplex stainless steel did cause a few notable failures which resulted in a fairly steep learning curve.

In one particular case, a length of flowline was hydro-tested with the most readily available water source, which was canal water, and left with the water in place for a period of some months before being flushed out. That length of pipe was subsequently attached to a longer length of flowline and the complete flowline was then hydro-tested as a single entity. The section of the line which had been originally hydro-tested on its own was found to be leaking at many of the girth welds. Examination of these welds showed that they had suffered from severe crevice corrosion both at the weld bead and at the adjacent heat-affected zone. This highlighted the fact that, whilst 22Cr duplex stainless steels were highly resistant in the production environment, the grades available at that time were not very resistant to aerated natural waters.

It was particularly noticeable that corrosion had initiated at locations where there was a surface heat tint on the weld and it was subsequently shown in corrosion tests that the presence of heat tint significantly reduced resistance to corrosion in aerated aqueous environments. Whilst this general principle was not new, it had been expected that the 22Cr duplex steels would be sufficiently corrosion-resistant to avoid the problem.

The advice which was then issued by NAM was that the quality of hydrotest water should be carefully controlled with chemical dosing to deaerate the water, inhibit corrosion and prevent any harmful bacterial action. Furthermore, weld specifications demanded that much greater care should be taken in the protection of the internal surface of the pipe to prevent surface oxidation. This entailed maintaining a backing shield for a minimum of two weld passes to guarantee that heat tint was limited. Whilst this advice was helpful, it was difficult nonetheless to give guidance on what was an acceptable level of discolouration and what was regarded as dangerous with respect to the corrosion properties. To facilitate this, a series of photographs was produced, showing varying degrees of metal discolouration and inspection of the weld could then be made by direct visual comparison with the photographs (see figures 1–7, all showing duplex stainless steel weldments, Werkstoffnr. 1.4462).

The selected quality level (allowed amount of discolouration) might vary in different circumstances; for example, stainless steels carrying potable water would tolerate slightly more surface heat tint than applications where less



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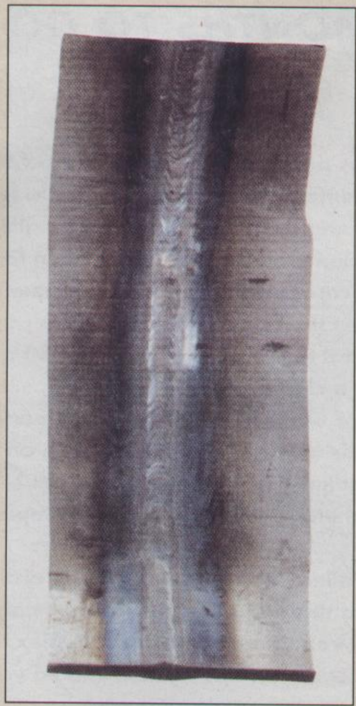

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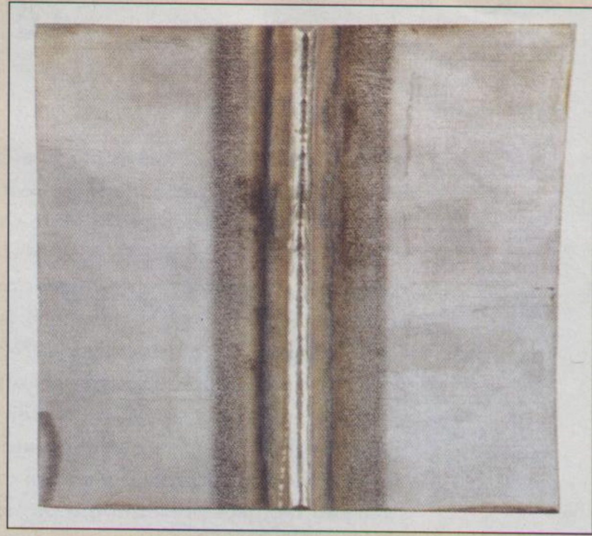

