Technical Note N-1172

CORROSION OF MATERIALS IN HYDROSPACE - PART VI - STAINLESS STEELS

By

Fred M. Reinhart

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NAVAL CIVIL ENGINEERING LABORATORY
Port Hueneme, California 93043

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ABSTRACT

A total of 1,750 specimens of 57 different stainless steels were exposed in seawater at the surface and at depths of 2,500 and 6,000 feet in the Pacific Ocean for periods of time varying from 123 to 1,064 days in order to determine the effects of the seawater environments at different depths on their corrosion resistance.

Corrosion rates, type of corrosion, pit depths and stress corrosion cracking resistance are presented.

Cast stainless steel, Ni-Cr-Mo-Si, was uncorroded.

AISI Types 317 and 329 stainless steels were attacked by incipient (less than 1 mil deep) crevice corrosion. Stainless steel 20Cb-3 was attacked by both incipient crevice corrosion and incipient pitting corrosion. Most of the corrosion on AISI Type 325 stainless steel was of the general surface type.

All the other stainless steels, AISI Types 200, 300, 400 and 600 series and miscellaneous alloys, both cast and wrought, were attacked by pitting, tunneling and crevice types of corrosion varying in intensity from depths of 1 mil to complete perforation of the thickness of the material and tunnels to 12 inches long.

In general, corrosion in surface seawater was more severe than in the deep seawater and in the bottom sediments at depths of 2,500 and 6,000 feet for equivalent periods of exposure.

Sensitization decreased the corrosion resistance of AISI Types 304 and 316 stainless steels.

Stainless steel wire ropes were also attacked by the pitting and crevice types of corrosion.

Precipitation hardening stainless steels 630-H925, 631-TH1050 and RH1050, 632-RH1100, 15-7AMV-annealed, RH950 and RH1150 and PH14-8Mo-SRH950 failed by stress corrosion cracking.

PREFACE

Since 1959 the Naval Civil Engineering Laboratory has been developing the technology necessary for designing, constructing, inspecting and maintaining Naval structures and fixed equipment on the ocean floor. A part of this program is to determine the effects of deep ocean environments on the corrosion of metals and alloys.

A Submersible Test Unit (STU) was designed, on which many test specimens can be mounted. The STU can be lowered to the ocean floor for long periods of exposure, then retrieved.

Thus far, two deep-ocean test sites in the Pacific Ocean have been selected. Six STUs have been exposed and recovered. Test Site I (nominal depth of 6,000 feet) is approximately 81 nautical miles west-southwest of Port Hueneme, California, latitude 33°44'N and longitude 120°45'W. Test Site II (nominal depth of 2,500 feet) is 75 nautical miles west of Port Hueneme, California, latitude 34°06'N and longitude 120°42'W. In addition, a surface seawater exposure Site V was established at Point Mugu, California, latitude 34°06'N and longitude 119°07'W, to obtain surface immersion data for comparison purposes.

This report presents the results of the evaluations of stainless steels exposed at the above three sites.

INTRODUCTION

The development of deep diving vehicles which can stay submerged for long periods of time has focused attention on the deep ocean as an operating environment. This has created a need for information concerning the behavior of common materials of construction as well as newly developed materials with promising potentials, at depths in the oceans.

Since 1959 the Naval Civil Engineering Laboratory has been developing the technology necessary for designing, constructing, inspecting and maintaining structures and fixed equipment on the ocean floor. A part of this program is to determine the effects of deep ocean environments on the corrosion of metals and alloys.

In order to determine the effects of deep ocean environments on the corrosion of metals and alloys, a Submersible Test Unit (STU) was designed, on which many test specimens can be mounted. A STU unit is shown in the inset of Figure 1.

The test sites for the deep ocean exposures are shown in Figure 1, and their specific geographical locations are given in Table 1. The complete oceanographic data at these sites, obtained from NCEL cruises between 1961 and 1967, are summarized in Figure 2. Initially, it was decided to utilize the site at the 6,000-foot depth (STU I-1, 2, 3 and 4). Because of the minimum oxygen concentration zone found between the 2,000- and 3,000-foot depths during the early oceanographic cruises, it was decided to establish a second site (STU II-1 and II-2) at a nominal depth of 2,500 feet. For comparative purposes the surface water Site V was established. Even though the actual depths are shown in the tables, the nominal depths of 6,000 and 2,500 feet are used throughout the text.

A summary of the characteristics of the waters 10 feet above the bottom sediments at the two deep ocean exposure sites and 5 feet below the surface at the surface exposure site is given in Table 1.

Sources of information pertaining to the biological characteristics of the bottom sediments, biological deterioration of materials, detailed oceanographic data, and construction, emplacement and retrieval of STU structures are given in Reference 1. Bottom sediments as used herein means from the water-mud interface to a mud depth of about 6 inches.

The procedures for the preparation of the specimens for exposure and for evaluating them after exposure are described in Reference 2.

Previous reports pertaining to the performance of materials in the deep ocean environments are given in References 1 through 11.

This report presents a discussion of the results of the corrosion of stainless steels obtained for the seven exposure periods shown in Table 1.

RESULTS AND DISCUSSIONS

The results presented and discussed herein also include the corrosion data for stainless steels exposed on the STUs for the International Nickel Company, Inc. Permission for their incorporation in this report has been granted by Dr. T. P. May, Reference 12.

Results from the Annapolis Division, Naval Ship Research and Development Center, another participant in the NCEL exposures, are also included, Reference 13.

Deep ocean corrosion results from the Atlantic Ocean (Reference 14) and surface seawater corrosion data from the Pacific Ocean (Reference 15) are included for comparison purposes.

The corrosion resistance of the stainless steels is by virtue of a very thin stable film on the surface of the alloy which results from the alloying of carbon steels and chromium. Chromium, being a passive metal (corrosion resistant), imparts its passivity to steel when alloyed with it in amounts of 12 percent or greater. These iron-chromium alloys are very corrosion resistant in oxidizing environments because the passive film is maintained in most environments when a sufficient amount of oxidizing agent or oxygen is present to repair any breaks in the protective film.

The corrosion resistance of the stainless steels is further enhanced by the addition of nickel to the iron-chromium alloys. This group of alloys is popularly known as the 18-8 (18 percent chromium - 8 percent nickel) stainless steels.

In general, oxidizing conditions favor passivity (corrosion resistance) while reducing conditions destroy it. Chloride ions also destroy passivity.

The stainless steels usually corrode by pitting in seawater. Pits begin by breakdown of the passive film at weak spots or at inhomogenities. The breakdown is followed by the formation of an electrolytic cell, the anode of which is a minute area of active metal and the cathode of which is a considerable area of passive metal. The large potential difference characteristic of this "passive-active" cell accounts for considerable flow of current with attendant rapid corrosion at the small anode (pitting).

Pitting is most likely to occur in the presence of chloride ions (for example, seawater), combined with such depolarizers as oxygen or oxidizing salts. An oxidizing environment is usually necessary for preservation of passivity with accompanying high corrosion resistance, but, unfortunately, it is also a condition for occurence of pitting. The oxidizer can often act as depolarizer for passive-active cells established by breakdown of passivity at a specific point or area. The chloride ion in particular can accomplish this breakdown.

Aerated seawater (near neutral chloride solution) can pit stainless steels. Pitting is less pronounced in rapidly moving seawater (aerated solution) as compared with partially aerated stagnant seawater. The flow of seawater carries away corrosion products which would otherwise accumulate at crevices or cracks. It also insures uniform passivity through free access of dissolved oxygen.

The chemical compositions of the stainless steels in this investigation are given in Table 2.

CORROSION

As discussed above, stainless steels generally corrode by pitting, particularly in seawater; therefore, as much as 90 to 95 percent of the exposed surface can be uncorroded. Pitting typical of that usually found in stainless steels is shown in Figure 3. With such low percentages of the total exposed area affected, corrosion calculated from loss in weight as mils per year (MPY) can give a very misleading picture. MPY infers a uniform decrease in thickness, which for stainless steels is not the case.

A manifestation of pitting corrosion whose presence and extent is often overlooked is tunnel corrosion. An illustration of tunnel corrosion extending almost the entire length of a 12-inch specimen is shown in Figure 4. Tunnel corrosion is also classified by some as edge, honeycomb or underfilm corrosion. Tunnel corrosion is insidious because of its nature and by virtue of the fact that many times it is not apparent from the outside surfaces of the object. It starts as a pit on the surface or on an edge and propogates laterally through the material, many times leaving thin films of uncorroded metal on the exposed surfaces.

Another manifestation of localized attack in stainless steels is oxygen concentration cell corrosion in crevices (usually known as crevice corrosion). An illustration typical of crevice corrosion in stainless steels is shown in Figure 5. This type of corrosion occurs underneath deposits of any kind on the metal surface, underneath barnacles and at the faying surfaces of a joint. The area of stainless steel which is shielded from the surrounding solution becomes deficient in oxygen, thus creating a difference in oxygen concentration between the shielded and unshielded areas. An electrolytic cell is created with a difference of potential being generated between the high and low oxygen concentration areas with the low oxygen concentration area becoming the anode of the cell.

Low weight losses and corrosion rates accompany these manifestations of corrosion. Thus, the integrity of a stainless steel structure can be jeopardized if designed solely on the basis of corrosion rates calculated from weight losses rather than on the basis of measured depths of pits, lengths of tunnel corrosion and crevice corrosion. Pitting, tunneling and crevice corrosion can, and do, penetrate stainless steel rapidly, thus rendering it useless in short periods of time.

Therefore, corrosion rates expressed as MPY calculated from weight losses, maximum pit depths, maximum lengths of tunnel corrosion, and depths of crevice corrosion are shown graphically in the figures to provide an overall picture of the corrosion of the stainless steels.

The corrosion rates, maximum pit depths, maximum lengths of tunnel corrosion, depth of crevice corrosion and types of corrosion are given in Tables 3 through 7 and all except tunnel corrosion are shown graphically in Figures 6 through 44.

AISI Type 200 Series Stainless Steels

The AISI 200 Series stainless steels are 300 Series stainless steels modified by substituting manganese for about half of the nickel. This modification does not hinder the corrosion resistance of the iron-chromium-nickel alloys in many environments.

The corrosion rates, maximum pit depths, depths of crevice corrosion and types of corrosion are given in Table 3. The corrosion rates, maximum pit depths and depths of crevice corrosion are shown graphically in Figures 6 and 7.

Corrosion of AISI Type 201 stainless steel, Figure 6, after 6 months of exposure was more severe at the 2,500-foot depth than at the surface or at a depth of 6,000 feet because of crevice corrosion. After 1 year at the surface, there was severe edge corrosion and at the 2,500-foot depth there was crevice corrosion. There was only incipient crevice corrosion in seawater after 2 and 3 years of exposure at the 6,000-foot depth. The bottom sediments at both depths were no more corrosive than the seawater except after 3 years of exposure at the 6,000-foot depth where the specimen was perforated by pitting corrosion.

AISI Type 202 stainless steel was attacked more severely in the seawater by pitting and crevice corrosion after 6 and 12 months of exposure at the surface than at depths of 2,500 and 6,000 feet, Figure 7. The 64-mil thick material was perforated both by pitting and crevice corrosion within 6 months at the surface as contrasted to incipient or no corrosion at depth. After 1 year crevice corrosion had penetrated to a depth of 17 mils at a depth of 2,500 feet with no attack at the 6,000-foot depth.

There was neither pitting corrosion nor incipient crevice corrosion after 2 and 3 years of exposure at the 6,000-foot depth.

Corrosion in bottom sediments at both depths was about the same as in the seawater.

The rapidity of the progress of pitting and crevice corrosion at the surface as contrasted to the progress at both depths (2,500 and 6,000 feet) indicates that the surface environment was more aggressive to AISI Type 202 stainless steel than were the environments at depth. Variables at the surface which differ from those at depth, to which could be attributed the more rapid corrosion,are higher oxygen concentration and the attachment of fouling organisms.

AISI Type 205 stainless steel exposed in the Tongue-of-the-Ocean, Atlantic Ocean, for 111 days at a depth of 5,600 feet corroded much more rapidly than did the two Cr-Mn-Ni steels at depths of 2,500 and

6,000 feet in the Pacific Ocean after 6 months of exposure, Reference 14. The oxygen concentration of the seawater at a depth of 5,600 feet in the Atlantic was about the same as that at the surface in both the Atlantic and Pacific Oceans, which could be the reason for the rapid rate of pitting. Its performance at the 5,600-foot depth in the Atlantic is comparable with the performance of AISI Type 202 after 6 months of exposure at the surface in the Pacific where the oxygen concentrations were about the same.

AISI Type 201 stainless steel was much more resistant to corrosion by seawater at the surface and at depth than was AISI 202.

AISI Type 300 Series Stainless Steels

The AISI Type 300 stainless steels are those which contain a minimum of 16 percent chromium and 6 percent nickel and are classed as austenitic.

The corrosion rates, maximum pit depths, maximum lengths of tunnel corrosion, depths of crevice corrosion and types of corrosion are given in Table 4 and all except the types of corrosion and tunnel corrosion are shown graphically in Figures 8 through 23.

Corrosion of AISI Type 301 stainless steel was predominately of the pitting and tunneling types, Figure 8. The 103-mil thick specimens were perforated by pitting and tunneling within 6 months of exposure in seawater at the surface and by tunneling within 6 months of exposure at both the 2,500- and 6,000-foot depths. The bottom sediments at the 2,500- and 6,000-foot depths were about as corrosive as the seawater above.

AISI Type 302 stainless steel, Figure 9, was perforated by pitting and tunneling corrosion within 6 months at the surface and by pitting, tunneling and crevice corrosion within the same period of exposure at the 2,500-foot depth. Only crevice corrosion was significant at the 6,000-foot depth after longer than 6 months of exposure except that the alloy was perforated by tunnel corrosion after 751 days in the bottom sediment and the longest tunnel was 6 inches. The bottom sediments generally were no more aggressive than the seawater above. Crevice and tunneling corrosion were more prevalent than was the pitting type of corrosion.

Forgeson, Southwell and Alexander, Reference 15, reported that AISI Type 302 stainless steel was perforated (261 mils) within 1 year when exposed in surface seawater in the Pacific Ocean at Fort Amador, Panama Canal Zone. This corrosion attack was considerably more rapid than at both the 2,500- and 6,000-foot depths and at the surface at Port Hueneme for the same period of exposure. It is attributed to the differences in oxygen contents of the seawater and to differences in temperature.

The pitting and tunneling types of corrosion were more severe in AISI Type 304 stainless steel than was crevice corrosion, Figure 10.

The 210-mil thick specimens were perforated by pitting and tunneling after 6 months of exposure at the surface and after 1 year and longer at depths of 2,500 and 6,000 feet. Crevice corrosion was serious but its penetration rate was lower than either the pitting or tunneling rates. The bottom sediments were less aggressive at both depths than was the seawater above them.

Brown, et. al. (Reference 14), reported that the maximum pit depth of AISI Type 304 was 27 mils after 111 days of exposure in the Tongue of the Ocean at a depth of 5,600 feet. In the NCEL tests there was no pitting of Type 304 after 6 months of exposure at depths of either 2,500 or 6,000 feet but there was tunneling, the longest of which was about 1 inch at the 2,500-foot depth.

Sensitized (heated for 1 hour at 1200°F and cooled in air) AISI Type 304 was more susceptible to pitting and crevice corrosion at the surface and at depths of 2,500 and 6,000 feet (Figure 11) than was the unsensitized alloy (Figure 10). The 50-mil thick specimens were perforated by crevice corrosion in all three seawater environments after 6 months of exposure. The bottom sediments of both depths were not as aggressive as was the seawater at these depths.

The corrosion of AISI Type 304L stainless steel was comparable with that of AISI Type 304 stainless steel as shown by comparing Figure 12 with Figure 10. Pitting and tunneling corrosion were more severe than was crevice corrosion, the 115-mil thick specimens being perforated by the pitting and tunneling types after 1 year of exposure at the surface and at both depths, 2,500 and 6,000 feet. From the standpoint of pitting and tunneling corrosion, the seawater at the 2,500- and 6,000-foot depths was more aggressive than the bottom sediments, but from the standpoint of crevice corrosion the reverse was true.

As shown in Figure 13, AISI Type 309 stainless steel was free of pitting during surface exposures and at the 2,500-foot depth for 1 year and at the 6,000-foot depth for exposures as long as 3 years. There was only incipient crevice corrosion of this alloy except after 6 months at the surface where it had penetrated to a depth of 33 mils. The aggressiveness of the bottom sediments was the same as the water above them.

There was no pitting corrosion of AISI Type 310 stainless steel during surface seawater exposures or during exposure at a depth of 2,500 feet for 1 year or at a depth of 6,000 feet for 3 years, Figure 14. There was only incipient crevice corrosion except after exposure for 1 year at the surface, perforated (50 mils), and at the 2,500-foot depth, 14 mils. The bottom sediments were no more aggressive than was the water above them.

There was no pitting corrosion of AISI Type 311 stainless steel except during the surface exposures, Figure 15. The alloy was penetrated to a depth of 28 mils after 6 months of exposure with only incipient pitting being present after 1 year of exposure. Crevice corrosion was the most prevalent type, it being incipient or shallow at depth, but perforated the 50-mil thick specimens after 6 months of exposure at the surface. The aggressiveness of the bottom sediments was the same as the seawater at depth.

The pitting and tunneling types of corrosion were more severe on the AISI Type 316 stainless steel than was crevice corrosion although the incidence of crevice corrosion was greater, Figure 16. The pitting corrosion was also associated with the tunneling type of corrosion with the tunnels being longer in the surface exposures. The intensity of the pitting corrosion is indicated by the fact that the 230-mil thick specimens were perforated within 181 days of exposure at the surface and after 402 days of exposure at the 2,500-foot depth. Pitting corrosion was slightly worse in the seawater at depth than in the bottom sediments but the reverse was found for crevice corrosion.

The corrosion of AISI Type 316 stainless steel at the 6,000-foot depth in the Pacific Ocean after 1064 days of exposure was slightly faster than at the 5,600-foot depth in the Tongue-of-the-Ocean after 1050 days of exposure; Brown, et al., Reference 14, reported no pitting or crevice corrosion in the Tongue-of-the-Ocean while the maximum pit depth in the Pacific was 21 mils and crevice corrosion was 1 mil.

Forgeson, et al., Reference 15, reported perforation by pitting (245 mils) of AISI Type 316 stainless steel after 1 year of exposure in surface seawater in the Pacific Ocean at Fort Amador, Panama Canal Zone. Specimens 230 mils thick were perforated both by pitting and tunneling within 6 months exposure in seawater at the surface at Port Hueneme. With a higher water temperature at Fort Amador than at Port Hueneme one would expect more rapid corrosion at Fort Amador. The faster corrosion at Port Hueneme indicates that other variables have an effect, at least in the case of stainless steel.

