REMR Technical Note EM-CR-8.1

STAINLESS STEEL TAINTER GATE AND TRACTOR-TYPE DAM GATE COMPONENTS: SUCCESSFUL CASE HISTORIES

PURPOSE: To prove that properly selected, corrosion-resistant stainless steels are viable and cost-effective options for tainter gate hoist cable attachment bolts, tainter gate hoist chains, and roller assemblies for tractor-type dam gates (such as intake gates).

APPLICATIONS AND FIELD EXPERIENCE:

Tainter Gate Hoist Cable Attachment Bolts:

In 1972, Type 416 martensitic stainless steel bolts were used for tainter gate hoist cable attachments at both Uniontown Lock and Dam and Newburgh Lock and Dam on the Ohio River. A number of these bolts failed by stress-corrosion cracking after only a few months of service, primarily because the material had been rendered susceptible to this form of environmentally induced delayed fracture during heat treatment.

Based upon the results of testing by personnel at the US Army Construction Engineering Research Laboratory (CERL), the 1.875-in.-diam, 26.75-in.-long tainter gate hoist cable attachment bolts were replaced with bolts fabricated from a martensitic PH (precipitation-hardening) alloy. This stainless steel, Carpenter Custom 450, satisfies the requirements of American Society for Testing and Materials (ASTM) Standard Specification A 564 for a Grade XM25 stainless steel. Carpenter Custom 450 bolts were also installed instead of Type 416 at Smithland Lock and Dam on the Ohio River.

After over 13 years of service involving 468 bolts at Newburgh, 520 bolts at Uniontown, and 572 bolts at Smithland, there has not been a single incident of corrosion-induced hoist cable attachment bolt failure at the three dams.

Tainter Gate Hoist Chains:

In 1977, the underwater portions of the hoist chains on the six tainter gates at Hildebrand Dam on the Monongahela River required replacement. Corrosion of the low-alloy steel hoist chain components (such as forged bars and pins) had created serious binding/seizing problems after less than 19 years of exposure to the river water. Although unacceptable corrosion of the chain sections exposed to the atmosphere could be effectively mitigated by routinely greasing them, a similar solution could not be successfully implemented for the underwater portions.

A change in the material used to fabricate the hoist chain was considered to be the most viable and cost-effective solution to the corrosion problem.

The material selected for this change was Carpenter Custom 450 stainless steel.

The Carpenter Custom 450 stainless steel underwater sections of the tainter gate hoist chains at Hildebrand have been in service for over eight years without corrosion and its associated binding/seizing problems. Based upon this performance, Carpenter Custom 450 stainless steel hoist chains are being installed for the underwater sections on the 11 tainter gates at New Cumberland Lock and Dam on the Ohio River.

Rollers for Tractor-Type Dam Gates:

Until about 20 years ago, the rollers for tractor-type dam gates (sometimes referred to as intake gates) were conventionally fabricated from Type 410 stainless steel which had been heat treated to the strength level provided by a hardness of 259 to 307 Brinell. The heavier-than-usual hydrostatic loads (over 4,000,000 pounds) on the tractor-type gates for Oahe Dam on the Missouri River necessitated the use of either larger Type 410 stainless steel rollers or rollers of increased strength and hardness. During engineering design, it was quickly established that: (1) rollers fabricated from Type 410 would be too large, and (2) the desired size rollers could not be fabricated from any martensitic 400-series stainless steel without some undesirable loss in corrosion resistance. Further, there had been some incidents of rollers cracking when they had been fabricated from Type 410. Serious consideration and evaluation of numerous candidate materials by the design engineers culminated in the selection of corrosion-resistant, martensitic, precipitation-hardening 17-4 PH stainless steel for the rollers at Oahe Dam.

The rollers were cost effectively machined from centerless ground bars of solution-heat-treated 17-4 PH. Subsequently, the rollers were given a simple, low-temperature, precipitation-hardening heat treatment which developed a hardness of 385 to 418 Brinell (a hardness considerably higher than the specified minimum of 365). Equally significant, there was no need to final machine the rollers. The 17-4 PH has excellent resistance to both oxidation/scaling and distortion during the precipitation-hardening heat treatment.

Another advantage obtained by selecting 17-4 PH for the roller material was that the width of the individual rollers could be reduced over 25% which permitted the use of a narrower track. This overall decrease in size in the rollers allowed a more corrosion-resistant, higher strength stainless steel (compared to Type 410) to be used without an increase in cost.

The 17-4 PH rollers and their associated Type 304 stainless steel links and pins, and PH 15-7 Mo stainless steel retaining rings have been in service, both totally immersed and alternately immersed in Missouri River water, since their original installation without corrosion problems. Similar experience has been reported for the roller assemblies on the tractor-type gates at Gavins Point Dam on the Missouri River.

Some Districts are considering using round link chain and pocket wheels for tainter gate hoists. These may fulfill the required design and cost criteria better than roller chain. If suitability is proven, round link chain will be used exclusively on dams on the Mississippi River during major rehabilitation, in the interest of standardization of gate operating machinery.

CONCLUSIONS: High-strength, corrosion-resistant "aerospace" stainless steels have been successfully and cost-effectively used for tainter gate and tractor-type dam gate components. Reduced maintenance costs can be achieved with improved (but generally more costly) stainless steels, through innovations in design.

REFERENCE: CERL return on investment case study: material selection and corrosion analysis. In: US Army Corps of Engineers Information Exchange Bulletin, Vol R3, No. 2, January 1980.