THE CORROSION OF TYPE 304L STAINLESS STEEL BY SOLUTIONS
OF NITRIC ACID-SODIUM DICHROMATE AND NITRIC-HYDROFLUORIC ACIDS

INTRODUCTION

Two solutions commonly used for cleaning, flushing, and decontamination on this project are nitric acid-sodium dichromate and nitric-hydrofluoric acid mixtures. Since these solutions may be used repeatedly, it is desirable that the short-term corrosion rates for these solutions be known so that an estimate of the damage incurred in their use can be made.

OBJECTIVE

The purpose of this report is to provide quantitative data pertaining to the corrosion damage incurred in the use of solutions of 20 wt.% nitric acid-20 wt.% sodium dichromate and 20 wt.% nitric acid-3 wt.% hydrofluoric acid as flushing or decontaminating solutions.

SUMMARY AND CONCLUSIONS

Forty-eight samples of Type 304L stainless steel were given a sensitizing heat treatment and exposed to solutions of 20 wt.% nitric acid-20 wt.% sodium dichromate and 20 wt.% nitric acid-3 wt.% hydrofluoric acid for times ranging from one-half to 24 hours at temperatures from 25°C. to the atmospheric boiling points of the two solutions. At the boiling point, the nitric-dichromate solution exhibited corrosion rates as high as 0.2 inches penetration per month (ipm) and the nitric-hydrofluoric solution gave rates of about 1.0 ipm. The nitric-dichromate solution appeared to show a change in corrosive mechanism with increasing temperature, while the nitric-hydrofluoric solution simply exhibited an increase in corrosion rate with increasing temperature. Both solutions are extremely corrosive; however, judicious selection of contact time and temperature can minimize the damage.

DETAILS

Forty-eight corrosion sample coupons were prepared from Type 304L stainless steel and subjected to a sensitizing heat treatment: one hour at 1250°F., with a water quench. The samples were passivated in 20 wt.% nitric acid prior to exposure. Single samples were immersed in solutions of 20 wt.% nitric acid-20 wt.% sodium dichromate and 20 wt.% nitric acid-3 wt.% hydrofluoric acid for time periods of 0.5, 1, 2, 4, 8, and 24 hours at temperatures of 25, 50, and 75°C. and the atmospheric boiling points of the two solutions. The results of these exposures are shown in Figures 1 and 2.

Figure 1 represents the corrosion rates in the nitric acid-dichromate solution. An examination of these data indicates that the corrosion mechanism in this solution may be temperature dependent. The corrosion rate decreases with time, within the test's duration, at a temperature of 25°C.; remains essentially constant with time at temperatures of 50 and 75°C.; and increases with time at the atmospheric boiling point. The reason for this effect is unknown. This dependence on time and temperature should be considered when using this solution as a repetitive cleaner. Another fact which should be stressed is this: solutions of nitric acid containing as little as 2 wt.% sodium dichromate, or any other hexivalent chromium salt, are

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practically as corrosive as the solution used in this investigation. A solution of 20 wt.% nitric acid-1.3 wt.% sodium dichromate is only one-half as corrosive as a 20 wt.% nitric-20 wt.% dichromate solution.

Figure 2 represents the corrosion rates observed in the nitric-hydrofluoric acid solution. In this solution, the corrosion mechanism appears to be the same at all temperatures. The corrosion rate decreases with time, within the test's duration, with the exception of the curve at the boiling point. This curve reaches a maximum at four hours and then decreases to the end of the test. This decrease in corrosion rate with time is normal for short-term tests. Initially, the surface of the sample is covered with minute irregularities which provide a large surface area-to-volume ratio. These irregularities, or burrs, will corrode quite rapidly until they dissolve. At this time, the corrosion rate curve will level off at the equilibrium rate.

In conclusion, it can be said that the solutions involved in this investigation are extremely corrosive; exhibiting corrosion rates as high as 0.2 ipm for the nitric-dichromate solution at the boiling point and as high as 1.0 ipm for the nitric-hydrofluoric solution at the boiling point. However, judicious selection of time and temperature can minimize the damage incurred in their use as repetitive cleaners.

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FIGURE 1

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CORROSION RATES OF SENSITIZED TYPE 304-L STAINLESS STEEL IN A 20 WEIGHT PERCENT NITRIC ACID-20 WEIGHT PERCENT SODIUM DICHROMATE SOLUTION AT VARIOUS TIMES AND TEMPERATURES

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FIGURE 2

CORROSION RATES OF SENSITIZED TYPE 304-L STAINLESS STEEL
IN A 20 WEIGHT PERCENT NITRIC ACID-3 WEIGHT PERCENT
HYDROFLUORIC ACID SOLUTION AT VARIOUS TIMES
AND TEMPERATURES