Sensitization (heated 1 hour at 1200°F and cooled in air) rendered AISI Type 316 stainless steel more susceptible to corrosion, (crevice corrosion particularly) than the unsensitized steel, as shown by comparison of Figures 16 and 17. Crevice corrosion ranged from incipient to perforation of the 50-mil thick specimens after 1 year in seawater at the surface and after 2 years at the 6,000-foot depth both in seawater and the bottom sediment. The bottom sediments were about the same as seawater at depth with regard to crevice corrosion but were less aggressive with regard to pitting corrosion.

The corrosion of AISI Type 316L (the low-carbon version of AISI Type 316) stainless steel, Figure 18, is comparable with that of AISI Type 316 stainless steel even though crevice corrosion was more frequent and pitting and tunneling corrosion were less frequent than on the Type 316. Corrosion in the bottom sediments was about the same as in the seawater above them.

AISI Types 317 and 329 stainless steels were attacked only by incipient crevice corrosion when exposed in seawater at the surface and at a depth of 2,500 feet for 1 year and when exposed at a depth of 6,000 feet for 3 years, Figure 19. The same was true for the bottom sediments.

There was no pitting corrosion of AISI Type 321 stainless steel in seawater except to a depth of 22 mils after 1 year of surface exposure,

Figure 20. Crevice corrosion in seawater was more prevalent than pitting corrosion and ranged from incipient to perforation of the 30-mil thick specimens after exposure for 1 year at a depth of 2,500 feet. Pitting corrosion was the same in the bottom sediments as in seawater at both depths but crevice corrosion was less intense than in the seawater.

Forgeson, et al.,Reference 15, reported perforation (270 mils) by pitting of AISI Type 321 stainless steel after 1 year of exposure in seawater at the surface at Fort Amador, Panama Canal Zone in the Pacific Ocean as compared to a maximum pit depth of 22 mils after 1 year of exposure at the surface at Port Hueneme in the Pacific Ocean. This performance at Fort Amador is considerably greater than the corrosion of this alloy at both depths in the Pacific Ocean at Port Hueneme. These differences can be attributed to the higher temperature and oxygen concentration at Fort Amador.

AISI Type 325 stainless steel differed from the other 300 Series stainless steels in its corrosion behavior in that the types of corrosion were general or pitting associated with higher calculated corrosion rates, Figure 21. On the basis of corrosion rates calculated from weight losses the seawater at depth was more corrosive than the bottom sediments, and seawater at the surface was more aggressive than that at depth.

Except for perforation of the 50-mil thick specimens of AISI Type 330 stainless steel exposed at the surface for 6 months and 1 year, there was no pitting corrosion of this alloy, Figure 22. Crevice corrosion in the seawater was more prevalent than pitting corrosion ranging from incipient to perforation of the 50 mil thick specimens after 6 months of exposure at the surface and of the 30-mil thick specimens after 1 year of exposure at the 2,500-foot depth. The aggressiveness of the bottom sediments was about the same as that of the seawater at depth.

Pitting and crevice corrosion were much more severe on AISI Type 347 stainless steel in seawater at the surface than at depth, the 50 mil thick specimens being perforated by both types of corrosion as shown in Figure 23. There was no pitting in seawater at either depth, 2,500 or 6,000 feet, while crevice corrosion ranged from none to 10 mils deep. Crevice corrosion in the bottom sediments was more severe than in the seawater at depth, the 50-mil thick specimens were perforated after 3 years of exposre at the 6,000-foot depth. Pitting corrosion in the bottom sediments was of the same severity as in seawater at depth.

The predominate types of corrosion on the AISI 300 Series stainless steels were crevice, tunneling and pitting corrosion. The one exception was AISI Type 325 stainless steel which contained only 9.0 percent chromium and 23.5 percent nickel, which was chiefly attacked by general corrosion with some pitting and crevice corrosion.

The surface seawaters were more aggressive than the seawater at either depth. The rates of penetration of pitting, tunneling and crevice corrosion were much greater for 11 of the 16 alloys exposed for 6 months at the surface than at either 2,500 or 6,000 feet. This can be attributed to the higher oxygen concentration and the attachment of sea life to the specimens at the surface.

In general the degree of corrosion appeared to decrease as the chromium and nickel contents of the 300 Series stainless steels increased. For example, the incidence and depth of pitting, tunneling and crevice corrosion were less on the Types 309, 310 and 311 steels than on the Types 304 and 316 steels.

Sensitization of AISI 304 and 316 stainless steels decreased their corrosion resistance.

AISI Type 400 Series Stainless Steels

The AISI Type 400 stainless steels are those which contain a minimum of 12 percent chromium. Steels containing up to 18 percent chromium are hardenable by heat treatment and are classed as martensitic, i.e., Type 410. Those with chromium above 18 percent and the normal amounts of carbon are non-hardenable by heat treatment and are classed ferritic; ferritic stainless steels in this investigation were Types 405, 430 and 446.

The corrosion rates, maximum pit depths, maximum tunnel lengths, maximum depths of crevice corrosion and types of corrosion are given in Table 5 and are shown, except for tunnel corrosion, graphically in Figures 24 through 27.

The corrosion of the martensitic stainless steel AISI Type 410 was chiefly of the pitting, tunneling and crevice types, Figures 24 and Table 5. The 50-mil thick specimens were perforated and tunnels nearly 3 inches long had developed within 181 days at the surface and 123 days at a depth of 6,000 feet.

The corrosion of the ferritic stainless steel AISI Type 405 was chiefly of the tunneling type for the shorter periods of exposure (6 months) but was perforated by pitting corrosion after 751 days of exposure at a depth of 6,000 feet, Figure 25. After 1,064 days of exposure at the 6,000-foot depth a tunnel 12 inches long had developed which nearly severed the panel longitudinally. On the basis of maximum pit depths and the maximum length of tunnels, Type 405 was less susceptible than Type 410; the 50-mil thick specimens of Type 410 were perforated after 123 and 197 days at depth whereas the maximum pit depth in seawater of Type 405 was 40 mils after 402 days of exposure at depth.

Ferritic stainless steel AISI Type 430 was perforated by pitting and crevice corrosion after 6 months of exposure at the surface and at the 2,500-foot depth but was less severe at the 6,000-foot depth, Figure 26. The alloy, also, was perforated by tunnels 2.375 and 1 inch long within 6 months of exposure at the 2,500- and 6,000-foot depths, respectively.

The high chromium (30 percent) ferritic stainless steel, AISI Type 446, was much less corroded at either depth (2,500 and 6,000 feet) than at the surface, Figure 27. The 50-mil thick specimens were perforated by pitting and creivce corrosion in seawater within 6 months of surface exposure as contrasted to incipient crevice corrosion at the 2,500-foot depth.

In general, the martensitic stainless steel, AISI Type 410, was more susceptible to corrosion than the ferritic stainless steels. This is attributed to the lower chromium content of the AISI Type 410 stainless steel.

Precipitation Hardening Stainless Steels

The precipitation hardening stainless steels differ from the conventional stainless steels (AISI Series 200, 300 and 400) in that they can be hardened to very high strength levels by heating the annealed steels to low temperatures (900-1200°F) and cooling in air.

The corrosion rates, maximum pit depths, maximum tunnel lengths, maximum depths of crevice corrosion and types of corrosion are given in Table 6 and are shown, except for tunneling, graphically in Figures 28 through 38. The predominant modes of corrosive attack were pitting, tunneling and crevice.

Surface seawater was more aggressive to AISI Type 630-H925 than was seawater at depths of either 2,500 or 6,000 feet as shown in Figure 28. At the surface the specimens were perforated by pitting, tunneling and crevice corrosion with no pitting or crevice corrosion at either depth after 6 and 13 months of exposure. After 13 months of exposure both at the surface and at the 6,000-foot depth the weld beads were perforated. Welding did not adversely affect the corrosion resistance of the alloy. The bottom sediments were no more aggressive than was the seawater above them.

The welded specimens of AISI Type 631-TH1050 were perforated by pitting, tunneling and crevice corrosion after 6 months of exposure both at the surface and at the 2,500-foot depth, Figure 29. The bottom sediments were equally as aggressive as the seawater above them. The specimens with the unrelieved circular welds failed by stress corrosion cracking with the cracks chiefly extending radially across the weld beads after 13 months of exposure at the surface and in the bottom sediment at the 6,000-foot depth.

The welded AISI Type 631-RH1050 specimens were perforated by pitting, tunneling and crevice corrosion after 6 months of exposure in seawater at the surface, Figure 30. However, the specimens at the 2,500-foot depth were less severely attacked than were those at the surface. The specimens with the unrelieved circular weld bead failed by stress corrosion cracking after 6 months and 1 year of exposure in the seawater at the 2,500-foot depth and after 1 year of exposure at the 6,000-foot depth. Portions of the specimens partially embedded in the bottom sediment at the 6,000-foot depth were corroded away after 1 year of exposure, chiefly because of tunneling corrosion.

Welded AISI Type 633-RH1100 specimens were perforated by tunneling type of pitting corrosion within 6 months of exposure at the surface and at the 2,500-foot depth, Figure 31. After 1 year of exposure at the surface and at the 6,000-foot depth they were also perforated by crevice corrosion. The weld beads were unattacked except after 1 year of exposure in the bottom sediment, at the 2,500-foot depth where the butt welded specimen was perforated by tunneling corrosion in the heat affected zone and the circular weld specimen failed by stress corrosion cracking.

AISI Type 633 stainless steel was attacked only by incipient crevice corrosion at the surface and at both depths except that it was 1 mil deep after 1064 days of exposure in the bottom sediment, Figure 19.

Crevice and incipient pitting were the manifestations of corrosion on AISI Type 634-CRT stainless steel, Figure 32. Crevice corrosion was most severe after 1 year of exposure at depth of 2,500 and 6,000 feet.

Corrosion of the crevice, tunneling and pitting types were more severe and rapid at the surface than at depth for AISI Type 635 stainless steel, Figure 33. The specimens were perforated by crevice corrosion within 6 months of exposure at the surface but not until after 1 year of exposure at the 2,500-foot depth.

Except for pitting to a maximum depth of 3 mils after 6 months of exposure at the surface,a precipitation hardening stainless steel containing 17Cr-14Ni-3Cu-2Mo was attacked by incipient crevice corrosion after longer periods of exposure both at the surface and at depth, Figure 34.

The rates of pitting and of tunneling attack on welded stainless steel Ph14-8Mo-SRH950 was greater in surface seawater than at either depth for equivalent periods of exposure, Figure 35. Pitting and tunneling corrosion were more prevalent than crevice corrosion. Pitting corrosion perforated the weld bead in one specimen after 6 months of exposure at the surface and the heat affected zone adjacent to the weld bead after 1 year at the 6,000-foot depth.

Precipitation hardening stainless steel 15-7AMV in three heat-treated (aged) conditions; annealed, RH1150 and RH950 corroded at extremely rapid rates by crevice, pitting, tunneling and edge corrosion as shown in Figures 36, 37 and 38. In many instances, large portions of the specimens had been consumed by corrosion; in other cases tunneling corrosion had progressed for 11 of the 12-inch length of the specimens within a year's time.

The 15-7AMV precipitation hardening stainless steels were more susceptible to corrosion than the others.

In general the corrosion resistance of the precipitation hardening stainless steels was less than that of the 200, 300 and 400 Series stainless steels.

Miscellaneous Stainless Steels

Included in this category are cast, specialty and modified stainless steels.

The corrosion rates, maximum pit depth, maximum tunnel length, maximum depth of crevice corrosion and types of corrosion are given in Table 7 and shown, except for tunneling, graphically in Figures 39 through 44.

Wrought stainless steel 20Cb which was developed to resist reducing conditions was susceptible to some pitting and crevice corrosion, Figure 39. The only case of pitting occurred during 398 days of exposure at the surface where the maximum depth was 14 mils. There was no pitting at either depth for as long as 3 years of exposure. The deepest crevice corrosion in seawater was 26 mils after 2 years of exposure at the 6,000-foot depth. Except for these isolated cases of corrosion the alloy was not attacked.

A slightly modified version of 20Cb, (4 percent higher nickel) designated 20Cb-3, was more resistant than 20Cb to seawater and the bottom sediments. There was only incipient pitting and incipient crevice corrosion after exposure at the surface for 1 year and at depth for 3 years, Figure 19.

The corrosion of two cast versions of 20Cb, Ni-Cr-Cu-Mo numbers 1 and 2, are shown in Figures 40 and 41. There were isolated cases of crevice corrosion and pitting corrosion similar to the behavior of 20Cb. For both cast Ni-Cr-Cu-Mo alloys crevice corrosion during surface exposure was more rapid than at depth. Their behavior in the bottom sediments was the same as in the seawater immediately above the sediments.

A cast Ni-Cr-Mo stainless alloy was free of pitting corrosion during exposure at the surface and at depth both in seawater and in the bottom sediments, Figure 42. Crevice corrosion was slight, the maximum depth being 1 mil after 1 year at the 2,500-foot depth.

A cast stainless steel containing Ni-Cr-Mo-Si was free of any type of corrosion both during surface exposure and during exposure at depths of 2,500 and 6,000 feet. This was the only stainless steel which was not corroded insome manner.

Cast alloy RL-35-100 was free from both pitting and crevice corrosion in seawater and the bottom sediments, Figure 43. The type of corrosion was surface etching or general surface attack which is completely different from any of the other stainless steels used in this program.

An alloy containing 18Cr-14Mn-0.5N is a modified 300 Series stainless steel in which 14 percent Mn and 0.5N were substituted for the nominal 8 percent Ni to conserve the use of nickel. The substitution did not improve the corrosion resistance of the 300 Series stainless steels; its corrosion behavior is shown in Figure 44. It was rapidly attacked by pitting, crevice and tunneling types of corrosion, both at the surface and at depth, both in seawater and the bottom sediments.

WIRE ROPE

Stainless steel wire ropes of different diameters, types of construction and compositions were exposed at the 2,500- and 6,000-foot depths. These wire ropes and their conditions after exposure are given in Table 8.

The AISI Type 304 lubricated stainless steel wire ropes in diameters less than 0.250 inch were all seriously corroded within 6 months or 1 year of exposure at the 6,000-foot depth. During 1 year of exposure at the 6,000-foot depth they lost a minimum of 86 percent of their origianl breaking loads. The types of corrosion observed in all cases were pitting, tunneling, internal wire corrosion or crevice corrosion, and in most cases all types. The corrosion caused the individual wires to break in many cases.

There were only a few rust stains and no broken wires on the AISI Type 304 wire ropes after 1 year of exposure at the 6,000-foot depth and after 6 months of exposure at the 2,500-foot depth in the 0.25-inch and larger diameter ropes.

AISI Type 316 stainless steel wire rope which was stressed at 20 percent (350 lb) of its breaking strength during exposure for 3 years at the 6,000-foot depth lost 41 percent of its breaking strength due to the internal wires being broken at corrosion pits.

An 18Cr-14Mn stainless steel wire rope stressed at 20 percent (250 lb) of its original breaking strength did not lose any strength after 3 years of exposure at the 6,000-foot depth, even though there were many broken wires, both external and internal, caused by pitting and crevice corrosion.

Stress relieving after stranding of AISI Type 304 stainless steel wire rope was ineffective with regard to the corrosion resistance of the rope.

The addition of vanadium (V) and nitrogen (N) did not improve the corrosion resistance of the conventional stainless steel rope (Type 304).

The corrosion resistance of the conventional AISI Type 304 stainless steel was improved by the addition of other alloying elements in the following order, from most to least:

(a) Molybdenum (Mo), silicon (Si) and nitrogen (N)

(b) Molybdenum (Mo) and copper (Cu)

(c) Silicon (Si)

Cladding AISI Type 304 stainless steel wire rope with an alloy consisting of 90 percent Cu - 10 percent Ni protected the rope as long as the cladding material remained on the wires. A 0.3-mil thick clad layer was completely depleted on the outside wires within 1 year of exposure at a depth of 2,500 feet and they were covered with a thin film of rust. A clad layer 0.7-mil thick had not been depleted on the outer wires within 1 year of exposure since they were covered with green corrosion products. The internal wires of both ropes were brown in color indicating no sacrifice of the cladding.

STRESS CORROSION

Applied Stresses

Some of the stainless steels were stressed at 35, 50 and 75 percent of their respective yield strengths and exposed in seawater at the surface and at depths of 2,500 and 6,000 feet for various periods of time to determine their susceptibilities to stress corrosion cracking. This data is shown in Table 9.

The 300 and 400 Series stainless steels were not susceptible to stress corrosion cracking in seawater either at the surface or at depths of 2,500 and 6,000 feet.

Some of the 600 Series precipitation hardening stainless steels were susceptible to stress corrosion cracking in seawater either at the surface or at depth, or both. AISI Types 630-H925, 632-RH1100, 634-CRT and 635 were not susceptible to stress corrosion cracking but Types 630-H925 and 632-RH1100 failed by crevice corrosion at the supporting anvils of the stress jigs.

AISI Type 631-TH1050 failed by stress corrosion cracking at the surface at stresses equivalent to 50 and 75 percent of its yield strength; at the 2,500-foot depth at 75 percent of its yield strength; and at the 6,000-foot depth at 50 and 75 percent of its yield strength. AISI Type 631-RH1050 failed by stress corrosion cracking at the 2,500-foot depth at a stress equivalent to 75 percent of its yield strength.

Precipitation hardening stainless steel PH14-8Mo-SRH950 failed by stress corrosion cracking at the 2,500-foot depth at stresses equivalent to 50 and 75 percent of its yield strength and at the 6,000-foot depth at 75 percent of its yield strength.

Precipitation hardening stainless steel 15-7 AMV-A failed by stress corrosion cracking at the 6,000-foot depth at a stress equivalent to 75 percent of its yield strength. The same alloy in the RH1150 condition failed by stress corrosion cracking at the 2,500-foot depth at stresses equivalent to 50 and 75 percent of its yield strength. Also, in the RH950 condition the same alloy failed by stress corrosion cracking at the 2,500-foot depth at stresses equivalent to 50 and 75 percent of its yield strength and at the 6,000-foot depth at 35, 50 and 75 percent of its yield strength.

Stainless steels 20Cb and 18Cr-14Mn-0.5N were not susceptible to stress corrosion cracking in seawater at either the 2,500- or the 6,000-foot depths.

Of the stainless steels tested only 3 precipitation hardening steels failed by stress corrosion cracking, 631 in the TH1050 and RH1050 conditions, PH14-8Mo-SRH950 and 15-7AMV in the annealed, RH1150 and RH950 conditions.

Residual Stresses

Residual stresses are those which are present in an alloy when it has been subjected to certain fabricating treatments, such as welding. Such stresses are triaxial rather than uniaxial as in the intentionally stressed specimens and, in addition, their levels are indeterminable. Residual multiaxial welding stresses were intentionally induced in precipitation hardening stainless steels by making a 3-inch diameter weld in the center of the 6-inch by 12-inch specimens. These specimens were then exposed in the "as welded" condition; i.e., they were not subsequently heated to low temperatures to relieve the internal stresses created by the welding operation. The data on these specimens as well as some with other fabricating stresses are given in Table 10.

