STAINLESS STEELS AND THE WATER INDUSTRY: FROM KNOWLEDGE TO APPLICATIONS

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Abstract

There is increasing pressure to provide more clean drinking water to more people. At the same time, impact on the environment must be minimized. Stainless steels can and do play an important part in providing cost-effective solutions to these requirements. However, this can only happen when the relevant properties and costs are understood by those who have to make the choice of material for a particular application.

This paper describes how knowledge of corrosion resistance of stainless steels translates into standards and approvals for drinking water contact. It then considers how the properties of stainless steels can be used to advantage when designing durable, cost-effective equipment. This information has to be presented to design engineers and manufacturers locally if they are to consider using stainless steel. Examples will be given of the approaches taken in different countries to increase the market, which might find wider applicability.

One of the most persuasive factors is practical experience. Case studies from Europe, America and Australasia show the reasons behind the choice of stainless steel for applications in water treatment plants, distribution and storage systems, and plumbing in both prestigious and high-rise buildings. Examples are also given of recent innovations.

Taken together, this knowledge from other parts of the world may be used to advantage in local markets.

Introduction

Clean drinking water is a precious resource which many of us take for granted. However, there is increasing pressure to provide more of it to more people throughout the world. There is also a growing awareness of the need to reduce our impact on the environment. That has been particularly apparent in the last few years with wider debate of climate change and sustainability. We know that stainless steels can help to meet these two challenges but we need to convince designers, fabricators and operators in the water industry. That is where the link is needed between Science and Market.

We are very familiar with the properties of stainless steels but we need to present them from the user's point of view. From that perspective, what is required from a material for use in equipment in the water industry is:

- maintenance of water purity, both biological and chemical;
- approval for use;
- durability and low maintenance;

- ease of use;
- cost effectiveness;
- proven performance.

Maintaining water purity and approval for use

The most important factor in making water fit to drink is removal of bacteria and parasites. The water must then be kept clean and safe during storage and distribution, which requires both resistance to residual disinfectants and systems of high integrity. The corrosion resistance of stainless steels make them suitable to meet these requirements in both treatment facilities and distribution networks.

There have been many tests undertaken on the leaching of metal ions from stainless steel into drinking water.[1] All have shown levels well below those allowed by the European Drinking Water Directive 98/83/EC. The UK Drinking Water Inspectorate summarised its tests thus: "… the use of products made from the specified stainless steel grades [1.4307, 1.4404, 1.4462 and similar] in contact with water for public supply would be unobjectionable on health grounds."[2] There have been similar approvals for the use of stainless steels in other EU countries, in the USA and elsewhere. A European Approval Scheme for Construction Products in Contact with Drinking Water is being developed. Eurofer is actively engaged with its development and that of the associated test protocols.

The EU based its maximum permitted levels for metals on the World Health Organisation's Guidelines which at the time were 20 µg/L for nickel. Since then the WHO's guideline value for nickel has been revised upwards to 70 µg/L but there has not yet been any corresponding revision of the EU Drinking Water Directive maximum.

Durability and low maintenance

The low leaching levels of metal ions into drinking water are a direct consequence of the corrosion resistance of these stainless steels. From the designer's point of view, this corrosion resistance has other benefits:

- no need for a corrosion allowance;
- no need for a protective coating;
- no need to control water chemistry (except for adding a biocide);
- no need for a corrosion protection system;
- high flow rates are acceptable;
- disinfectants do not harm the equipment;
- equipment does not suffer degradation by corrosion;
- at the end of life, equipment is recyclable.

Nearly all of those factors contribute to the durability of the equipment and to comparatively low maintenance needs. Those are considerable benefits when seen against the annual cost of corrosion, which has been estimated as $36 billion for the water and sewage systems in the USA.[3]

Full recyclability of materials at end of life is an important consideration for an industry which is as conscious of its environmental impact as the water industry.

Other characteristics of stainless steels

The strength of stainless steels means that thin walled pipe designs are possible, even where yield strength is the limiting factor. The duplex grades have a particular advantage in this respect, offering twice the yield strength of the traditional 300 series stainless steels. At the same time, the ductility of stainless steels allows tees to be pulled directly in pipe walls, thus simplifying assembly. Similarly, the ends of pipes can be flared to allow either bell and spigot joints to be made or loose backing flanges to be used. Advantage can be taken of the ready weldability of stainless steels to design high integrity systems which not only reduce water loss but also prevent ingress of pathogens and other contaminants.

Lightweight construction

The above characteristics can be combined so that stainless steel equipment may be lighter than similar equipment constructed in other materials. That has advantages in reducing the carrying capacity of transport and installation equipment as well as of support structures, see Figure 1.