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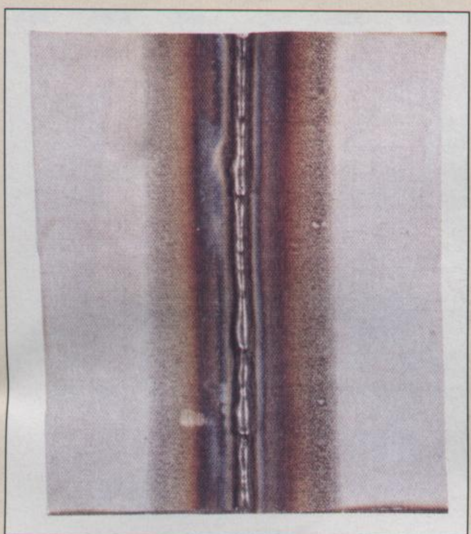
Figure 1 Acceptable. Very good result. No discolouration. Figure 2 Acceptable. Weld free of significant oxidation. Figure 3 Acceptable. Slight discolouration. Weld shiny, no scale present. Figure 4 Acceptable. Slight discolouration. Weld shiny, no scale present. Figure 5 Unacceptable. Oxide layer present (grey colour) on and near weld. Lack of proper backpurging. Figure 6 Unacceptable. Oxide layer present (grey colour), weld burnt. Lack of proper backpurging. Figure 7 Unacceptable. Extremely bad result. Very heavy oxide layer present. This scale may develop when welding with coated electrodes (SMAW) or with TIG welding (GTAW) with severe lack of backpurging.



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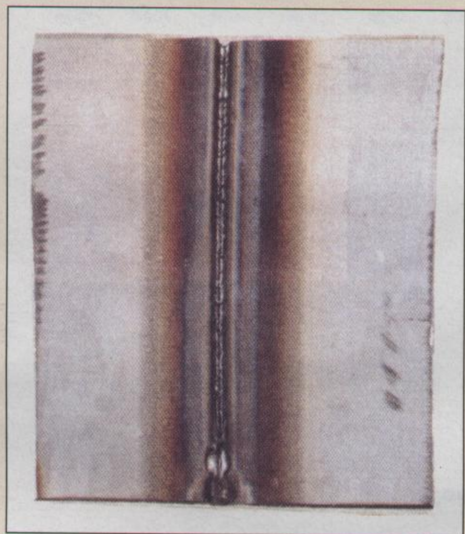

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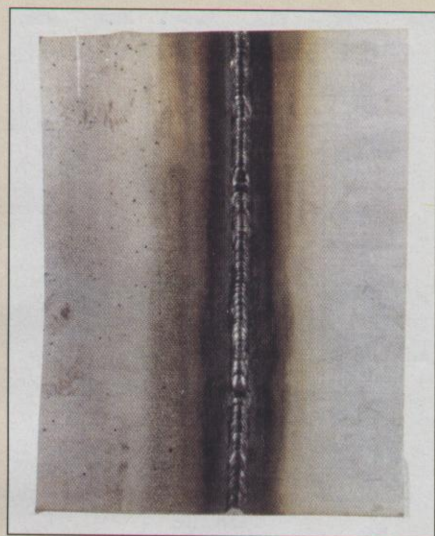

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high quality water had to be carried. Thus there is no absolute acceptance limit, just a graded series of quality levels. It should be noted that in other industries, such as certain chemical environments, much higher cleanliness levels are demanded. In some circumstances it is necessary for welds to be pickled in order to achieve sufficient freedom from surface oxidation. Whilst these still leave a certain amount of interpretation open to the inspector, the existence of the reference photographs has greatly improved the inspector's job and has led to much greater consistency in weld procedure qualification acceptance and, much more importantly, performance of hydro-tested flowlines in actual service. ◄

About the authors

Liane Smith established Intetech Ltd five years ago to provide consultancy services in the field of corrosion analysis, materials selection and welding. Max Klein is Welding Engineer with NAM, the Netherlands.