Specimens of AISI Type alloys 630-H925, 631-TH1050, 631-RH1050 and 632-RH1100 failed by stress corrosion cracking in seawater at the surface and at depths of 2,500 and 6,000 feet.

Precipitation hardening stainless steel 15-7AMV-RH1150 failed by stress corrosion cracking at stresses imposed by the insulators holding it in the rack which caused the specimen to bow slightly.

Stress corrosion cracking of alloys 15-7AMV-RH1150 and 15-7AMV-RH950 was caused by stresses induced by unreamed, drilled 1/8-inch diameter holes.

SUMMARY

The purpose of this investigation was to determine the effects of deep ocean environments on the corrosion of stainless steels. To accomplish this a total of 1,750 specimens of 57 different stainless steels were exposed in the seawater at the surface and at nominal depths of 2,500 and 6,000 feet for eight time periods varying from 123 to 1,064 days.

It must be re-emphasized that corrosion rates for stainless steels calculated from wieght loss determinations are very misleading because most corrosion is manifested as the pitting, tunneling and crevice types, all localized. With these types of corrosion most of the surface area of a specimen is uncorroded, therefore corrosion rates based on uniform removal of metal from the surface do not reflect the true condition of the metal. Hence, using corrosion rates of stainless steels calculated from weight loss data for design purposes usually results in disappointment and frustration for the designer becuase the equipment is rendered useless in much less time than the expected life because of localized attack.

Even using corrosion rates based on pitting, tunneling or crevice corrosion for design purposes is not satisfactory. To illustrate this, examine the extent of these three types of corrosion reported for Type 302 stainless steel in Table 4. During 1,064 days of exposure in seawater at a depth of 6,000 feet the alloy was completely free of any type of corrosion, and if only these data were considered equipment could be designed upon a 3-year life. However, to design on these data would be unsound practice because this same alloy was perforated (53 mils) by both pitting and crevice corrosion and tunnel corrosion extended for a distance of 1-3/8 inches laterally through the sheet within only 197 days of exposure at a depth of 2,500 feet; and,it was perforated by pitting corrosion with tunnel corrosion extending for 0.5 inch laterally through the sheet during 181 days of exposure at the surface. The information from this example shows that from an engineering standpoint no reliability could be expected from applications of stainless steels in seawater.

Generally the rates of corrosion based upon the pitting, tunneling and crevice types of corrosion were greater in surface seawater than in the seawater and in the bottom sediments at depths of 2,500 and 6,000 feet for equivalent periods of exposure.

Cast stainless steel, Ni-Cr-Mo-Si, was the only alloy not attacked by any type of corrosion during exposure for 366 days at the surface, 402 days at a depth of 2,500 feet, and 1,064 days of exposure at a depth of 6,000 feet.

Series 200 Stainless Steels (Cr-Ni-Mn)

Type 201 was more resistant to corrosion in seawater than was Type 202. There was severe edge corrosion of Type 201 within 366 days of exposure at the surface whereas Type 202 was perforated (50 mils) by both pitting and crevice corrosion within 182 days of exposure at the surface. Also Type 201 was not perforated by pitting corrosion until between 751 and 1,064 days of exposure at the 6,000-foot depth.

Series 300 Stainless Steels

Basic Type, 18% Cr-8% Ni, Nos. 301, 302, 304 and 304L. During surface exposure in the seawater Types 301, 302 and 304 were perforated by pitting attack within 6 months and Type 304L was penetrated by pitting to 84 percent of its thickness. Tunneling corrosion was most severe in Type 302, being twice as long as in Type 301 and 10 times as long in Types 304 and 304L. At depth all four alloys were perforated by pitting corrosion within 400 days of exposure while crevice corrosion was not as severe. Tunnel corrosion at depth varied from none to 5.0 inches within the first year of exposure.

Basic Type Plus Stabilizing Elements, Types 321 and 347. The addition of Ti (Type 321) and Cb&Ta (347) to stabilize carbide formation resulted in improved corrosion resistance over the Basic Type alloys, especially on Type 321. The maximum depth of pitting corrosion on Type 321 was 22 mils within 366 days of exposure at the surface and perforation by crevice corrosion within 402 days of exposure at 2,500 feet. Type 347 was perforated (50 mils) by both pitting and crevice corrosion within 182 days of exposure at the surface and was perforated by crevice corrosion within 1,064 days of exposure in the bottom sediment at a depth of 6,000 feet.

Basic Type Plus Molybdenum, Types 316, 316L and 317. Molybdenum is added to the Basic Type stainless steel to improve its resistance to pitting corrosion. The incidence of pitting, but not the intensity, was decreased during surface seawater exposure in Types 316 and 316L stainless steels which contained 2.5 percent molybdenum. Both steels were perforated by pitting corrosion within 181 days of exposure at the surface. At depth, Type 316 was perforated by pitting corrosion (230 mils) during 402 days of exposure at 2,500 feet while there was no pitting of Type 316L at depth. Also, the incidence of tunnel corrosion was less than in the Basic Type steels.

The addition of 3.5 percent molybdenum, Type 317, resulted in further improvement in resistance to pitting corrosion. Type 317 was free from pitting and tunnel corrosion at the surface and at both depths,and there was only incipient crevice corrosion in all three environments.

Steels with Increased Chromium and Nickel, Types 309, 310, 311, 23-25% Cr-13-20% Ni. Increasing the chromium and nickel contents resulted in some increase in corrosion resistance, particularly resistance to pitting corrosion. Types 309 and 310 were free of pitting corrosion in all three environments while Type 311 was attacked by pitting corrosion in surface seawater. There was less improvement in resistance to crevice corrosion, all three of them being attacked, with Types 310 and 311 being perforated in surface seawater exposure.

Miscellaneous Type 300 Series, Types 325, 329 and 330

Type 325 stainless steel which contained 9% Cr-23% Ni corroded chiefly by pitting and general surface corrosion, the general corrosion being contrary to the behavior of all other 300 Series stainless steels. The reason for this behavior is the low chromium content, 9% in contrast to the minimum of 12% required to impart a completely passive surface for stainless steels.

Type 329 stainless steel contains 27% Cr-4% Ni-1.4% Mo. The 27% chromium is more than twice as much as is necessary to form a completely passive film in an oxidizing environment and this steel can be classed as an austenitic stainless steel. There was incipient crevice corrosion in only three exposures, indicating better corrosion resistance than the basic 18-8 type stainless steels.

Type 330 stainless steel contains 15% Cr-35% Ni. This alloy was developed with such a high nickel content chiefly for high temperature applications. Type 330 was perforated (50 mils) by both pitting and crevice corrosion during exposure for 181 days in surface seawater. It was free from pitting at depth in seawater but was attacked by crevice corrosion varying from none to perforation.

The least corroded 300 Series alloys were Types 317 and 329 on which only incipient crevice corrosion (less than 1 mil deep) was observed after 366 days of exposure in surface sea water, after 402 days of exposure at the 2,500-foot depth, and after 1,064 days of exposure at the 6,000-foot depth, both in seawater and in the bottom sediments.

Sensitization (heating for 1 hour at 1200°F and cooling in air) rendered AISI Types 304 and 316 more susceptible, particularly to crevice corrosion, than their unsensitized counterparts.

Series 400 Stainless Steels (12%-30% Cr)

The straight chromium stainless steels, except AISI Type 446, were corroded at faster rates in seawater at the surface and at depths of 2,500 and 6,000 feet than were the 300 Series stainless steels. Type 446 was perforated (50 mils) by both pitting and crevice corrosion during 182 days of exposure in surface seawater, while there was no pitting, and crevice corrosion varied from none to 2 mils deep in seawater at depth.

Series 600 Stainless Steels (Precipitation Hardening)

Precipitation hardening staineless steels AISI Types 630, 631, 632 and 635, PH14-8Mo and 15-7AMV were severely attacked by the pitting, tunneling and crevice types of corrosion. The 15-7AMV was the most severely corroded of these types; portions of many of the specimens were missing because of the tunnel type of corrosion. In contrast to this (similar to the behavior of stainless steels of the 200 and 300 Series), Type 633 (17% Cr-4% Ni-3% Mo) precipitation hardening stainless steel was attacked only by crevice corrosion to a maximum depth of 1 mil during 1,064 days of exposure in the bottom sediment at a depth of 6,000 feet.

Miscellaneous Wrought and Cast Stainless Steels

A cast alloy (Ni-Cr-Mo-Si) was uncorroded in seawater both at the surface and at depth. Another cast alloy (RL-35-100) was corroded only by general surface attack and cast alloy (Ni-Cr-Mo) was attacked only by incipient crevice corrosion in all three seawater environments.

There were isolated cases of pitting (14 mils) and crevice corrosion (to 102 mils) on wrought alloy 20Cb while there was only incipient crevice corrosion on its modified counterpart, alloy 20Cb-3. The cast alloy equivalents (Ni-Cr-Cu-Mo numbers 1 and 2) of the wrought 20Cb alloys behaved similarly to the wrought alloy 20Cb.

The wrought alloy (18Cr-14Mn-0.5N) was severely corroded by the pitting, tunneling and crevice types of corrosion. Its behavior was comparable with that of Type 301 stainless steel.

The stainless steel wire ropes were also attacked by pitting and crevice corrosion, the degree of severity varying from rust stains and incipient pits to complete parting of some wires with losses in breaking strength equivalent to 97 percent of the original. A metallic coating composed of 90 percent copper-10 percent nickel, 0.3 mil thick, on AISI Type 304 stainless steel wire was completely corroded away within 402 days of exposure at a depth of 2,500 feet, whereas a 0.7 mil thick coating was still green, indicating that some of it was still present after the same period of exposure. However, this rate of removal indicates that permanent protection cannot be expected.

The 300 and 400 Series stainless steels were not susceptible to stress corrosion cracking in seawater at depth in the Pacific Ocean. However, some of the precipitation hardening stainless steels were susceptible to stress corrosion cracking when stresses equivalent to 50 or 75 percent of the alloy's yield strength were imposed on the alloy: AISI Type 631 in the TH1050 and RH1050 conditions, PH14-8Mo-SRH950 and 15-7AMV in the annealed, RH1150 and RH950 conditions.

Unrelieved internal residual stresses caused by welding circular welds on specimens caused the following alloys to fail by stress corrosion cracking: AISI Type 630-H925, AISI Type 631 in the TH1050 and RH1050 conditions, and AISI Type 632-RH1100. Precipitation hardening alloy 15-7AMV in the RH1150 and RH950 conditions failed by stress corrosion cracking as a result of internal stresses imposed by drilling holes in the specimens which subsequently were not reamed or deburred.

CONCLUSIONS

Based on the intensity of the pitting, tunneling and crevice types of corrosion, seawater at the surface was more aggressive than was either the seawater or the bottom sediments at depths of 2,500 and 6,000 feet in the Pacific Ocean. The bottom sediments were no more aggressive than was the seawater immediately above them.

Because of the propensity of stainless steels to pitting, tunneling and crevice corrosion and because of their unpredictable behavior in seawater, stainless steels, in general, are not recommended for use in seawater. Two cast alloys, Ni-Cr-Mo-Si which did not corrode and RL-35-100 which corroded uniformly in this investigation, could be used with confidence in seawater applications for periods of time as long as 3 years. Four alloys, AISI 317 and 329, 20Cb-3 and cast Ni-Cr-Mo (all molybdenum-containing alloys) showed traces of crevice and pitting corrosion, and because of the unpredictability of the performance of stainless steels in seawater, they can be recommended for seawater applications only when adequately protected. At least one, and usually more, specimens of each of the other alloys exhibited corrosion in the nature of pitting, tunneling or crevice corrosion sufficient to make the use of the alloy in seawater applications at least questionable.

If, because of its mechanical or magnetic properties, it is desirable to use a particular stainless steel in seawater application, provision must be made for its protection.

Table 1. STU Locations and Bottom Water Characteristics

Site No.	Lat. N	Longit. W	Depth, ft.	Exposure, Days	Temp., °C	Oxygen, ml/l	Salinity, ppt	pH	Current, Knots, Av.
I-1	33°46'	120°37'	5300	1064	2.6	1.2	34.51	7.5	0.03
I-2	33°44'	120°45'	5640	751	2.3	1.3	34.51	7.6	0.03
I-3	33°44'	120°45'	5640	123	2.3	1.3	34.51	7.6	0.03
I-4	33°46'	120°46'	6780	403	2.2	1.6	34.40	7.7	0.03
II-1	34°06'	120°42'	2340	197	5.0	0.4	34.36	7.5	0.06
II-2	34°06'	120°42'	2370	402	5.0	0.4	34.36	7.5	0.06
V	34"06'	119°07'	5	181	12-19	3.9-6.6	33.51	8.1	Variable
V	34°06'	119°07'	5	366	12-19	3.9-6.6	33.51	8.1	Variable

Table 2. Chemical Compositions of Corrosion Resistant Steels, Percent by Weight

Alloy	C	Mn	P	S	Si	Ni	Cr	Mo	Al	Cu	Other	Remainder	Source[3]
AISI Type 201	0.08	6.8	---	---	---	4.0	17.1	---	---	---	---	Fe	INCO[12]
AISI Type 202	0.09	7.6	---	---	---	4.5	17.8	---	---	---	---	Fe	INCO[12]
AISI Type 301	0.11	1.17	0.025	0.021	0.34	6.73	17.4	---	---	---	---	Fe	NCEL
AISI Type 302	0.06	1.05	0.020	0.013	0.60	9.33	18.21	---	---	---	---	Fe	NCEL
AISI Type 302	0.11	1.36	---	---	---	9.9	17.3	0.12	---	0.26	---	Fe	INCO[12]
AISI Type 304	0.06	1.73	0.024	0.013	0.43	10.0	18.8	---	---	---	---	Fe	NCEL
AISI Type 304	0.05	1.73	0.020	0.012	0.52	9.55	18.2	0.18	---	---	---	Fe	NCEL
AISI Type 304	0.06	1.46	---	---	---	9.5	18.2	0.34	---	0.16	---	Fe	INCO[12]
AISI Type 304[1]	0.06	1.62	---	---	---	9.5	18.2	0.34	---	0.16	---	Fe	INCO[12]
AISI Type 304L	0.03	1.24	0.028	0.023	0.68	10.20	18.7	---	---	---	---	Fe	NCEL
AISI Type 304L	0.02	1.45	---	---	---	9.5	17.9	---	---	---	---	Fe	INCO[12]
AISI Type 309	0.1	1.60	---	---	---	12.7	23.3	---	---	---	---	Fe	INCO[12]
AISI Type 310	0.04	1.78	---	---	---	20.9	25.3	---	---	---	---	Fe	INCO[12]
AISI Type 311	0.2	2.0	---	---	---	19.0	25.0	---	---	---	---	Fe	INCO[12]
AISI Type 316	0.06	1.61	0.021	0.016	0.40	13.60	18.3	2.41	---	---	---	Fe	NCEL
AISI Type 316	0.05	1.73	---	---	---	13.2	17.2	2.60	---	---	---	Fe	INCO[12]
AISI Type 316[1]	0.05	1.73	---	---	---	13.2	17.2	2.60	---	---	---	Fe	INCO[12]
AISI Type 316L	0.03	1.29	0.015	0.019	0.51	13.10	17.5	2.32	---	---	---	Fe	NCEL
AISI Type 316L	0.02	1.31	0.013	0.015	0.47	13.70	17.9	2.76	---	---	---	Fe	NCEL
AISI Type 316L	0.02	1.78	---	---	---	13.6	17.7	2.15	---	---	---	Fe	INCO[12]
AISI Type 317	0.05	1.61	---	---	---	13.6	18.7	3.3	---	---	---	Fe	INCO[12]
AISI Type 321	0.06	2.0	---	---	---	10.5	18.5	---	---	---	---	Fe	INCO[12]
AISI Type 325	0.03	0.7	---	---	---	23.5	9.0	---	---	---	---	Fe	INCO[12]
AISI Type 329	0.07	0.46	---	---	---	4.4	27.0	1.40	---	---	---	Fe	INCO[12]
AISI Type 330	0.20	---	---	---	---	34.5	15.0	---	---	---	---	Fe	INCO[12]
AISI Type 347	0.04	1.19	---	---	---	11.3	18.1	---	---	---	---	Fe	INCO[12]
AISI Type 405	0.06	0.41	0.025	0.019	0.56	---	12.6	---	0.26	---	---	Fe	NCEL
AISI Type 405	0.05	0.85	0.017	0.015	0.57	---	12.46	---	0.21	---	---	Fe	NCEL
AISI Type 405	0.05	0.62	0.014	0.011	0.27	---	14.5	---	0.27	---	---	Fe	NCEL
AISI Type 410	0.13	0.43	0.019	0.005	0.45	0.010	12.30	---	----	---	---	Fe	NCEL
AISI Type 410	0.13	0.4	---	---	---	0.2	12.1	---	----	---	---	Fe	INCO[12]
AISI Type 430	0.07	0.47	0.029	0.011	0.36	---	16.4	---	----	---	---	Fe	NCEL
AISI Type 430	0.05	0.46	0.012	0.010	0.36	0.12	16.5	---	----	---	---	Fe	NCEL
AISI Type 430	0.06	0.4	---	---	---	---	17.7	---	----	---	---	Fe	INCO[12]
AISI Type 446	0.15	0.8	---	---	---	0.2	30.0	---	----	---	---	Fe	INCO[12]

Table 2. Chemical Compositions of Corrosion Resistant Steels, Percent by Weight (cont'd)

Alloy	C	Mn	P	S	Si	Ni	Cr	Mo	Al	Cu	Other	Remainder	Source[3]
AISI Type 630	0.03	0.24	0.017	0.011	0.59	4.17	15.92	---	----	3.23	0.24Cb	Fe	NCEL
AISI Type 631	0.07	0.48	0.017	0.018	0.42	7.42	17.12	---	1.19	---	---	Fe	NCEL
AISI Type 632	0.07	0.50	0.016	0.016	0.28	7.19	15.05	2.19	1.11	---	---	Fe	NCEL
AISI Type 633	---	---	---	---	---	4.0	17.0	3.0	----	---	---	Fe	INCO[12]
AISI Type 634	0.12	0.77	0.021	0.009	0.34	6.42	15.35	2.73	----	---	0.095N	Fe	NCEL
AISI Type 635	0.05	0.54	0.011	0.006	0.57	6.89	16.8	---	0.14	---	0.64Ti	Fe	NCEL
AISI Type 635	0.05	0.56	0.026	0.009	0.74	6.80	16.8	---	0.09	---	0.79Ti	Fe	NCEL
17-14-Cu-Mo	---	---	----	---	---	14.0	16.0	2.0	----	3.0	---	Fe	INCO[12]
15-7 AMV	0.27	0.67	0.020	0.012	0.84	7.4	15.0	2.42	1.55	---	0.16V	Fe	NCEL
PH14-8Mo	0.04	0.36	0.004	0.002	0.34	8.12	14.71	2.25	1.21	---	---	Fe	NCEL
20Cb	0.04	0.79	0.018	0.004	0.67	28.38	19.80	2.06	----	3.11	Cb+Ta, 0.77	Fe	NCEL
20Cb	0.05	0.82	---	---	0.70	28.43	20.09	2.32	----	3.37	Cb+Ta, 0.83	Fe	NCEL
20Cb	---	---	---	---	---	33.0	20.0	2.5	----	3.5	---	Fe	INCO[12]
20Cb-3	0.07[2]	2.0[2]	0.035[2]	0.035[2]	1.0[2]	34.0	20.0	2.5	----	3.5	Cb+Ta, 8XC	Fe	NCEL
20Cb-3	---	---	---	---	---	34.0	20.0	2.3	----	3.4	---	Fe	INCO[12]
Ni-Cr-Cu-Mo #1	---	---	---	---	---	30.0	20.0	2.5	----	4.0	---	Fe	INCO[12]
Ni-Cr-Cu-Mo #2	---	---	---	---	---	30.0	20.0	2.5	----	3.5	---	Fe	INCO[12]
18Cr-14Mn-.5N	0.07	14.3	0.021	0.03	0.67	0.27	18.4	---	----	---	0.48N	Fe	NCEL
18Cr-14Mn-.5N	---	15.0	---	---	---	0.5	18.0	---	----	---	0.5N	Fe	INCO[12]
Ni-Cr-Mo	---	---	---	---	---	24.0	19.0	3.0	----	---	---	Fe	INCO[12]
Ni-Cr-Mo-Si	---	---	---	---	1.0	23.0	21.0	5.0	----	---	---	Fe	INCO[12]
RL-35-100	---	1.0	---	---	---	31.0	23.0	9.0	---	---	---	Fe	INCO[12]

