REPORT

TITLE **USE OF ZERON 100 FOR FASTENERS**

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USE OF ZERON 100 FOR FASTENERS

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SUMMARY

This report describes the fasteners available in Zeron 100, and how they can be used to avoid problems of galvanic corrosion of carbon steel and 316 stainless bolts used with high alloy stainless steel piping/flanges.

1.0 INTRODUCTION

Zeron 100 (UNS S32760) is frequently specified for pipework systems handling corrosive fluids. Although many pipes and fittings are joined by welding, in some places it is necessary to use flange connections. Where corrosion of the flange bolts may occur it is desirable to use corrosion resistant fasteners. Zeron 100 is available as a fastener in three different grades. FG grade meets the tensile properties of ASTM A193 grade B7, and FLT grade meets the tensile and Charpy impact properties of ASTM A320 grade L7. In addition Zeron 100 is available as fasteners in the solution annealed form. This has a lower yield and tensile strength compared with FG and FLT grades, but headed fasteners can be manufactured more cheaply in the solution annealed condition. This is because solution annealed bolts can be headed by forging followed by solution annealing, while FG and FLT grades, whose properties are produced by controlled strain hardening, must be machined from bar.

The properties of the fastener grades are summarised in Appendix 1.

A wide range of sizes of fastener grade materials is held in stock, as follows:-

Solution Annealed bar:	¼"	to	11.8"	(6.35mm	to	300mm)	diameter
FG and FLT bar:	½"	to	2½"	(12.7mm	to	63.5mm)	diameter

2.0 APPLICATIONS

Although carbon or low alloy steel bolts could be used with Zeron 100 flanges, in a corrosive environment e.g. marine atmosphere, corrosion will occur and this can be aggravated by the galvanic couple between the steel and Zeron 100. The use of corrosion resistant fasteners eliminates this problem. In submerged marine applications, cathodic protection is sometimes applied to protect carbon or low alloy steel. The need for cathodic protection can be eliminated by the use of Zeron 100 fasteners due to the excellent resistance of Zeron 100 to corrosion in seawater.

Coatings are sometimes used to protect carbon or low alloy steel bolts. Metallic coatings (e.g. zinc) will corrode very quickly when coupled to Zeron 100 in chloride-containing solutions. Organic coatings must be thin to be useful on fasteners, and these can easily be damaged either in storage or during assembly. The area of steel exposed is very small and hence the acceleration of corrosion by the galvanic couple with Zeron 100 will be much greater than for an uncoated bolt. This can lead to very rapid, severe corrosion. The use of Zeron 100 corrosion resistant bolting eliminates this potential problem.

Other stainless fasteners, e.g. 316L have been used with Zeron 100. However, in chloride environments such as seawater, not only can 316 suffer from crevice corrosion, but this will be exacerbated by the galvanic couple between Zeron 100 and the 316. Electrical isolation is sometimes attempted by the use of isolation flanges and/or bolts with non-metallic sleeves. However, these can be damaged either on assembly or in service, and the electrical isolation is then lost and galvanic corrosion can occur. Connection of the piping to a common earth can also negate the effectiveness of an isolation flange. The use of corrosion resistant bolting, such as Zeron 100, eliminates this potential problem.

When fasteners are used subsea they will often be exposed to the cathodic protection which is applied to the rest of the subsea structure. This is typically ~ -1V SCE, and concern has been expressed about the potential for hydrogen embrittlement of duplex stainless steel fasteners. WM&F have been supplying Zeron 100 fasteners since 1990 and have yet to see a failure by any corrosion mechanism, including hydrogen embrittlement. Failures of high strength 25% Cr duplex stainless steel fasteners under cathodic protection have occurred[1], but the high strength had been achieved by ageing. Ageing has been shown to greatly increase the susceptibility of duplex stainless steels to hydrogen embrittlement[1]. The high strength of Zeron 100 FG and FLT grades is achieved by light cold work. Research by TWI[2] has shown that the threshold stress for the initiation of hydrogen embrittlement cracks is around the 0.2% proof stress. The recommendation for loading bolts is usually between 60% and 70% of the proof stress. At these levels of stressing, cracking due to hydrogen embrittlement will not occur.

Zeron 100 fasteners can be used not only with Zeron 100 pipes and flanges, but also with other high alloy, corrosion resistant alloys. These include other superduplex alloys, 6%Mo austenitic stainless steels, and nickel-base alloys such as alloys 625 and C-276.

Zeron 100 fasteners have been used in a wide variety of applications where corrosion resistance is importance. The alloy has been used for attaching the buoyancy modules on subsea risers on several offshore platforms, as shown in Figures 1 and 2. Zeron 100 has also been used to anchor rubber fenders to concrete docks in a Middle East harbour (Figure 3). Weir Materials and Foundries supplied two quarter mile stretches of cast Zeron 100 tunnel lining to London Underground, where the local groundwater was very acidic, due to microbial action, and contained high levels of chloride. The cast sections were all fastened together with Zeron 100 bolts, as were the assembled rings (Figure 4).