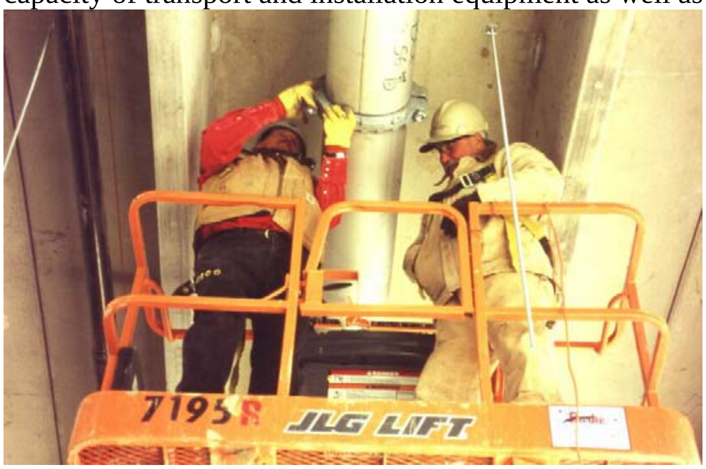

Figure 1. Installation of 300 mm drinking water piping in a sports stadium in Detroit, USA.

More shop and less site fabrication may be possible. Overall, that makes for better control, lower installation cost and a smaller site footprint. More importantly from a sustainability point of view is the reduced material intensity – less material is needed to achieve the same output.

Cost benefits

The cost of using stainless steel is always under scrutiny, particularly at times of high alloying element costs. However, the above discussion shows that it is necessary to take more factors into consideration than just the prevailing price per tonne of material. For example, a study of the installed cost of distribution piping in the USA showed that whilst ductile iron was lower cost in smaller sizes, above 300 mm (12 inches)diameter, the cost advantage favoured stainless steel because of the thinner wall, lighter weight and consequent ease of installation, see Table 1.

Table 1. 2003 costs of stainless steel distribution piping relative to ductile iron.

Nominal Pipe Diameter Inches	Relative Total Cost Comparison Per Linear Foot* 2000LF Project using 40 foot lengths of S.S. Pipe Pipe Material and Diameter				
	Ductile Iron Class 51	304 Sch. 10	316 Sch. 10	2304 Sch. 10	2205 Sch. 10
6	1	1.03	1.11	1.22	1.45
8	1	1.06	1.15	1.27	1.57
10	1	1.09	1.20	1.34	1.63
12	1	0.82	0.91	1.02	1.26
14	1	0.69	0.75	0.96	0.99
16	1	0.69	0.76	0.97	0.98

There may not always be an initial cost benefit for stainless steel. Then it is necessary to look at the resulting operating and maintenance costs by carrying out a life cycle cost study. The necessary discounting calculations are straightforward if the costs are available but it is very important to understand which factors will be the real drivers behind material choice for a particular project. For example, in some projects, reduced leakage and increased plant availability have been the key factors.

From knowledge to application

The body of knowledge about the characteristics and behaviour of stainless steels in water industry applications has been built up over many years. Information can be found in many technical publications and articles. The International Stainless Steel Forum has provided access to many of these through its website www.worldstainless.org. Engineers need straightforward practical guidance on grade selection, design and fabrication because in most cases these will not be prescribed by the codes and standards. Guidance has been produced by the national stainless steel development associations (SSDAs), often in conjunction with a local water industry body – for example, in the UK[4], Germany, Italy and France. Crucially, these guidance documents give confidence in the use of stainless steel by showing how to obtain best performance in practice and how to avoid pitfalls: for example, minimising the risks of crevice corrosion and microbiologically influenced corrosion. These documents are also closely related to the local national standards and approvals because without those it is very difficult to introduce and make use of a new material. Although it has been used in many countries for well over a quarter of a century, stainless steel is still regarded by many water engineers as a new material.

As an example of the need for practical guidance, the question often arises of whether or not heat tint after welding can be left on equipment when it goes into service. The best advice from the point of view of corrosion is to avoid it in the first place or to remove it. However, neither of those is completely practical in some situations. Studies have been made which indicate what degree of heat tint is likely to be acceptable in what circumstances.[5]

Individual companies will always promote their own products but the SSDAs have all been active in promoting the use of stainless steels in the water industry. They produce their own literature and put on seminars in their local language. The important concept is that of global messages being tailored for local delivery. In some cases, there is sufficient interest for national suppliers to work together in order to develop the market. This has happened for distribution piping in the USA (e.g. SPLASH, www.S-P-L-A-S-H.org), pipework in Japan (Japanese Pipe Club) and plumbing in Australia via the SSDA.

Technology transfer is important in getting more widespread use of stainless steel in water applications. That applies not only to the basic applications but also, more importantly, to innovative applications. For example, in many countries – especially in the cities - the distribution networks are now old and in need of replacement; the trenchless method developed to reline old mains in Italy with minimum traffic disruption, see Figure 2, has received wider interest.

Figure 2. Trenchless relining of a water main in a busy street in Padua, Italy

Figure 3 shows some of the different coupling methods available for stainless steel plumbing installations.

Figure 3. Stainless steel capillary, compression and press-fit plumbing fittings.

In conclusion, there are plenty of opportunities for greater use of stainless steels to meet the needs of the water industry around the world if the knowledge can be transferred to the market place.

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