1 - Sensitized (heated) for 1 hour at 1200°F, air cooled
2 - Maximum
3 - Numbers refer to references at end of paper

Table 3. Corrosion Rates and Types of Corrosion of 200 Series Stainless Steels

Alloy[1]	Environment[2]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[3]	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils[4]	Corrosion Type[4]	Source[5]
201	W	182	5	<0.1	0	I	C	INCO[12]
201	W	366	5	0.6	0	0	SE	INCO[12]
201	W	197	2340	<0.1	0	4	C	INCO[12]
201	S	197	2340	<0.1	0	3	C	INCO[12]
201	W	402	2370	<0.1	0	1	C	INCO[12]
201	S	402	2370	<0.1	0	2	C	INCO[12]
201	W	123	5640	<0.1	0	I	C	INCO[12]
201	S	123	5640	<0.1	0	0	NC	INCO[12]
201	W	403	6780	<0.1	0	I	C	INCO[12]
201	S	403	6780	<0.1	0	2	C	INCO[12]
201	W	751	5640	<0.1	0	I	C	INCO[12]
201	S	751	5640	<0.1	0	0	NC	INCO[12]
201	W	1064	5300	<0.1	0	I	C	INCO[12]
201	S	1064	5300	0.5	50(PR)	I	C,P	INCO[12]
202	W	182	5	0.6	50(PR)	50(PR)	C,P	INCO[12]
202	W	366	5	0.5	50(PR)	50(PR)	C,P	INCO[12]
202	W	197	2340	<0.1	0	I	C	INCO[12]
202	S	197	2340	<0.1	0	I	C	INCO[12]
202	W	402	2370	<0.1	0	17	C	INCO[12]
202	S	402	2370	<0.1	17	0	P	INCO[12]
202	W	123	5640	<0.1	0	0	NC	INCO[12]
202	S	123	5640	<0.1	0	0	NC	INCO[12]
202	W	403	6780	<0.1	0	I	C	INCO[12]
202	S	403	6780	<0.1	0	I	C	INCO[12]
202	W	751	5640	<0.1	0	I	C	INCO[12]
202	S	751	5640	<0.1	0	I	C	INCO[12]
202	W	1064	5300	<0.1	0	0	NC	INCO[12]
202	S	1064	5300	<0.1	0	50(PR)	C	INCO[12]

1. AISI Type
2. W - Specimens exposed on sides of STU in water.
   S - Specimens exposed in base of STU, partially embedded in the bottom sediment.
3. MPY - mils penetration per year calculated from weight loss.
4. Abbreviations signify the following types of corrosion:
   I - Incipient
   C - Crevice
   P - Pitting
   S - Severe
   E - Edge
   NC - No visible corrosion
   PR - Perforated
   Number indicate maximum depth in mils.
5. Numbers refer to references at end of paper.

Table 4. Corrosion Rates and Types of Corrosion of 300 Series Stainless Steels

Alloy	Environment (2)	Exposure, Days	Depth, Feet	Corrosion Rate, MPY (3)	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils (4)	Corrosion, Tunnel, Maximum Length, Mils	Corrosion Type (4)	Source (5)
301 (1)	W	181	5	1.9	103(PR)	0	2200	SE,T,P	NCEL
301	W	398	5	2.3	103(PR)	0	1150	T,P	NCEL
301	W	197	2340	0.3	0	SL	1250	C,T	NCEL
301	S	197	2340	0.3	0	SL	1400	C,T	NCEL
301	W	402	2370	0.5	103(PR)	0	2500	T,P	NCEL
301	S	402	2370	0.6	103(PR)	0	2500	T,P	NCEL
301	W	123	5640	0.3	0	SL	1200	C,T	NCEL
301	S	123	5640	0.7	0	SL	750	C,T	NCEL
301	W	403	6780	1.4	103(PR)	15	2450	C,T,P	NCEL
301	S	403	6780	1.6	103(PR)	25	4000	C,T,P	NCEL
301	W	751	5640	1.7	103(PR)	0	6000	E,T,P	NCEL
301	S	751	5640	1.0	103(PR)	0	10500	E,T,P	NCEL
301	W	1064	5300	0.4	103(PR)	0	11000	E,T,P	NCEL
301	S	1064	5300	1.0	103(PR)	0	6500	E,T,P	NCEL
302	W	181	5	0.9	53(PR)	0	4950	E,T,P	NCEL (12)
302	W	182	5	<0.1	15	7	----	C,P	INCO (12)
302	W	398	5	0.4	53(PR)	53(PR)	5400	C,E,T,P	NCEL (12)
302	W	366	5	<0.1	I	I	----	C,P	INCO (12)
302	W	197	2340	<0.1	53(PR)	53(PR)	1375	C,ST,P	NCEL (12)
302	W	197	2340	<0.1	0	I	----	C	INCO (12)
302	S	197	2340	<0.1	0	20	250	C,ST	NCEL (12)
302	S	197	2340	<0.1	0	I	----	C	INCO (12)
302	W	402	2370	<0.1	0	18	6000	C,T	NCEL (12)
302	W	402	2370	<0.1	0	I	----	C	INCO (12)

Table 4. Corrosion Rates and Types of Corrosion of 300 Series Stainless Steels (cont'd)

Alloy	Environment[2]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[3]	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils[4]	Corrosion, Tunnel, Maximum Length, Mils	Corrosion Type[4]	Source[5]
302	S	402	2370	<0.1	0	53(PR)	0	C	NCEL(12)
302	S	402	2370	<0.1	0	I	----	C	INCO
302	W	123	5640	<0.1	0	SL	0	C	NCEL(12)
302	W	123	5640	<0.1	0	0	----	NC	INCO
302	S	123	5640	<0.1	0	SL	0	C	NCEL(12)
302	S	123	5640	<0.1	0	0	----	NC	INCO
302	W	403	6780	<0.1	0	18	0	C	NCEL(12)
302	W	403	6780	<0.1	0	I	----	C	INCO
302	S	403	6780	<0.1	0	23	0	C	NCEL(12)
302	S	403	6780	<0.1	0	I	----	C	INCO
302	W	751	5640	<0.1	0	21	0	C	NCEL(12)
302	W	751	5640	<0.1	0	0	----	NC	INCO
302	S	751	5640	<0.1	0	I	6000	C,E,T	NCEL(12)
302	S	751	5640	<0.1	0	I	----	C	INCO(12)
302	W	1064	5300	<0.1	0	0	----	NC	INCO(12)
302	S	1064	5300	<0.1	50(PR)	50(PR)	----	C,P	INCO
304	W	181	5	1.8	210(PR)	0	500	E,P,T	NCEL(12)
304	W	181	5	1.3	45	20	----	C,P	INCO(12)
304	W	366	5	0.4	34	33	----	C,P	INCO
304	W	197	2340	0.3	0	11	950	C,E,T	NCEL(12)
304	W	197	2340	<0.1	0	I	----	C	INCO
304	S	197	2340	<0.1	0	SL	1000	C,E,T	NCEL(12)
304	S	197	2340	<0.1	0	I	----	C	INCO
304	W	402	2370	0.4	210(PR)	0	2000	E,T,P	NCEL(12)
304	W	402	3270	<0.1	0	13	----	C	INCO
304	S	402	2370	0.1	0	0	1250	SE,T	NCEL(12)
304	S	402	2370	<0.1	0	4	----	C	INCO
304	W	123	5640	<0.1	0	0	450	T	NCEL

Table 4. Corrosion Rates and Types of Corrosion of 300 Series Stainless Steels (cont'd)

Alloy	Environment[2]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[3]	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils[4]	Corrosion, Tunnel, Maximum Length, Mils	Corrosion Type[4]	Source[5]
304	W	123	5640	<0.1	0	I	----	C	INCO[12]
304	S	123	5640	<0.1	0	0	0	NC	NCEL
304	S	123	5640	<0.1	0	0	----	NC	INCO[12]
304	W	403	6780	0.5	210(PR)	0	2000	E,T,P	NCEL
304	W	403	6780	<0.1	0	I	----	C	INCO[12]
304	S	403	6780	<0.1	0	0	0	SLE	NCEL
304	S	403	6780	<0.1	0	I	----	C	INCO[12]
304	W	751	5640	0.5	210(PR)	0	1600	T,P	NCEL
304	W	751	5640	<0.1	0	0	----	NC	INCO[12]
304	S	751	5640	<0.1	0	13	----	C	INCO[12]
304	W	1064	5300	<0.1	13	74	1750	C,E,P,T	NCEL
304	W	1064	5300	<0.1	0	I	----	C	INCO[12]
304	S	1064	5300	<0.1	210(PR)	29	1500	C,E,T,P	NCEL
304	S	1064	5300	<0.1	0	50(PR)	----	C	INCO[12]
304[6]	W	182	5	1.1	50(PR)	50(PR)	----	C,P	INCO[12]
304[6]	W	366	5	1.2	50(PR)	50(PR)	----	C,P	INCO[12]
304[6]	W	197	2340	0.6	0	50(PR)	----	C	INCO[12]
304[6]	S	197	2340	<0.1	0	I	----	C	INCO[12]
304[6]	W	402	2370	0.3	0	50(PR)	----	C	INCO[12]
304[6]	S	402	2370	<0.1	0	17	----	C	INCO[12]
304[6]	W	123	5640	0.7	0	50(PR)	----	C	INCO[12]
304[6]	S	123	5640	0.8	0	37	----	C	INCO[12]
304[6]	W	403	6780	0.7	0	50(PR)	----	C	INCO[12]
304[6]	S	403	6780	0.4	0	2	----	C	INCO[12]
304[6]	W	751	5640	0.5	50(PR)	50(PR)	----	C,P	INCO[12]
304[6]	S	751	5640	0.2	0	50(PR)	----	C	INCO[12]
304[6]	W	1064	5300	0.4	50(PR)	50(PR)	----	C,P	INCO[12]
304[6]	S	1064	5300	0.2	50(PR)	50(PR)	----	C,P	INCO[12]

Table 4. Corrosion Rates and Types of Corrosion of 300 Series Stainless Steels (cont'd)

Alloy	Environment[2]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[3]	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils[4]	Corrosion, Tunnel, Maximum Length, Mils	Corrosion Type[4]	Source[5]
304L	W	181	5	0.7	97	0	400	E,P,T	NCEL
304L	W	181	5	<0.1	0	I	----	C	INCO[12]
304L	W	398	5	1.0	115(PR)	0	1100	E,T,P	NCEL
304L	W	366	5	0.5	50(PR)	0	----	P	INCO[12]
304L	W	123	2500	<0.1	0	0	0	NC	NCEL
304L	W	197	2340	0.2	0	8	800	C,T	NCEL
304L	W	197	2340	<0.1	0	I	----	C	INCO[12]
304L	S	197	2340	0.1	0	18	0	C	NCEL
304L	S	197	2340	<0.1	0	I	----	C	INCO[12]
304L	W	402	2370	0.4	115(PR)	0	3000	T,P	NCEL
304L	W	402	2370	<0.1	0	I	----	C	INCO[12]
304L	S	402	2370	0.2	0	0	1000	T	NCEL
304L	S	402	2370	<0.1	0	I	----	C	INCO[12]
304L	W	123	5640	0.2	0	SL	200	C,T	NCEL
304L	W	123	5640	<0.1	0	0	----	NC	INCO[12]
304L	S	123	5640	<0.1	0	SL	0	C	NCEL
304L	S	123	5640	<0.1	0	0	----	NC	INCO[12]
304L	W	403	6780	<0.1	115(PR)	12	4850	C,E,T,P	NCEL
304L	W	403	6780	<0.1	0	I	----	C	INCO[12]
304L	S	403	6780	0.1	0	29	1000	C,E,T	NCEL
304L	S	403	6780	<0.1	0	2	----	C	INCO[12]
304L	W	751	5640	0.3	115(PR)	0	4000	T,P	NCEL
304L	W	751	5640	<0.1	0	0	----	NC	INCO[12]
304L	S	751	5640	0.6	0	45	1000	C,T	NCEL
304L	S	751	5640	<0.1	0	0	----	NC	INCO[12]
304L	W	1064	5300	0.2	115(PR)	115(PR)	4000	C,E,T,P	NCEL
304L	W	1064	5300	<0.1	0	I	----	C	INCO[12]
304L	S	1064	5300	0.1	115(PR)	0	3000	T,P	NCEL
304L	S	1064	5300	0.2	50(PR)	50(PR)	----	C,P	INCO[12]

Table 4. Corrosion Rates and Types of Corrosion of 300 Series Stainless Steels (cont'd)

Alloy	Environment[2]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[3]	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils[4]	Corrosion Tunnel, Maximum Length, Mils	Corrosion Type[4]	Source[5]
309	W	182	5	<0.1	0	33	----	C	INCO[12]
309	W	366	5	<0.1	0	I	----	C	INCO[12]
309	W	197	2340	<0.1	0	I	----	C	INCO[12]
309	S	197	2340	<0.1	0	I	----	C	INCO[12]
309	W	402	2370	<0.1	0	I	----	C	INCO[12]
309	S	402	2370	<0.1	0	I	----	C	INCO[12]
309	W	123	5640	<0.1	0	0	----	NC	INCO[12]
309	S	123	5640	<0.1	0	0	----	NC	INCO[12]
309	W	403	6780	<0.1	0	I	----	C	INCO[12]
309	S	403	6780	<0.1	0	I	----	C	INCO[12]
309	W	751	5640	<0.1	0	0	----	NC	INCO[12]
309	S	751	5640	<0.1	0	0	----	NC	INCO[12]
309	W	1064	5300	<0.1	0	I	----	C	INCO[12]
309	S	1064	5300	<0.1	0	I	----	C	INCO[12]
310	W	182	5	<0.1	0	I	----	C	INCO[12]
310	W	366	5	0.1	0	50(PR)	----	C	INCO[12]
310	W	197	2340	<0.1	0	I	----	C	INCO[12]
310	S	197	2340	<0.1	0	I	----	C	INCO[12]
310	W	402	2370	<0.1	0	14	----	C	INCO[12]
310	S	402	2370	<0.1	0	2	----	C	INCO[12]
310	W	123	5640	<0.1	0	0	----	NC	INCO[12]
310	S	123	5640	<0.1	0	0	----	NC	INCO[12]
310	W	403	6780	<0.1	0	I	----	C	INCO[12]
310	S	403	6780	<0.1	0	I	----	C	INCO[12]
310	W	751	5640	<0.1	0	0	----	NC	INCO[12]
310	S	751	5640	<0.1	0	I	----	C	INCO[12]
310	W	1064	5300	<0.1	0	I	----	C	INCO[12]
310	S	1064	5300	<0.1	0	I	----	C	INCO[12]

Table 4. Corrosion Rates and Types of Corrosion of 300 Series Stainless Steels (cont'd)

Alloy	Environment[2]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[3]	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils[4]	Corrosion Tunnel, Maximum Length, Mils	Corrosion Type[4]	Source[5]
311	W	182	5	0.5	28	50(PR)	----	C,P	INCO[12]
311	W	366	5	<0.1	I	I	----	C,P	INCO[12]
311	W	197	2340	<0.1	0	I	----	C	INCO[12]
311	S	197	2340	<0.1	0	2	----	C	INCO[12]
311	W	402	2370	<0.1	0	6	----	C	INCO[12]
311	S	402	2370	<0.1	0	I	----	C	INCO[12]
311	W	123	5640	<0.1	0	0	----	NC	INCO[12]
311	S	123	5640	<0.1	0	0	----	NC	INCO[12]
311	W	403	6780	<0.1	0	I	----	C	INCO[12]
311	S	403	6780	<0.1	0	I	----	C	INCO[12]
311	W	751	5640	<0.1	0	0	----	NC	INCO[12]
311	S	751	5640	<0.1	0	0	----	NC	INCO[12]
311	W	1064	5300	<0.1	0	I	----	C	INCO[12]
311	S	1064	5300	<0.1	0	5	----	C	INCO[12]
316	W	181	5	1.3	230(PR)	0	1250	E,T,P	NCEL
316	W	181	5	<0.1	0	I	----	C	INCO[12]
316	W	398	5	0.4	154	20	1350	C,E,T,P	NCEL
316	W	366	5	<0.1	0	0	----	NC	INCO[12]
316	W	197	2340	<0.1	0	0	0	NC	NCEL
316	W	197	2340	<0.1	0	0	----	NC	INCO[12]
316	S	197	2340	<0.1	0	0	0	NC	NCEL
316	S	197	2340	<0.1	0	I	----	C	INCO[12]
316	W	402	2370	0.1	230(PR)	0	500	E,T,P	NCEL
316	W	402	2370	<0.1	0	I	----	C	INCO[12]
316	S	402	2370	<0.1	I	0	0	P	NCEL
316	S	402	2370	<0.1	0	I	----	C	INCO[12]
316	W	123	5640	<0.1	0	0	12	SLE,SLT	NCEL
316	W	123	5640	<0.1	0	0	----	NC	INCO[12]
316	S	123	5640	<0.1	0	0	0	SLE	NCEL

Table 4. Corrosion Rates and Types of Corrosion of 300 Series Stainless Steels (cont'd)