3.0 GALLING

Galling is often assumed to be a problem with stainless steels. The problem is traditionally associated with 300 series austenitic alloys. Galling is less of a problem with more highly alloyed austenitic and duplex alloys. Bar in Zeron 100 SA for nuts, is supplied in the solution annealed condition. This typically has a hardness of 50HV less than that of cold worked FG and FLT material. This minimises the risk of galling. Zeron 100 bolts have been used for many years in submersible marine pumps and it is common practice to coat fasteners with ~6µm of copper. This is produced by electroplating and is usually applied to the male stud. This is to ensure ease in dismantling for servicing of the pumps. In critical applications, where very high torques are required, successful use has been reported of conventional anti-galling sprays (e.g. Rocol), copper-loaded greases, and PTFE coatings. The use of molybdenum disulphide lubricant should be avoided for elevated temperature service, because of the risk of decomposition of the lubricant leading to sulphide attack.

4.0 CONCLUSIONS

The use of Zeron 100 fasteners provides a corrosion resistant bolting material that overcomes the galvanic corrosion problems which can occur with less corrosion resistant fastener materials, such as carbon steel and 316L.

References

1. R. Francis, G. Byrne and G. R. Warburton
Corrosion 53 (1997) 234.

2. P. Woollin and A. Gregori, “Avoiding Hydrogen Embrittlement Stress Corrosion Cracking of Ferritic Austenitic Stainless Steels Under Cathodic Protection”, OMAE 2004 – 51203. 23rd Int. Conference on Offshore Mechanics and Arctic Engineering, Vancouver, Canada, June 2004.

Figure 1 Zeron 100 fasteners for locating buoyancy modules on an offshore riser.

FIGURE 2 Deployment of riser with buoyancy modules.

FIGURE 3 Zeron 100 fasteners attaching rubber fenders on a Middle East dock.

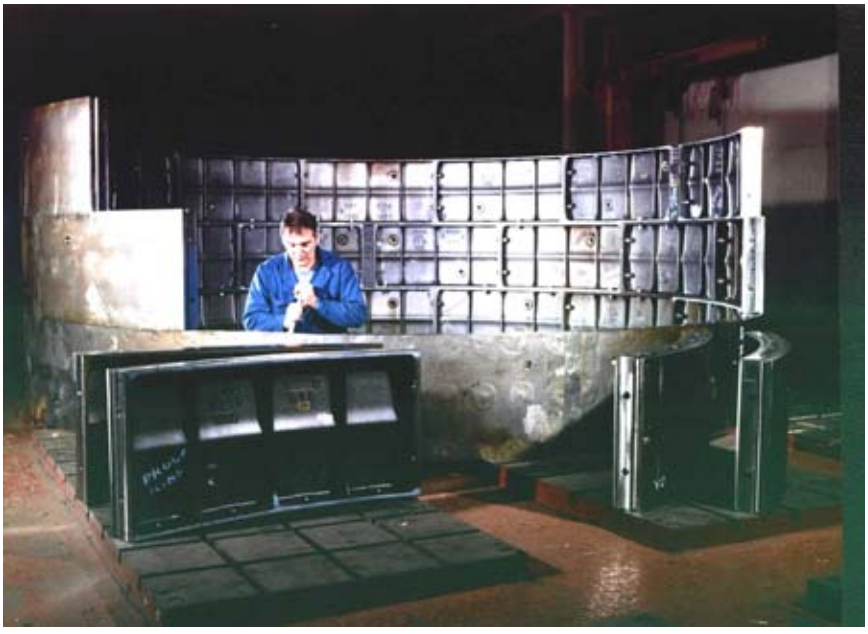

FIGURE 4 LUL tunnel linings fastened with Zeron 100 bolts.

Appendix 1 SUMMARY OF PROPERTIES OF ZERON 100 FOR FASTENERS

BOLTING BAR GRADES – MINIMUM MECHANICAL PROPERTIES

Grade	Yield Strength (0.2% offset) MPa (ksi)	Tensile Strength MPa (ksi)	Elongation in 50mm (%)	Reduction of Area (%)	Charpy V-notch Impact Energy
Zeron 100 SA	550 (80)	≤ 90mm: 800 (116) > 90mm: 750 (109)	25	50	70J (51ft.lbf) mean at -46℃ (-50℉)
Zeron 100 FG	725 (105)	860 (125)	16	50	40J (30ft.lbf) mean at -46℃ (-50℉)
Zeron 100 FLT	725 (105)	860 (125)	16	50	27J (20ft.lbf) mean at -101℃ (-150℉)

ZERON 100 SA - Maximum 28 HRC, meets NACE MR0103-2005 for the solution annealed condition.

ZERON 100 FG – Tensile properties of ASTM A193-B7, plus Charpy impacts, maximum 36 HRC meets NACE MR0175/ISO 15156-3 for the solution annealed & cold worked condition.

ZERON 100 FLT – Tensile and Charpy impact properties of ASTM A320-L7, maximum 36 HRC meets NACE MR0175/ISO 15156-3 for the solution annealed & cold worked condition. .

NUTS

For SA Bolts - SA condition
For FG Bolts - SA condition
For FLT Bolts - SA condition

MANUFACTURING ROUTE

- SA bolting can be forged and solution annealed prior to final testing, or machined from SA bar.
- FG and FLT bolting must be machined from the appropriate grade of bar.