Alloy	Environment[2]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[3]	Maximum Pit Depth, Mils	Corrosion, Crevice,[4] Mils	Corrosion, Tunnel, Maximum Length, Mils	Corrosion Type[4]	Source[5]
316	S	123	5640	<0.1	0	0	----	NC	INCO[12]
316	W	403	6780	<0.1	0	0	0	NC	NCEL[12]
316	W	403	6780	<0.1	0	I	----	C	INCO
316	S	403	6780	<0.1	0	5	0	C	NCEL[12]
316	S	403	6780	<0.1	0	I	----	C	INCO
316	W	751	5640	<0.1	0	0	0	NC	NCEL[12]
316	W	751	5640	<0.1	0	0	----	NC	INCO
316	S	751	5640	<0.1	0	0	0	NC	NCEL[12]
316	S	751	5640	<0.1	0	0	----	NC	INCO
316	W	1064	5300	0.2	21	0	0	P	NCEL[12]
316	W	1064	5300	<0.1	0	1	----	C	INCO
316	S	1064	5300	0.2	0	I	0	C	NCEL[12]
316	S	1064	5300	<0.1	0	I	----	C	INCO
316[6]	W	182	5	0.8	7	38	----	C,P	INCO[12]
316[6]	W	366	5	0.6	50(PR)	50(PR)	----	C,P	INCO[12]
316[6]	W	197	2340	<0.1	0	8	----	C	INCO[12]
316[6]	S	197	2340	<0.1	0	I	----	C	INCO[12]
316[6]	W	402	2370	<0.1	0	8	----	C	INCO[12]
316[6]	S	402	2370	<0.1	0	I	----	C	INCO[12]
316[6]	W	123	5640	<0.1	0	I	----	C	INCO[12]
316[6]	S	123	5640	0.1	0	21	----	C	INCO[12]
316[6]	W	403	6780	<0.1	0	I	----	C	INCO[12]
316[6]	S	403	6780	<0.1	0	2	----	C	INCO[12]
316[6]	W	751	5640	1.5	50(PR)	50(PR)	----	C,P	INCO[12]
316[6]	S	751	5640	0.3	0	50(PR)	----	C	INCO[12]
316[6]	W	1064	5300	<0.1	0	15	----	C	INCO[12]
316[6]	S	1064	5300	<0.1	0	6	----	C	INCO[12]

Table 4. Corrosion Rates and Types of Corrosion of 300 Series Stainless Steels (cont'd)

Alloy	Environment[2]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[3]	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils[4]	Corrosion, Tunnel, Maximum Length, Mils	Corrosion Type[4]	Source[5]
316L	W	181	5	0.3	125(PR)	0	1400	E,P,T	NCEL (12)
316L	W	181	5	<0.1	0	25	----	C	INCO
316L	W	398	5	<0.1	0	0	0	SLE	NCEL (12)
316L	W	366	5	<0.1	0	I	----	C	INCO
316L	W	123	2500	<0.1	0	0	0	NC	NCEL
316L	W	197	2340	<0.1	0	18	0	C	NCEL (12)
316L	W	197	2340	<0.1	0	8	----	C	INCO
316L	S	197	2340	<0.1	0	12	0	C	NCEL (12)
316L	S	197	2340	<0.1	0	I	----	C	INCO
316L	W	402	2370	<0.1	0	0	0	NC	NCEL (12)
316L	W	402	2370	<0.1	0	I	----	C	INCO
316L	S	402	2370	<0.1	0	45	0	C	NCEL (12)
316L	S	402	2370	<0.1	0	I	----	C	INCO
316L	W	123	5640	<0.1	0	SL	0	C	NCEL (12)
316L	W	123	5640	<0.1	0	0	----	NC	INCO
316L	S	123	5640	<0.1	0	SL	0	C	NCEL (12)
316L	S	123	5640	<0.1	0	0	----	NC	INCO
316L	W	403	6780	<0.1	0	0	0	NC	NCEL (12)
316L	W	403	6780	<0.1	0	I	----	C	INCO
316L	S	403	6780	<0.1	0	0	0	NC	NCEL (12)
316L	S	403	6780	<0.1	0	I	----	C	INCO
316L	W	751	5640	<0.1	0	13	0	C	NCEL (12)
316L	W	751	5640	<0.1	0	0	----	NC	INCO (12)
316L	S	751	5640	<0.1	0	0	----	NC	INCO
316L	W	1064	5300	<0.1	0	25	0	C	NCEL (12)
316L	W	1064	5300	<0.1	0	I	----	C	INCO
316L	S	1064	5300	<0.1	0	20	0	C	NCEL (12)
316L	S	1064	5300	<0.1	0	I	----	C	INCO

Table 4. Corrosion Rates and Types of Corrosion of 300 Series Stainless Steels (cont'd)

Alloy	Environment[2]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[3]	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils[4]	Corrosion Tunnel, Maximum Length, Mils	Corrosion Type[4]	Source[5]
317	W	181	5	<0.1	0	0	----	NC	INCO[12]
317	W	366	5	<0.1	0	I	----	C	INCO[12]
317	W	197	2340	<0.1	0	I	----	C	INCO[12]
317	S	197	2340	<0.1	0	I	----	C	INCO[12]
317	W	402	2370	<0.1	0	I	----	C	INCO[12]
317	S	402	2370	<0.1	0	I	----	C	INCO[12]
317	W	123	5640	<0.1	0	0	----	NC	INCO[12]
317	S	123	5640	<0.1	0	0	----	NC	INCO[12]
317	W	403	6780	<0.1	0	I	----	C	INCO[12]
317	S	403	6780	<0.1	0	I	----	C	INCO[12]
317	W	751	5640	<0.1	0	0	----	NC	INCO[12]
317	S	751	5640	<0.1	0	0	----	NC	INCO[12]
317	W	1064	5300	<0.1	0	I	----	C	INCO[12]
317	S	1064	5300	<0.1	0	0	----	NC	INCO[12]
321	W	182	5	<0.1	0	2	----	C	INCO[12]
321	W	366	5	<0.1	22	0	----	P	INCO[12]
321	W	197	2340	<0.1	0	I	----	C	INCO[12]
321	S	197	2340	<0.1	0	2	----	C	INCO[12]
321	W	402	2370	0.2	0	30(PR)	----	C	INCO[12]
321	S	402	2370	<0.1	0	I	----	C	INCO[12]
321	W	123	5640	<0.1	0	0	----	NC	INCO[12]
321	S	123	5640	<0.1	0	0	----	NC	INCO[12]
321	W	403	6780	<0.1	0	I	----	C	INCO[12]
321	S	403	6780	<0.1	0	I	----	C	INCO[12]
321	W	751	5640	<0.1	0	0	----	NC	INCO[12]
321	S	751	5640	<0.1	0	I	----	C	INCO[12]
321	W	1064	5300	<0.1	0	I	----	C	INCO[12]
321	S	1064	5300	<0.1	0	0	----	NC	INCO[12]

Table 4. Corrosion Rates and Types of Corrosion of 300 Series Stainless Steels (cont'd)

Alloy	Environment[2]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[3]	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils[4]	Corrosion, Tunnel, Maximum Length, Mils	Corrosion Type[4]	Source[5]
325	W	182	5	10.0	0	0	----	G	INCO[12]
325	W	366	5	6.3	16	12	----	C,P	INCO[12]
325	W	197	2340	2.8	12	0	----	P	INCO[12]
325	S	197	2340	<0.1	0	2	----	C	INCO[12]
325	W	402	2370	1.9	0	0	----	G	INCO[12]
325	S	402	2370	0.3	0	0	----	G	INCO[12]
325	W	123	5640	4.2	11	0	----	P	INCO[12]
325	S	123	5640	3.3	13	0	----	P	INCO[12]
325	W	403	6780	4.6	14	0	----	P	INCO[12]
325	S	403	6780	1.3	0	3	----	C	INCO[12]
325	W	751	5640	2.1	0	0	----	G	INCO[12]
325	S	751	5640	3.5	0	0	----	NU	INCO[12]
325	W	1064	5300	1.1	0	0	----	G	INCO[12]
325	S	1064	5300	1.3	0	0	----	G	INCO[12]
329	W	182	5	<0.1	0	I	----	C	INCO[12]
329	W	366	5	<0.1	0	I	----	C	INCO[12]
329	W	197	2340	<0.1	0	0	----	NC	INCO[12]
329	S	197	2340	<0.1	0	0	----	NC	INCO[12]
329	W	402	2370	<0.1	0	0	----	NC	INCO[12]
329	S	402	2370	<0.1	0	0	----	NC	INCO[12]
329	W	123	5640	<0.1	0	0	----	NC	INCO[12]
329	S	123	5640	<0.1	0	0	----	NC	INCO[12]
329	W	403	6780	<0.1	0	0	----	NC	INCO[12]
329	S	403	6780	<0.1	0	I	----	C	INCO[12]
329	W	751	5640	<0.1	0	0	----	NC	INCO[12]
329	S	751	5640	<0.1	0	0	----	NC	INCO[12]
329	W	1064	5300	<0.1	0	0	----	NC	INCO[12]
329	S	1064	5300	<0.1	0	0	----	NC	INCO[12]

Table 4. Corrosion Rates and Types of Corrosion of 300 Series Stainless Steels (cont'd)

Alloy	Environment[2]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[3]	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils[4]	Corrosion, Tunnel, Maximum Length Mils	Corrosion Type[4]	Source[5]
330	W	182	5	0.8	50(PR)	50(PR)	----	C,P	INCO[12]
330	W	366	5	0.4	50(PR)	0	----	P	INCO[12]
330	W	197	2340	<0.1	0	I	----	C	INCO[12]
330	S	197	2340	<0.1	0	I	----	C	INCO[12]
330	W	402	2370	<0.1	0	30(PR)	----	C	INCO[12]
330	S	402	2370	<0.1	0	2	----	C	INCO[12]
330	W	123	5640	<0.1	0	I	----	C	INCO[12]
330	S	123	5640	<0.1	0	0	----	NC	INCO[12]
330	W	403	6780	<0.1	0	I	----	C	INCO[12]
330	S	403	6780	<0.1	0	I	----	C	INCO[12]
330	W	751	5640	<0.1	0	I	----	C	INCO[12]
330	S	751	5640	<0.1	0	I	----	C	INCO[12]
330	W	1064	5300	<0.1	0	I	----	C[7]	INCO[12]
330	S	1064	5300	<0.1	0	3	----	C	INCO[12]
347	W	182	5	0.8	50(PR)	50(PR)	----	C,P	INCO[12]
347	W	366	5	0.7	50(PR)	50(PR)	----	C,P	INCO[12]
347	W	197	2340	<0.1	0	0	----	NC	INCO[12]
347	S	197	2340	<0.1	0	I	----	C	INCO[12]
347	W	402	2370	<0.1	0	I	----	C	INCO[12]
347	S	402	2370	<0.1	0	2	----	C	INCO[12]
347	W	123	5640	<0.1	0	10	----	C	INCO[12]
347	S	123	5640	<0.1	0	0	----	NC	INCO[12]
347	W	403	6780	<0.1	0	I	----	C	INCO[12]
347	S	403	6780	<0.1	0	3	----	C	INCO[12]
347	W	751	5640	<0.1	0	0	----	NC	INCO[12]
347	S	751	5640	<0.1	0	29	----	C	INCO[12]
347	W	1064	5300	<0.1	I	I	----	C,P	INCO[12]
347	S	1064	5300	<0.1	0	50(PR)	----	C	INCO[12]

Table 4. Corrosion Rates and Types of Corrosion of 300 Series Stainless Steels (cont'd)

1. AISI Type
2. W - Specimens exposed on sides of STU in water.
   S - Specimens exposed in base of STU, partially embedded in bottom sediment.
3. MPY - mils penetration per year calculated from weight loss.
4. Symbols signify the following types of corrosion:

   C - Crevice
   E - Edge
   G - General
   I - Incipient
   NC - No visible corrosion
   NU - Non-uniform
   P - Pitting
   PR - Perforated
   S - Severe
   SL - Slight
   T - Tunneling
   Numbers indicate maximum depth in mils
5. Numbers refer to references at end of paper
6. Sensitized for 1 hour at 1200°F, air cooled
7. Corroded at an inclusion

Table 5. Corrosion Rates and Types of Corrosion of 400 Series Stainless Steels

Alloy	Environment[2]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[3]	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils[4]	Corrosion, Tunnel, Maximum Length, Mils	Corrosion Type[4]	Source[5]
405[1]	W	197	2340	2.1	0	0	125	E,T	NCEL
405	S	197	2340	1.4	0	0	380	E,T	NCEL
405	W	402	2370	1.8	40	15	0	C,P	NCEL
405	S	402	2370	2.0	52	11	0	C,P	NCEL
405	W	123	5640	2.4	0	0	I	E,T	NCEL
405	S	123	5640	2.0	0	0	I	E,T	NCEL
405	W	403	6780	3.9	0	0	2000	E,T	NCEL
405	S	403	6780	2.4	0	0	2500	E,T	NCEL
405	W	751	5640	2.8	262(PR)	0	500	E,T,P	NCEL
405	W	1064	5300	1.2	262(PR)	47	12000	C,E,T,P	NCEL
405[6]	W	1064	5300	1.7	262(PR)	262(PR)	2150	C,E,T,P	NCEL
405	S	1064	5300	1.1	262(PR)	262(PR)	6250	C,E,T,P	NCEL
410	W	181	5	2.1	40(PR)	40(PR)	1000	C,E,T,P	NCEL
410	W	181	5	3.4	50(PR)	50(PR)	----	C,P	INCO[12]
410	W	366	5	3.0	50(PR)	50(PR)	----	C,P	INCO[12]
410	W	197	2340	0.3	0	10	7000	E,T	NCEL
410	W	197	2340	1.3	50(PR)	0	----	P	INCO[12]
410	S	197	2340	0.2	0	15	7000	C,E,T	NCEL
410	S	197	2340	0.2	0	18	----	C	INCO[12]
410	W	402	2370	0.5	40(PR)	40(PR)	6400	C,T,P	NCEL
410	W	402	2370	0.8	50(PR)	50(PR)	----	C,P	INCO[12]
410	S	402	2370	0.4	40(PR)	40(PR)	12000	C,T,P	NCEL
410	S	402	2370	0.2	0	50(PR)	----	C	INCO[12]
410	W	123	5640	0.2	40(PR)	SL	2950	C,T,P	NCEL
410	W	123	5640	3.1	50(PR)	0	----	P	INCO[12]
410	S	123	5640	0.3	40(PR)	SL	1600	C,T,P	NCEL
410	S	123	5640	2.3	50(PR)	0	----	P	INCO[12]
410	W	403	6780	0.2	40(PR)	40(PR)	6000	C,T,P	NCEL
410	W	403	6780	5.7	50(PR)	50(PR)	----	C,P	INCO[12]

Table 5. Corrosion Rates and Types of Corrosion of 400 Series Stainless Steels (cont'd)

Alloy	Environment (2)	Exposure, Days	Depth, Feet	Corrosion Rate, MPY (3)	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils (4)	Corrosion, Tunnel, Maximum Length, Mils	Corrosion Type (4)	Source (5)
410	S	403	6780	1.0	40(PR)	40(PR)	8850	C,T,P	NCEL (12)
410	S	403	6780	<0.1	0	6	----	C	INCO (12)
410	W	751	5640	0.5	40(PR)	40(PR)	10000	C,T,P	NCEL (12)
410	W	751	5640	4.4	50(PR)	50(PR)	----	C,P	INCO (12)
410	S	751	5640	0.4	40(PR)	40(PR)	12000	C,T,P	NCEL (12)
410	W	1064	5300	1.7	50(PR)	50(PR)	----	C,P	INCO (12)
410	S	1064	5300	0.9	50(PR)	50(PR)	----	C,P	INCO (12)
430	W	182	5	1.7	50(PR)	50(PR)	----	C,P	INCO (12)
430	W	366	5	1.1	50(PR)	50(PR)	----	C,P	INCO (12)
430	W	123	2500	0.0	0	0	0	SLE	NCEL
430	W	197	2340	0.5	0	17	2375	C,T	NCEL (12)
430	W	197	2340	0.4	30(PR)	30(PR)	----	C,P	INCO (12)
430	S	197	2340	0.3	0	19	2000	C,T	NCEL (12)
430	S	197	2340	<0.1	0	3	----	C	INCO (12)
430	W	402	2370	0.6	137(PR)	20	6000	C,E,T,P	NCEL (12)
430	W	402	2370	0.8	30(PR)	30(PR)	----	C,P	INCO (12)
430	S	402	2370	0.4	137(PR)	0	11500	E,T,P	NCEL (12)
430	S	402	2370	0.2	0	8	----	C	INCO (12)
430	W	123	5640	0.5	0	10	1000	C,T	NCEL (12)
430	W	123	5640	<0.1	0	I	----	C	INCO (12)
430	S	123	5640	0.1	0	10	2000	C,E,T	NCEL (12)
430	S	123	5640	<0.1	0	0	----	NC	INCO (12)
430	W	403	6780	0.2	137(PR)	30	3750	C,T,P	NCEL (12)
430	W	403	6780	<0.1	0	I	----	C	INCO (12)
430	S	403	6780	0.3	137(PR)	34	4500	C,T,P	NCEL (12)
430	S	403	6780	<0.1	0	I	----	C	INCO (12)
430	W	751	5640	0.6	137(PR)	30	5000	C,T,P	NCEL (12)
430	W	751	5640	0.2	0	23	----	C	INCO (12)
430	S	751	5640	0.1	50(PR)	50(PR)	9000	C,P,T	NCEL (12)
430	S	751	5640	<0.1	0	50(PR)	----	C	INCO

Table 5. Corrosion Rates and Types of Corrosion of 400 Series Stainless Steels (cont'd)

Alloy	Environment[2]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[3]	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils[4]	Corrosion, Tunnel, Maximum Length, Mils	Corrosion Type[4]	Source[5]
430	W	1064	5300	0.5	137(PR)	25	7200	C,T,P	NCEL
430[6]	W	1064	5300	1.3	137(PR)	97	500	C,E,T,P	NCEL
430	W	1064	5300	<0.1	0	I	----	C	INCO[12]
430	S	1064	5300	0.7	0	40	6500	C,T	NCEL
430	S	1064	5300	0.2	30(PR)	30(PR)	----	C,P	INCO[12]
446	W	182	5	0.3	50(PR)	50(PR)	----	C,P	INCO[12]
446	W	366	5	0.6	50(PR)	50(PR)	----	C,P	INCO[12]
446	W	197	2340	<0.1	0	I	----	C	INCO[12]
446	S	197	2340	<0.1	0	2	----	C	INCO[12]
446	W	402	2370	<0.1	0	I	----	C	INCO[12]
446	S	402	2370	<0.1	0	2	----	C	INCO[12]
446	W	123	5640	<0.1	0	0	----	NC	INCO[12]
446	S	123	5640	<0.1	0	0	----	NC	INCO[12]
446	W	403	6780	<0.1	0	0	----	NC	INCO[12]
446	S	403	6780	<0.1	0	I	----	C	INCO[12]
446	W	751	5640	<0.1	0	0	----	SL,ET	INCO[12]
446	S	751	5640	<0.1	0	0	----	NC	INCO[12]
446	W	1064	5300	<0.1	0	0	----	NC	INCO[12]
446	S	1064	5300	<0.1	0	I	----	C	INCO[12]
							----		

1. AISI Type
2. W - specimens exposed on sides of STU in water.
   S - specimens exposed in base of STU, partially embedded in the bottom sediment.
3. MPY - mils penetration per year calculated from weight loss.
4. Abbreviations signify the following types of corrosion:
   I - Incipient   S - Severe   SL - Slight   T - Tunneling
   C - Crevice   E - Edge   NC - No visible corrosion   Numbers indicate maximum depth of attack.
   P - Pitting   Et - Etching   PR - Perforation
5. Numbers refer to references at end of paper.
6. Specimens 1" X 6"

Table 6. Corrosion Rates and Types of Corrosion of Precipitation Hardening Stainless Steels

Alloy	Environment[1]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[2]	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils[3]	Corrosion, Tunnel, Maximum Length, Mils	Corrosion, Type[3]	Corrosion, Weld[3]	Source[4]
AISI 630, H925[5]	W	181	5	3.0	112(PR)	112(PR)	1800	C,E,P,T	NC	NCEL
AISI 630, H925[6]	W	181	5	3.2	112(PR)	112(PR)	1000	C,E,P,T	NC	NCEL
AISI 630, H925[6]	W	398	5	1.4	112(PR)	112(PR)	0	C,E,P	T, PR(WB&HAZ)	NCEL
AISI 630, H925[5]	W	197	2340	0.1	0	0	0	NC	NC	NCEL
AISI 630, H925[6]	W	197	2340	<0.1	0	0	0	NC	NC	NCEL
AISI 630, H925[5]	S	197	2340	0.2	0	0	0	NC	U(WB)	NCEL
AISI 630, H925[6]	S	197	2340	0.2	0	0	1200	T,PR	NC	NCEL
AISI 630, H925[5]	W	402	2370	<0.1	0	0	0	NC	NC	NCEL
AISI 630, H925[6]	W	402	2370	<0.1	0	0	0	NC	NC	NCEL
AISI 630, H925[5]	S	402	2370	0.6	112(PR)	0	1750	E,T,P	NC	NCEL
AISI 630, H925[6]	S	402	2370	<0.1	0	0	0	NC	NC	NCEL
AISI 630, H925[5]	W	403	6780	<0.1	0	0	0	NC	NC	NCEL
AISI 630, H925[6]	W	403	6780	<0.1	0	0	0	NC	T,PR(WB)	NCEL
AISI 630, H925[5]	S	403	6780	0.4	0	0	4500	T	T,PR(WB)	NCEL
AISI 630, H925[6]	S	403	6780	<0.1	0	0	1000	T	T,PR(HAZ)	NCEL
AISI 631, TH1050[5]	W	181	5	4.4	125(PR)	125(PR)	4000	C,E,P,T	NC	NCEL
AISI 631, TH1050[6]	W	181	5	2.7	125(PR)	125(PR)	1000	C,E,P,T	PR(WB&HAZ)	NCEL
AISI 631, TH1050[5]	W	398	5	1.9	125(PR)	125(PR)	2600	C,T,P	SCC	NCEL
AISI 631, TH1050[5]	W	197	2340	0.4	125(PR)	125(PR)	1250	C,T,P	NC	NCEL
AISI 631, TH1050[6]	W	197	2340	0.1	125(PR)	125(PR)	750	C,T,P	NC	NCEL
AISI 631, TH1050[5]	S	197	2340	0.3	125(PR)	125(PR)	1500	C,T,P	NC	NCEL
AISI 631, TH1050[6]	S	197	2340	<0.1	125(PR)	125(PR)	375	C,T,P	NC	NCEL
AISI 631, TH1050[5]	W	402	2370	0.4	125(PR)	0	3750	C,E,T,P	IP	NCEL
AISI 631, TH1050[6]	W	402	2370	0.6	125(PR)	0	3250	E,T,P	IP	NCEL
AISI 631, TH1050[5]	S	402	2370	0.6	125(PR)	0	3500	E,T,P	IP	NCEL
AISI 631, TH1050[6]	S	402	2370	0.5	125(PR)	0	4250	E,T,P	IP	NCEL
AISI 631, TH1050[5]	W	403	6780	0.2	0	0	1750	E,T	NC	NCEL
AISI 631, TH1050[6]	W	403	6780	1.1	125(PR)	0	1000	E,T,P	T,PR(WB)	NCEL
AISI 631, TH1050[5]	S	403	6780	0.6	125(PR)	0	1500	T,P	SCC	NCEL
AISI 631, TH1050[6]	S	403	6780	1.6	0	125(PR)	4000	C,SE,T	NC	NCEL

Table 6. Corrosion Rates and Types of Corrosion of Precipitation Hardening Stainless Steels (cont'd)

Alloy	Environment (1)	Exposure, Days	Depth, Feet	Corrosion Rate, MPY (2)	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils (3)	Corrosion, Tunnel, Maximum Length, Mils	Corrosion, Type (3)	Corrosion, Weld (3)	Source (4)
AISI 631, RH1050 (5)	W	181	5	2.9	125(PR)	125(PR)	2500	C,SE,T	NC	NCEL
AISI 631, RH1050 (6)	W	181	5	3.3	125(PR)	125(PR)	1000	C,SE,T	NC	NCEL
AISI 631, RH1050 (5)	W	197	2340	0.3	0	0	1375	T,SCC,IP	SCC	NCEL
AISI 631, RH1050 (6)	W	197	2340	0.6	125(PR)	0	1500	T	T,PR(HAZ)	NCEL
AISI 631, RH1050 (5)	S	197	2340	0.6	0	125(PR)	1000	C,T	NC	NCEL
AISI 631, RH1050 (6)	S	197	2340	0.3	125(PR)	0	1250	T	NC	NCEL
AISI 631, RH1050 (5)	W	402	2370	<0.1	0	0	1250	IP,T	IP	NCEL
AISI 631, RH1050 (6)	W	402	2370	0.7	125(PR)	0	2500	T,P	IP	NCEL
AISI 631, RH1050 (5)	S	402	2370	<0.1	125(PR)	0	3000	T	SCC	NCEL
AISI 631, RH1050 (6)	S	402	2370	0.5	125(PR)	0	5800	T	T,PR(HAZ)	NCEL
AISI 631, RH1050 (5)	W	403	6780	0.4	125(PR)	125(PR)	3000	C,T	SCC	NCEL
AISI 631, RH1050 (6)	W	403	6780	1.0	0	125(PR)	2000	C,IP	IP	NCEL
AISI 631, RH1050 (5)	S	403	6780	1.3	0	125(PR)	6000	C,SE,IP,X,T	IP	NCEL
AISI 631, RH1050 (6)	S	403	6780	0.8	125(PR)	0	1500	T,IP,X	IP	NCEL
AISI 632, RH1100 (5)	W	181	5	3.7	125(PR)	0	1150	SE,T	NC	NCEL
AISI 632, RH1100 (6)	W	181	5	3.7	125(PR)	0	1000	SE,T	NC	NCEL
AISI 632, RH1100 (6)	W	398	5	1.8	125(PR)	125(PR)	750	C,T	NC	NCEL
AISI 632, RH1100 (5)	W	197	2340	0.6	125(PR)	96	750	C,T	NC	NCEL
AISI 632, RH1100 (6)	W	197	2340	0.2	125(PR)	0	500	E,T	NC	NCEL
AISI 632, RH1100 (5)	S	197	2340	0.5	125(PR)	0	750	E,T	NC	NCEL
AISI 632, RH1100 (6)	S	197	2340	0.3	125(PR)	0	650	E,T	NC	NCEL
AISI 632, RH1100 (5)	W	402	2370	0.9	125(PR)	0	1400	T	IP	NCEL
AISI 632, RH1100 (6)	W	402	2370	0.7	125(PR)	0	1000	T	NC	NCEL
AISI 632, RH1100 (5)	S	402	2370	0.7	0	0	1000	IP,T	SCC	NCEL
AISI 632, RH1100 (6)	S	402	2370	0.6	125(PR)	0	1000	T	IP,T(HAZ)	NCEL
AISI 632, RH1100 (5)	W	403	6780	2.1	125(PR)	125(PR)	2850	C,T	NC	NCEL
AISI 632, RH1100 (6)	W	403	6780	1.5	125(PR)	125(PR)	2000	C,T	NC	NCEL
AISI 632, RH1100 (5)	S	403	6780	1.1	125(PR)	125(PR)	2100	C,T	NC	NCEL
AISI 632, RH1100 (6)	S	403	6780	1.2	125(PR)	125(PR)	5500	C,T	NC	NCEL

Table 6. Corrosion Rates and Types of Corrosion of Precipitation Hardening Stainless Steels (cont'd)

Alloy	Environment(1)	Exposure, Days	Depth, Feet	Corrosion Rate, MPY(2)	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils(3)	Corrosion, Tunnel, Maximum Length, Mils	Corrosion, Type(3)	Corrosion, Weld(3)	Source(4)
AISI 633	W	182	5	<0.1	0	I	----	C	----	INCO(12)
AISI 633	W	366	5	<0.1	0	I	----	C	----	INCO(12)
AISI 633	W	197	2340	<0.1	0	I	----	C	----	INCO(12)
AISI 633	S	197	2340	<0.1	0	I	----	C	----	INCO(12)
AISI 633	W	402	2370	<0.1	0	I	----	C	----	INCO(12)
AISI 633	S	402	2370	<0.1	0	I	----	C	----	INCO(12)
AISI 633	W	123	5640	<0.1	0	0	----	NC	----	INCO(12)
AISI 633	S	123	5640	<0.1	0	0	----	NC	----	INCO(12)
AISI 633	W	403	6780	<0.1	0	I	----	C	----	INCO(12)
AISI 633	S	403	6780	<0.1	0	0	----	NC	----	INCO(12)
AISI 633	W	751	5640	<0.1	0	0	----	NC	----	INCO(12)
AISI 633	S	751	5640	<0.1	0	I	----	C	----	INCO(12)
AISI 633	W	1064	5300	<0.1	0	0	----	NC	----	INCO(12)
AISI 633	S	1064	5300	<0.1	0	1.0	----	C	----	INCO(12)
AISI 634-CRT	W	197	2340	0.2	I	I	0	C,P	----	NCEL
AISI 634-CRT	S	197	2340	<0.1	I	0	0	P	----	NCEL
AISI 634-CRT	W	402	2370	0.4	I	38	0	C,P	----	NCEL
AISI 634-CRT	S	402	2370	0.1	I	20	0	C,P	----	NCEL
AISI 634-CRT	W	123	5640	<0.1	0	0	0	NC	----	NCEL
AISI 634-CRT	W	403	6780	0.2	0	50	0	C	----	NCEL
AISI 634-CRT	S	403	6780	<0.1	0	30	0	C	----	NCEL
AISI 634-CRT	W	751	5640	0.0	0	0	0	NC	----	NCEL
AISI 635	W	181	5	0.9	40	275(PR)	1000	C,E,P,T	----	NCEL
AISI 635	W	398	5	0.6	40	40	1200	C,E,T,P	----	NCEL
AISI 635	W	197	2340	<0.1	0	0	0	NC	----	NCEL
AISI 635	S	197	2340	<0.1	0	0	0	NC	----	NCEL
AISI 635	W	402	2370	0.3	0	275(PR)	1200	C,T	----	NCEL
AISI 635	S	402	2370	<0.1	0	0	0	NC	----	NCEL

Table 6. Corrosion Rates and Types of Corrosion of Precipitation Hardening Stainless Steels (cont'd)

Alloy	Environment[1]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[2]	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils[3]	Corrosion, Tunnel, Maximum Length, Mils	Corrosion, Type[3]	Corrosion, Weld[3]	Source[4]
AISI 635	W	123	5640	<0.1	0	SL	0	C	----	NCEL
AISI 635	S	123	5640	<0.1	0	0	0	NC	----	NCEL
AISI 635	W	403	6780	0.2	0	20	0	C	----	NCEL
AISI 635	S	403	6780	0.1	0	11	0	C	----	NCEL
AISI 635	W	751	5640	<0.1	0	0	0	NC	----	NCEL
AISI 635	W	1064	5300	<0.1	0	16	0	C	----	NCEL
AISI 635[7]	W	1064	5300	<0.1	0	50	0	C	----	NCEL
AISI 635	S	1064	5300	<0.1	0	0	0	NC	----	NCEL
17-14-Cu-Mo	W	182	5	<0.1	3	0	----	P	----	INCO[12]
17-14-Cu-Mo	W	366	5	<0.1	0	I	----	C	----	INCO[12]
17-14-Cu-Mo	W	197	2340	<0.1	0	I	----	C	----	INCO[12]
17-14-Cu-Mo	S	197	2340	<0.1	0	I	----	C	----	INCO[12]
17-14-Cu-Mo	W	402	2370	<0.1	0	I	----	C	----	INCO[12]
17-14-Cu-Mo	S	402	2370	<0.1	0	I	----	C	----	INCO[12]
17-14-Cu-Mo	W	123	5640	<0.1	0	0	----	NC	----	INCO[12]
17-14-Cu-Mo	S	123	5640	<0.1	0	0	----	NC	----	INCO[12]
17-14-Cu-Mo	W	403	6780	<0.1	0	I	----	C	----	INCO[12]
17-14-Cu-Mo	S	403	6780	<0.1	0	I	----	C	----	INCO[12]
17-14-Cu-Mo	W	751	5640	<0.1	0	I	----	C	----	INCO[12]
17-14-Cu-Mo	S	751	5640	<0.1	0	I	----	C	----	INCO[12]
17-14-Cu-Mo	W	1064	5300	<0.1	0	I	----	C	----	INCO[12]
17-14-Cu-Mo	S	1064	5300	<0.1	0	3	----	C	----	INCO[12]
PH14-8Mo, SHR950[5]	W	181	5	3.1	120(PR)	0	2400	SE,P,T	NC	NCEL
PH14-8Mo, SRH950[6]	W	181	5	1.7	120(PR)	0	1400	SE,P,T	90(PR)WB	NCEL
PH14-8Mo, SRH950[5]	W	197	2340	0.3	0	I	500	T,C	NC	NCEL
PH14-8Mo, SRH950[5]	S	197	2340	<0.1	0	I	0	C	NC	NCEL
PH14-8Mo, SRH950[6]	W	197	2340	<0.1	I	0	0	P	NC	NCEL
PH14-8Mo, SRH950[6]	S	197	2340	<0.1	0	0	0	NC	NC	NCEL

Table 6. Corrosion Rates and Types of Corrosion of Precipitation Hardening Stainless Steels (cont'd)

Alloy	Environment[1]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[2]	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils[3]	Corrosion, Tunnel, Maximum Length, Mils	Corrosion, Type[3]	Corrosion, Weld[3]	Source[4]
PH14-8Mo, SRH950[5]	W	402	2370	0.5	I	120(PR)	2000	P,C,T	IP	NCEL
PH14-8Mo, SRH950[5]	S	402	2370	0.3	120(PR)	0	3000	T,P	IP	NCEL
PH14-8Mo, SRH950[6]	W	402	2370	<0.1	I	0	0	P	IP	NCEL
PH14-8Mo, SRH950[6]	S	402	2370	<0.1	I	0	0	P	IP	NCEL
PH14-8Mo, SRH950[5]	W	403	6780	0.4	I	0	3000	T,P	IP	NCEL
PH14-8Mo, SRH950[5]	S	403	6780	0.2	120(PR)	0	2000	T,IP	120PR(HAZ)	NCEL
PH14-8Mo, SRH950[6]	W	403	6780	<0.1	I	0	0	P	IP	NCEL
PH14-8Mo, SRH950[6]	S	403	6780	<0.1	I	0	0	P	IP	NCEL
15-7AMV,A[8]	W	197	2340	0.4	48(PR)	48(PR)	2000	C,P,T,E	----	NCEL
15-7AMV,A	S	197	2340	0.3	48(PR)	48(PR)	4000	C,P,T,E	----	NCEL
15-7AMV,A	W	402	2370	0.5	48(PR)	48(PR)	7300	C,P,T,E	----	NCEL
15-7AMV,A	S	402	2370	0.5	48(PR)	48(PR)	13,800	C,P,T,E,X	----	NCEL
15-7AMV,A	W	123	5640	<0.1	48(PR)	48(PR)	750	C,P,T	----	NCEL
15-7AMV,A	S	123	5640	0.4	48(PR)	48(PR)	1800	C,P,T	----	NCEL
15-7AMV,A	W	403	6780	1.2	48(PR)	48(PR)	4000	C,P,T,X	----	NCEL
15-7AMV,A	S	403	6780	0.8	48(PR)	48(PR)	2500	C,P,T,X	----	NCEL
15-7AMV,A	W	751	5640	2.7	48(PR)	48(PR)	6000	C,P,T,X	----	NCEL
15-7AMV,A	S	751	5640	2.4	48(PR)	48(PR)	6000	C,P,T,X	----	NCEL
15-7AMV,A	W	1064	5300	3.0	48(PR)	48(PR)	----	C,P,T,X	----	NCEL
15-7AMV,A	S	1064	5300	0.9	48(PR)	48(PR)	----	C,P,T,X	----	NCEL
15-7AMV,RH1150	W	197	2340	0.4	45(PR)	45(PR)	3300	C,P,T	----	NCEL
15-7AMV,RH1150	S	197	2340	0.7	45(PR)	45(PR)	1150	C,P,T	----	NCEL
15-7AMV,RH1150	W	402	2370	1.0	45(PR)	45(PR)	8750	C,P,T,E,X	----	NCEL
15-7AMV,RH1150	S	402	2370	0.7	45(PR)	45(PR)	4000	C,P,T,E	----	NCEL
15-7AMV,RH1150	W	123	5640	0.1	45(PR)	45(PR)	0	C,P	----	NCEL
15-7AMV,RH1150	S	123	5640	0.1	45(PR)	45(PR)	1150	C,P,T	----	NCEL
15-7AMV,RH1150	W	403	6780	1.2	45(PR)	45(PR)	5750	C,P,T	----	NCEL
15-7AMV,RH1150	S	403	6780	1.2	45(PR)	45(PR)	4500	C,P,T	----	NCEL
15-7AMV,RH1150	W	751	5640	1.5	45(PR)	45(PR)	6000	C,P,T,X	----	NCEL
15-7AMV,RH1150	S	751	5640	1.2	45(PR)	45(PR)	6000	C,P,T,X	----	NCEL

Table 6. Corrosion Rates and Types of Corrosion of Precipitation Hardening Stainless Steels (cont'd)

Alloy	Environment (1)	Exposure, Days	Depth, Feet	Corrosion Rate, MPY (2)	Maximum Pit Depth, Mils	Corrosion, Crevice, Mils (3)	Corrosion, Tunnel, Maximum Length, Mils	Corrosion, Type (3)	Corrosion, Weld (3)	Source (4)
15-7AMV,RH1150	W	1064	5300	1.1	45(PR)	45(PR)	5000	C,P,T	----	NCEL
15-7AMV,RH1150	S	1064	5300	0.9	45(PR)	45(PR)	6000	C,P,T	----	NCEL
15-7AMV,RH950	W	123	2500	0.7	I	SL	0	C,P	----	NCEL
15-7AMV,RH950	W	197	2340	0.8	48(PR)	48(PR)	1000	C,P,T,E	----	NCEL
15-7AMV,RH950	S	197	2340	0.7	48(PR)	48(PR)	1750	C,P,T,E	----	NCEL
15-7AMV,RH950	W	402	2370	0.6	48(PR)	48(PR)	4650	C,P,T,E	----	NCEL
15-7AMV,RH950	S	402	2370	0.6	48(PR)	48(PR)	6000	C,P,T,E	----	NCEL
15-7AMV,RH950	W	123	5640	0.7	48(PR)	48(PR)	0	C,P	----	NCEL
15-7AMV,RH950	S	123	5640	1.3	48(PR)	48(PR)	2900	C,P,T,X	----	NCEL
15-7AMV,RH950	W	403	6780	1.0	48(PR)	48(PR)	3750	C,P,T,X	----	NCEL
15-7AMV,RH950	S	403	6780	1.2	48(PR)	48(PR)	5000	C,P,T,X	----	NCEL
15-7AMV,RH950 (7)	W	751	5640	1.6	48(PR)	48(PR)	6000	C,P,T,E	----	NCEL
15-7AMV,RH950	W	1064	5300	2.0	48(PR)	48(PR)	----	C,P,X	----	NCEL
15-7AMV,RH950	W	1064	5300	0.8	48(PR)	48(PR)	6000	C,P,X,T	----	NCEL
15-7AMV,RH950	S	1064	5300	0.9	48(PR)	48(PR)	6000	C,P,X,T	----	NCEL

1. W - Specimens exposed on sides of STU in water.
   S - Specimens exposed in base of STU, partially embedded in bottom sediment.
2. MPY - Mils penetration per year calculated from weight loss.
3. Symbols signify the following types and severity of corrosion:

C - Crevice	I - Incipient	S - Severe	WB - Weld bead
E - Edge	NC - No visible corrosion	SCC - Stress corrosion cracked	X - Portion of specimens missing due to corrosion
G - General	P - Pitting	SL - Slight	Numbers indicate maximum depth of pits or corrosion in mils.
HAZ - Heat affected zone	PR - Perforated	T - Tunneling	

4. Numbers refer to references at end of paper.
5. Three inch diameter circular weld in center of specimen.
6. Transverse butt weld.
7. Specimen size 1" X 6"
8. A - Annealed

Table 7. Corrosion Rates and Types of Corrosion of Miscellaneous Stainless Steels

Alloy	Environment[1]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[2]	Maximum Pit Depth, Mils	Crevice Corrosion, Mils[3]	Corrosion, Tunnel, Maximum Length, Mils	Corrosion, Type[3]	Source[4]
20Cb	W	181	5	<0.1	0	5	0	SLE,C	NCEL
20Cb	W	398	5	<0.1	14.0	0	0	SLE,P	NCEL
20Cb	W	197	2340	<0.1	0	I	0	C	NCEL
20Cb	S	197	2340	<0.1	0	I	0	C	NCEL
20Cb	W	402	2370	<0.1	0	0	0	NC	NCEL
20Cb	S	402	2370	<0.1	0	0	0	NC	NCEL
20Cb	W	123	5640	0.0	0	0	0	NC	NCEL
20Cb	S	123	5640	0.0	0	0	0	NC	NCEL
20Cb	W	403	6780	0.0	0	0	0	NC	NCEL
20Cb	S	403	6780	<0.1	0	102	0	C	NCEL
20Cb	W	751	5640	<0.1	0	26	0	C	NCEL
20Cb	S	751	5640	0.0	0	0	0	NC	NCEL
20Cb	W	1064	5300	0.0	0	0	0	NC	NCEL
20Cb	S	1064	5300	0.0	0	0	0	NC	NCEL
20Cb-3	W	182	5	<0.1	0	I	----	C	INCO[12]
20Cb-3	W	366	5	<0.1	0	0	----	NC	INCO[12]
20Cb-3	W	197	2340	<0.1	0	I	----	C	INCO[12]
20Cb-3	S	197	2340	<0.1	0	I	----	C	INCO[12]
20Cb-3	W	402	2370	<0.1	I	0	----	P	INCO[12]
20Cb-3	S	402	2370	<0.1	0	I	----	C	INCO[12]
20Cb-3	W	123	5640	<0.1	0	0	----	NC	INCO[12]
20Cb-3	S	123	5640	<0.1	0	0	----	NC	INCO[12]
20Cb-3	W	403	6780	<0.1	0	I	----	C	INCO[12]
20Cb-3	S	403	6780	<0.1	0	I	----	C	INCO[12]
20Cb-3	W	751	5640	<0.1	0	0	----	NC	INCO[12]
20Cb-3	S	751	5640	<0.1	0	0	----	NC	INCO[12]
20Cb-3	W	1064	5300	<0.1	0	I	----	C	INCO[12]
20Cb-3	S	1064	5300	<0.1	0	I	----	C	INCO[12]
Ni-Cr-Cu-Mo#1	W	182	5	0.5	0	20	----	C	INCO[12]
Ni-Cr-Cu-Mo#1	W	366	5	<0.1	0	I	----	C	INCO[12]
Ni-Cr-Cu-Mo#1	W	197	2340	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Cu-Mo#1	S	197	2340	<0.1	0	I	----	C	INCO[12]

Table 7. Corrosion Rates and Types of Corrosion of Miscellaneous Stainless Steels (cont'd)

Alloy	Environment[1]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[2]	Maximum Pit Depth, Mils	Crevice Corrosion, Mils[3]	Corrosion, Tunnel, Maximum Length, Mils	Corrosion, Type[3]	Source[4]
Ni-Cr-Cu-Mo#1	W	402	2370	<0.1	0	8	----	C	INCO[12]
Ni-Cr-Cu-Mo#1	S	402	2370	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Cu-Mo#1	W	123	5640	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Cu-Mo#1	S	123	5640	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Cu-Mo#1	W	403	6780	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Cu-Mo#1	S	403	6780	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Cu-Mo#1	W	751	5640	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Cu-Mo#1	S	751	5640	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Cu-Mo#1	W	1064	5300	<0.1	0	I	----	C	INCO[12]
Ni-Cr-Cu-Mo#1	S	1064	5300	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Cu-Mo#2	W	182	5	0.1	0	18	----	C	INCO[12]
Ni-Cr-Cu-Mo#2	W	366	5	0.1	0	27	----	C	INCO[12]
Ni-Cr-CU-Mo#2	W	197	2340	0.1	0	I	----	C	INCO[12]
Ni-Cr-Cu-Mo#2	S	197	2340	<0.1	0	I	----	C	INCO[12]
Ni-Cr-Cu-Mo#2	W	402	2370	0.2	3	0	----	P	INCO[12]
Ni-Cr-Cu-Mo#2	S	402	2370	<0.1	0	I	----	C	INCO[12]
Ni-Cr-Cu-Mo#2	W	123	5640	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Cu-Mo#2	S	123	5640	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Cu-Mo#2	W	403	6780	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Cu-Mo#2	S	403	6780	<0.1	0	I	----	C	INCO[12]
Ni-Cr-Cu-Mo#2	W	751	5640	0.1	0	I	----	C	INCO[12]
Ni-Cr-Cu-Mo#2	S	751	5640	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Cu-Mo#2	W	1064	5300	0.1	0	3	----	C	INCO[12]
Ni-Cr-Cu-Mo#2	S	1064	5300	0.1	0	5	----	C	INCO[12]
Ni-Cr-Mo	W	182	5	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo	W	366	5	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo	W	197	2340	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo	S	197	2340	<0.1	0	I	----	C	INCO[12]
Ni-Cr-Mo	W	402	2370	<0.1	0	1	----	C	INCO[12]
Ni-Cr-Mo	S	402	2370	<0.1	0	I	----	C	INCO[12]
Ni-Cr-Mo	W	123	5640	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo	S	123	5640	<0.1	0	0	----	NC	INCO[12]

Table 7. Corrosion Rates and Types of Corrosion of Miscellaneous Stainless Steels (cont'd)

Alloy	Environment[1]	Exposure, Days	Depth, Feet	Corrosion Rate, MPY[2]	Maximum Pit Depth, Mils	Crevice Corrosion, Mils[3]	Corrosion, Tunnel, Maximum Length, Mils	Corrosion, Type[3]	Source[4]
Ni-Cr-Mo	W	403	6780	<0.1	0	I	----	C	INCO[12]
Ni-Cr-Mo	S	403	6780	<0.1	0	I	----	C	INCO[12]
Ni-Cr-Mo	W	751	5640	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo	S	751	5640	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo	W	1064	5300	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo	S	1064	5300	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo-Si	W	182	5	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo-Si	W	366	5	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo-Si	W	197	2340	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo-Si	S	197	2340	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo-Si	W	402	2370	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo-Si	S	402	2370	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo-Si	W	123	5640	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo-Si	S	123	5640	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo-Si	W	403	6780	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo-Si	S	403	6780	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo-Si	W	751	5640	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo-Si	S	751	5640	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo-Si	W	1064	5300	<0.1	0	0	----	NC	INCO[12]
Ni-Cr-Mo-Si	S	1064	5300	<0.1	0	0	----	NC	INCO[12]
RL-35-100	W	197	2340	<0.1	0	0	----	NC	INCO[12]
RL-35-100	S	197	2340	<0.1	0	0	----	NUET	INCO[12]
RL-35-100	W	123	5640	0.3	0	0	----	G	INCO[12]
RL-35-100	S	123	5640	0.5	0	0	----	G	INCO[12]
RL-35-100	W	403	6780	<0.1	0	0	----	G	INCO[12]
RL-35-100	S	403	6780	0.3	0	0	----	G	INCO[12]
RL-35-100	W	751	5640	<0.1	0	0	----	UET	INCO[12]
RL-35-100	S	751	5640	0.3	0	0	----	ET	INCO[12]
RL-35-100	W	1064	5300	0.7	0	0	----	G	INCO[12]
RL-35-100	S	1064	5300	0.1	0	0	----	G	INCO[12]

Table 7. Corrosion Rates and Types of Corrosion of Miscellaneous Stainless Steels (cont'd)

Alloy	Environment (1)	Exposure, Days	Depth, Feet	Corrosion Rate, MPY (2)	Maximum Pit Depth, Mils	Crevice Corrosion, Mils (3)	Corrosion, Tunnel, Maximum Length, Mils	Corrosion, Type (3)	Source (4)
18Cr-14Mn-0.5N	W	182	5	4.9	50(PR)	50(PR)	----	C,P	INCO (12)
18Cr-14Mn-0.5N	W	366	5	2.6	50(PR)	50(PR)	----	C,P	INCO (12)
18Cr-14Mn-0.5N	W	197	2340	0.8	115(PR)	109	1250	C,T,P	NCEL
18Cr-14Mn-0.5N	W	197	2340	<0.1	0	I	----	C	INCO (12)
18Cr-14Mn-0.5N	S	197	2340	0.4	115(PR)	21	1000	C,T,P	NCEL
18Cr-14Mn-0.5N	S	197	2340	<0.1	0	13	----	C	INCO (12)
18Cr-14Mn-0.5N	W	402	2370	0.8	115(PR)	0	2000	T,P	NCEL
18Cr-14Mn-0.5N	W	402	2370	1.1	0	62(PR)	----	C	INCO (12)
18Cr-14Mn-0.5N	S	402	2370	1.0	115(PR)	0	3000	T,P	NCEL
18Cr-14Mn-0.5N	S	402	2370	<0.1	0	I	----	C	INCO (12)
18Cr-14Mn-0.5N	W	123	5640	<0.1	0	0	0	NC	NCEL
18Cr-14Mn-0.5N	W	123	5640	<0.1	0	0	----	NC	INCO (12)
18Cr-14Mn-0.5N	S	123	5640	0.3	0	115(PR)	0	C	NCEL
18Cr-14Mn-0.5N	S	123	5640	<0.1	0	0	----	NC	INCO (12)
18Cr-14Mn-0.5N	W	403	6780	0.5	115(PR)	0	2750	T,P	NCEL
18Cr-14Mn-0.5N	W	403	6780	<0.1	0	I	----	C	INCO (12)
18Cr-14Mn-0.5N	S	403	6780	0.6	115(PR)	115(PR)	2000	C,T	NCEL
18Cr-14Mn-0.5N	S	403	6780	<0.1	0	3	----	C	INCO (12)
18Cr-14Mn-0.5N	W	751	5640	0.2	115(PR)	24	2800	C,T	NCEL
18Cr-14Mn-0.5N	W	751	5640	<0.1	0	0	----	NC	INCO (12)
18Cr-14Mn-0.5N	S	751	5640	0.0	0	0	0	NC	NCEL
18Cr-14Mn-0.5N	S	751	5640	<0.1	0	3	----	C	INCO (12)
18Cr-14Mn-0.5N	W	1064	5300	0.1	115(PR)	0	2250	T	NCEL
18Cr-14Mn-0.5N (5)	W	1064	5300	0.2	0	0	0	NC	NCEL
18Cr-14Mn-0.5N	W	1064	5300	<0.1	0	0	----	NC	INCO (12)
18Cr-14Mn-0.5N	S	1064	5300	0.3	115(PR)	0	4000	T	NCEL
18Cr-14Mn-0.5N	S	1064	5300	0.4	62(PR)	62(PR)	----	C,P	INCO (12)

1. W - Specimens exposed on sides of STU in water.
   S - Specimens exposed in base of STU, partially embedded in bottom sediment.
2. MPY - Mils penetration per year calculated from weight loss.
3. Symbols signify the following types and severity of corrosion:

C - Crevice	G - General	NU - Non-uniform	SL - Slight	Numbers indicate maximum
E - Edge	I - Incipient	P - Pitting	T - Tunnel	depth of corrosion in
ET - Etching	NC - No visible corrosion	PR - Perforated	U - Uniform	mils.

4. Numbers refer to references at end of paper.
5. Specimens 1" X 6".

Table 8. Stainless Steel Wire Ropes.

Designation	Condition	Diameter, inch	Breaking Load, Percent Loss	Exposure, Days	Depth, Feet	Remarks
AISI Type 304	Lubricated, 7X7	0.094	90.0	403	6780	Outside, few rust spots; inside - many wires corroded thru, fractures at corrosion pits.
AISI Type 304	Lubricated, 7X19	0.125	86.3	403	6780	Outside, few rust stains; inside, many pits on wires, fractures at pits.
AISI Type 304	Lubricated, 7X19	0.187	96.9	403	6780	Outside, many rust stains, many broken wires both external and internal, fractures at corrosion pits.
AISI Type 304	Lubricated, 7X19	0.250	2.0	403	6780	Outside, few yellow stains; inside metallic lustre.
AISI Type 304	Lubricated, 7X19	0.313	0.0	403	6780	Outside, few rust stains; inside metallic lustre.
AISI Type 304	Lubricated, 7X19	0.375	2.5	197	2340	Outside, few rust stains; inside, few rust spots.
AISI Type 304	Lubricated, 3X19, Stress relieved	0.187	---	189	5900	Outside, numerous broken wires at corrosion pits; inside, corrosion pits and internal corrosion of wires, many broken wires.
AISI Type 304	Lubricated, 3X19, not stress relieved	0.187	---	189	5900	Outside, many broken wires, internal corrosion, pitting and crevice corrosion of wires; inside, same as outside.

Table 8. Stainless Steel Wire Ropes (cont'd)

Designation	Condition	Diameter, inch	Breaking Load, Percent Loss	Exposure, Days	Depth, Feet	Remarks
AISI Type 304	Lubricated, 3X7, stress relieved	0.187	---	189	5900	Outside, internal corrosion, pitting and crevice corrosion of wires, few broken wires; inside, same as outside.
AISI Type 304	Lubricated, 3X7, not stress relieved	0.187	---	189	5900	Outside, some broken wires, pitting, internal corrosion and crevice corrosion of wires; inside, same as outside.
AISI Type 316	Lubricated, 7X7	0.135	41.2	1064	5300	Stressed at 350 lb (20% original breaking load); outside, 50% rust stains; inside, many corrosion pits, broke at corrosion pits on internal wires.
Stainless steel, 18%Cr-14%Mn	Unlubricated, 7X19	0.395	0.0	1064	5300	Stressed at 250 lb (20% original breaking load); outside, considerable rust and broken wires; inside, some broken wires in all strands at corrosion pits.
Stainless steel, Cr-Ni-Mo-Cu	Lubricated, 3X7	0.125	---	189	5900	Outside, incipient crevice corrosion; inside, same.
Stainless steel, Cr-Ni-Mo-Si-N	Lubricated, 1X7	0.125	---	189	5900	Outside, no visible corrosion, metallic sheen; inside, same.
Stainless steel, Cr-Ni-V-N	Lubricated, 1X7	0.125	---	189	5900	Failed by crevice and internal corrosion at terminations underneath silicone compound, only ends recovered.
Stainless steel, Cr-Ni-Si	Lubricated, 1X7	0.125	---	189	5900	Outside, slight crevice corrosion and shallow pits; inside, same.
90Cu-10Ni Clad AISI Type 304	1X37X7, coating 0.3 mil thick	0.313	---	402	2370	Outside, light rust film; inside brown, uncorroded.
90Cu-10Ni Clad AISI Type 304	7X7, coating 0.7 mil thick	0.187	0.0	402	2370	Outside, green; inside, brown, uncorroded.

Table 9. Stress Corrosion of Stainless Steels, Calculated Stresses

Alloy	Stress, Ksi	Percent of Yield Strength	Exposure, Days	Depth, Feet	Number of Specimens	Number Failed(10)
AISI 301	62.4	50	402	2370	3	0
AISI 301	93.7	75	402	2370	3	0
AISI 302	21.8	50	402	2370	3	0
AISI 302	32.6	75	402	2370	3	0
AISI 304	16.3	50	402	2370	3	0
AISI 304	24.5	75	402	2370	3	0
AISI 304L	20.0	50	197	2340	3	0
AISI 304L	30.0	75	197	2340	3	0
AISI 304L	20.0	50	402	2370	3	0
AISI 304L	30.0	75	402	2370	3	0
AISI 304L	14.0	35	123	5640	3	0
AISI 304L	20.0	50	123	5640	3	0
AISI 304L	30.0	75	123	5640	3	0
AISI 304L	20.0	50	403	6780	3	0
AISI 304L	30.0	75	403	6780	3	0
AISI 304L	14.0	35	751	5640	3	0
AISI 304L	20.0	50	751	5640	3	0
AISI 304L	30.0	75	751	5640	3	0
AISI 316	18.3	50	402	2370	3	0
AISI 316	27.4	75	402	2370	3	0
AISI 316L	16.8	35	197	2340	3	0
AISI 316L	24.0	50	197	2340	3	0
AISI 316L	36.0	75	197	2340	3	0
AISI 316L	24.0	50	402	2370	3	0
AISI 316L	36.0	75	402	2370	3	0
AISI 316L	16.8	35	123	5640	3	0

Table 9. Stress Corrosion of Stainless Steels, Calculated Stresses (cont'd)

Alloy	Stress, Ksi	Percent of Yield Strength	Exposure, Days	Depth, Feet	Number of Specimens	Number Failed[10]
AISI 316L	24.0	50	123	5640	3	0
AISI 316L	36.0	75	123	5640	3	0
AISI 316L	16.8	35	403	6780	3	0
AISI 316L	24.0	50	403	6780	3	0
AISI 316L	36.0	75	403	6780	3	0
AISI 316L	16.8	35	751	5640	3	0
AISI 316L	24.0	50	751	5640	3	0
AISI 316L	36.0	75	751	5640	3	0
AISI 405	20.0	35	197	2340	3	0
AISI 405	28.6	50	197	2340	3	0
AISI 405	42.9	75	197	2340	6	0
AISI 405	42.9	75	402	2370	3	0
AISI 405	42.9	75	403	6780	3	0
AISI 410	24.2	50	402	2370	3	0
AISI 410	36.3	75	402	2370	3	0
AISI 430	27.0	50	402	2370	6	0
AISI 430	41.0	75	402	2370	6	0
AISI 630-H925[1]	64.9	35	70	5	3	3[2]
AISI 630-H925[1]	92.7	50	364	5	3	1(89)[2]
AISI 630-H925[1]	139.1	75	364	5	3	2(70,233)[2]
AISI 630-H925[1]	64.9	35	197	2340	2	0
AISI 630-H925[1]	92.7	50	197	2340	2	0
AISI 630-H925[1]	139.1	75	197	2340	2	0

Table 9. Stress Corrosion of Stainless Steels, Calculated Stresses (contd)

Alloy	Stress, Ksi	Percent of Yield Strength	Exposure, Days	Depth, Feet	Number of Specimens	Number Failed(10)
AISI 630-H925(1)	92.7	50	402	2370	3	0
AISI 630-H925(1)	139.1	75	402	2370	3	0
AISI 630-H925(1)	64.9	35	403	6780	2	0
AISI 630-H925(1)	92.7	50	403	6780	2	0
AISI 630-H925(1)	139.1	75	403	6780	2	0
AISI 631-TH1050(1)	65.8	35	364	5	3	0
AISI 631-TH1050(1)	94.1	50	364	5	3	1(253)(3)
AISI 631-TH1050(1)	141.1	75	364	5	3	1(253)(4)
AISI 631-TH1050(1)	65,8	35	197	2340	2	0
AISI 631-TH1050(1)	94.1	50	197	2340	2	0
AISI 631-TH1050(1)	141.1	75	197	2340	2	0
AISI 631-TH1050(1)	94.1	50	402	2370	3	0
AISI 631-TH1050(1)	141.1	75	402	2370	3	1
AISI 631-TH1050(1)	65.8	35	403	6780	2	0
AISI 631-TH1050(1)	94.1	50	403	6780	2	1
AISI 631-TH1050(1)	141.1	75	403	6780	2	1
AISI 631-RH1050(1)	68.8	35	364	5	3	0
AISI 631-RH1050(1)	98.4	50	364	5	3	0
AISI 631-RH1050(1)	147.4	75	364	5	3	1(90)(2)
AISI 631-RH1050(1)	68.8	35	197	2340	2	0
AISI 631-RH1050(1)	98.4	50	197	2340	2	0
AISI 631-RH1050(1)	147.4	75	197	2340	2	0
AISI 631-RH1050(1)	98.4	50	402	2370	3	0
AISI 631-RH1050(1)	147.4	75	402	2370	3	2
AISI 631-RH1050(1)	68.8	35	403	6780	2	0

Table 9. Stress Corrosion of Stainless Steels, Calculated Stresses (cont'd)

Alloy	Stress, Ksi	Percent of Yield Strength	Exposure, Days	Depth, Feet	Number of Specimens	Number Failed[10]
AISI 631-RH1050[1]	98.4	50	403	6780	2	0
AISI 631-RH1050[1]	147.4	75	403	6780	2	1[2]
AISI 632-RH1100[1]	64.2	35	364	5	3	0
AISI 632-RH1100[1]	91.6	50	364	5	3	1(322)[5]
AISI 632-RH1100[1]	137.5	75	364	5	3	3(56,70,133)[5]
AISI 632-RH1100[1]	64.2	35	197	2340	2	0
AISI 632-RH1100[1]	91.6	50	197	2340	2	0
AISI 632-RH1100[1]	137.5	75	197	2340	2	0
AISI 632-RH1100[1]	91.6	50	402	2370	3	0
AISI 632-RH1100[1]	137.5	75	402	2370	3	0
AISI 632-RH1100[1]	64.2	35	403	6780	2	0
AISI 632-RH1100[1]	91.6	50	403	6780	2	0
AISI 632-RH1100[1]	137.5	75	403	6780	2	0
AISI 634-CRT	107.7	50	402	2370	3	0
AISI 634-CRT	161.5	75	402	2370	3	0
AISI 635	67.6	35	197	2340	3	0
AISI 635	96.6	50	197	2340	3	0
AISI 635	144.9	75	197	2340	3	0
AISI 635	92.0	50	402	2370	3	0
AISI 635	138.0	75	402	2370	3	0
PH14-8Mo-SRH950[1]	75.0	35	364	5	3	2(322)[2]
PH14-8Mo-SRH950[1]	107.0	50	364	5	3	3(322)[2]
PH14-8Mo-SRH950[1]	160.6	75	364	5	3	0

Table 9. Stress Corrosion of Stainless Steels, Calculated Stresses (cont'd)

Alloy	Stress, Ksi	Percent of Yield Strength	Exposure, Days	Depth, Feet	Number of Specimens	Number Failed[10]
PH14-8Mo-SRH950[1]	75.0	35	197	2340	2	0
PH14-8Mo-SRH950[1]	107.0	50	197	2340	2	0
PH14-8Mo-SRH950[1]	160.6	75	197	2340	2	0
PH14-8Mo-SRH950[1]	107.0	50	402	2370	3	1
PH14-8Mo-SRH950[1]	106.6	75	402	2370	3	1
PH14-8Mo-SRH950[1]	75.0	35	403	6780	2	0
PH14-8Mo-SRH950[1]	107.0	50	403	6780	2	0
PH14-8Mo-SRH950[1]	160.6	75	403	6780	2	1
15--7AMV,A[6]	20.1	35	197	2340	3	0
15-7AMV,A[6]	28.7	50	197	2340	3	0
15-7AMV,A[6]	43.0	75	197	2340	3	0
15-7AMV,A[6]	28.7	50	402	2370	3	0
15-7AMV,A[6]	43.0	75	402	2370	3	0
15-7AMV,A[6]	20.1	35	403	6780	2	0
15-7AMV,A[6]	28.7	50	403	6780	2	0
15-7AMV,A[6]	43.0	75	403	6780	2	1
15-7AMV-RH1150	79.1	50	197	2340	3	2
15-7AMV-RH1150	118.7	75	197	2340	3	3
15-7AMV-RH1150	79.1	50	402	2370	3	1
15-7AMV-RH1150	118.7	75	402	2370	3	1
15-7AMV-RH1150	55.4	35	123	5640	3	0
15-7AMV-RH1150	79.1	50	123	5640	3	0
15-7AMV-RH1150	118.7	75	123	5640	3	0
15-7AMV-RH1150	55.4	35	403	6780	2	0
15-7AMV-RH1150	79.1	50	403	6780	2	0
15-7AMV-RH1150	118.7	75	403	6780	2	0

Table 9. Stress Corrosion of Stainless Steels, Calculated Stresses (cont'd)

Alloy	Stress, Ksi	Percent of Yield Strength	Exposure, Days	Depth, Feet	Number of Specimens	Number Failed[10]
15-7AMV-RH1150	55.4	35	751	5640	3	3[7]
15-7AMV-RH1150	79.1	50	751	5640	3	3[7]
15-7AMV-RH1150	118.7	75	751	5640	3	3[7]
15-7AMV-RH950	77.0	35	197	2340	3	0
15-7AMV-RH950	110.0	50	197	2340	3	2[8]
15-7AMV-RH950	165.0	75	197	2340	3	2
15-7AMV-RH950	110.0	50	402	2370	3	0
15-7AMV-RH950	165.0	75	402	2370	3	3
15-7AMV-RH950	77.0	35	123	5640	3	1[8]
15-7AMV-RH950	110.0	50	123	5640	3	3
15-7AMV-RH950	165.0	75	123	5640	3	3[9]
15-7AMV-RH950	77.0	35	403	6780	2	0
15-7AMV-RH950	110.0	50	403	6780	2	0
15-7AMV-RH950	165.0	75	403	6780	2	2
15-7AMV-RH950	77.0	35	751	5640	3	0
15-7AMV-RH950	110.0	50	751	5640	3	3
15-7AMV-RH950	165.0	75	751	5640	3	3
20Cb	23.5	50	197	2340	3	0
20Cb	35.2	75	197	2340	3	0
20Cb	23.5	50	402	2370	3	0
20Cb	35.2	75	402	2370	3	0
20Cb	16.4	35	123	5640	3	0
20Cb	23.5	50	123	5640	3	0
20Cb	35.2	75	123	5640	3	0
20Cb	23.5	50	403	6780	2	0

Table 9. Stress Corrosion of Stainless Steels, Calculated Stresses (cont'd)

Alloy	Stress, Ksi	Percent of Yield Strength	Exposure, Days	Depth, Feet	Number of Specimens	Number Failed(10)
20Cb	35.2	75	403	6780	2	0
20Cb	16.4	35	751	5640	3	0
20Cb	23.5	50	751	5640	3	0
20Cb	35.2	75	751	5640	3	0
18Cr-14Mn-0.5N	40.6	50	402	2370	3	0
18Cr-14Mn-0.5N	60.8	75	402	2370	3	0

1. Transverse butt weld, centered between anvils of stress jig.
2. Failed by crevice corrosion at anvils of stress jig.
3. Broke at edge of weld bead.
4. Broke at junction of heat-affected zone and sheet material.
5. Crevice corrosion at bolt hole, released tension.
6. A - Annealed.
7. Specimens were missing when structure was retrieved.
8. Incipient crack in one specimen.
9. One specimen broke prior to exposure in the sea water.
10. Numbers in parenthesis indicate days to failure.

Table 10. Stress Corrosion of Precipitation Hardening Stainless Steels, Residual Stresses.

Alloy	Exposure, Days	Depth, Feet	Type of Residual Stress	Remarks
AISI 630-H925	403	6780	Unrelieved circular weld	SCC[1] propogated across weld bead
AISI 631-TH1050	398	5	Unrelieved circular weld	SCC radially in three direction to circular weld bead
AISI 631-TH1050	403	6780	Unrelieved circular weld	SCC propogated across and around weld bead
AISI 631-RH1050	197	2340	Unrelieved circular weld	SCC, origin on outside of weld bead, propogated into heat - affected zone, circumferentially in both directions around weld
AISI 631-RH1050	402	2370	Unrelieved circular weld	SCC, origin on outside of weld bead, propagation in both directions around weld bead at edge of heat - affected zone
AISI 631-RH1050	403	6780	Unrelieved circular weld	SCC, origin on outside of weld bead and propagated in both directions around outside of weld bead
AISI 632-RH1100	402	2370	Unrelieved circular weld	SCC, origin on outside edge of weld bead, propagated in both directions around weld in heat - affected zone
15-7AMV-RH1150	123	5640	Imposed by insulator	SCC due to squeeze by insulators on sides of panel
15-7AMV-RH1150	1064	5300	Unreamed drilled hole	SCC, origin at unreamed hole, not deburred
15-7AMV-RH950	1064	5300	Unreamed drilled hole	SCC, origin at unreamed hole, not deburred

1. SCC - Stress corrosion cracking failure.

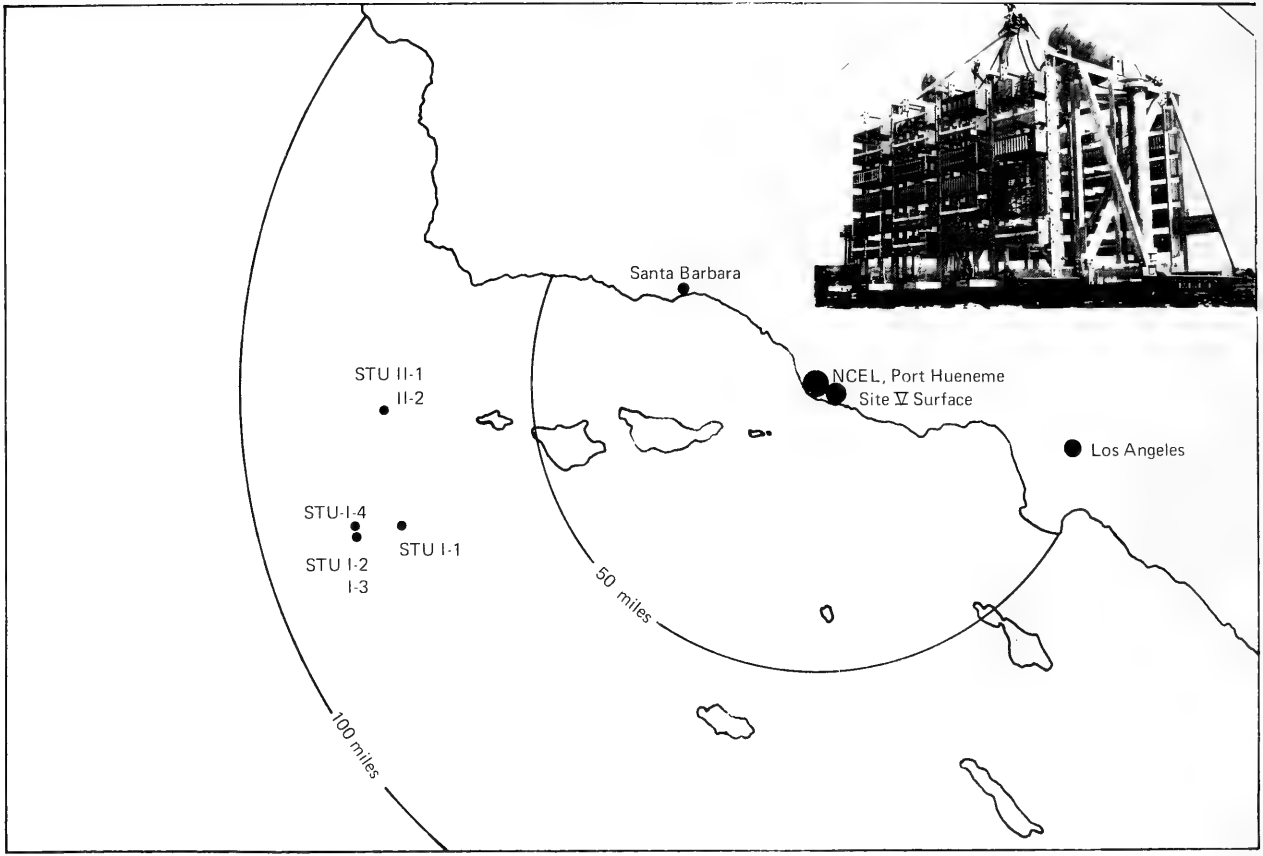

Figure 1. Area map showing STU sites off the Pacific Coast; STU structure in inset.

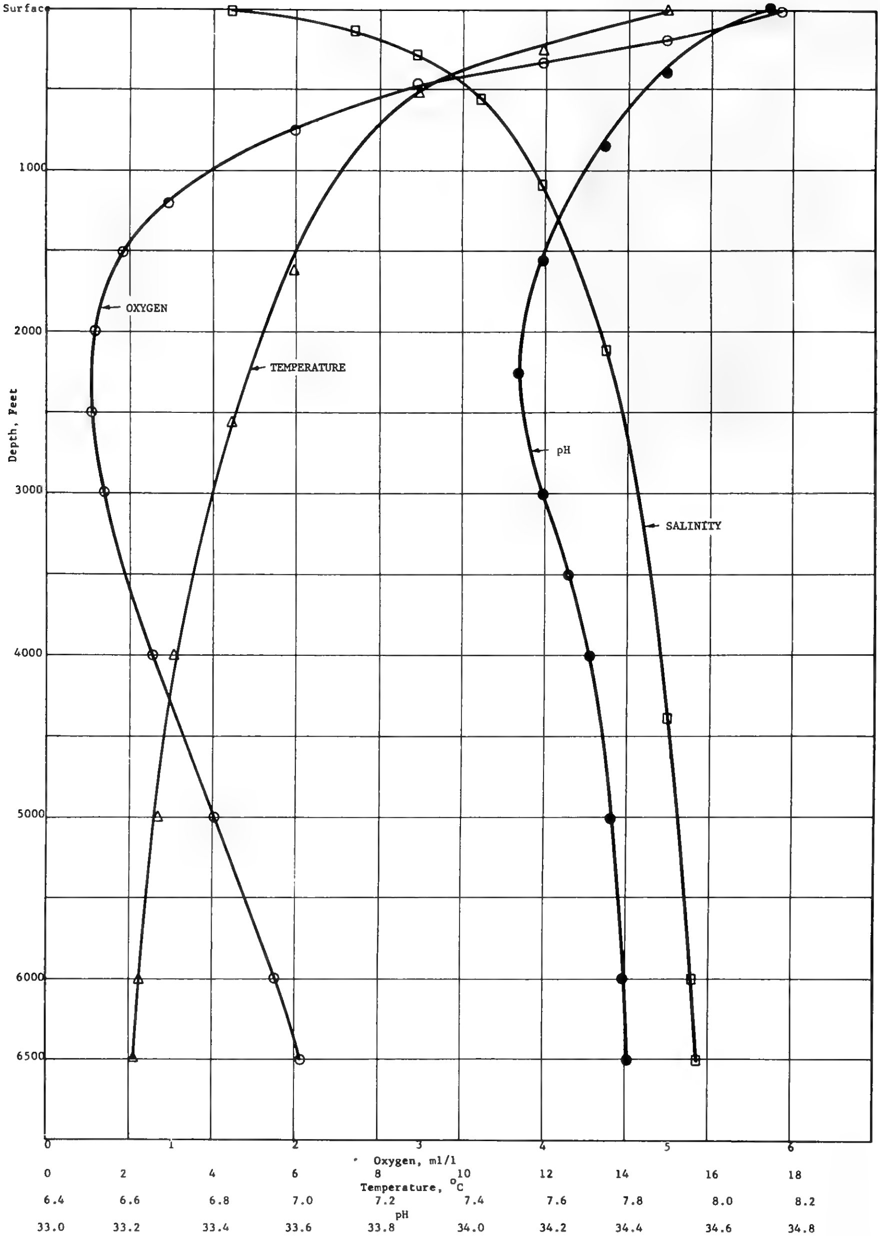

Figure 2. Oceanographic data at STU sites.

Figure 3. Typical pitting corrosion in stainless steel.

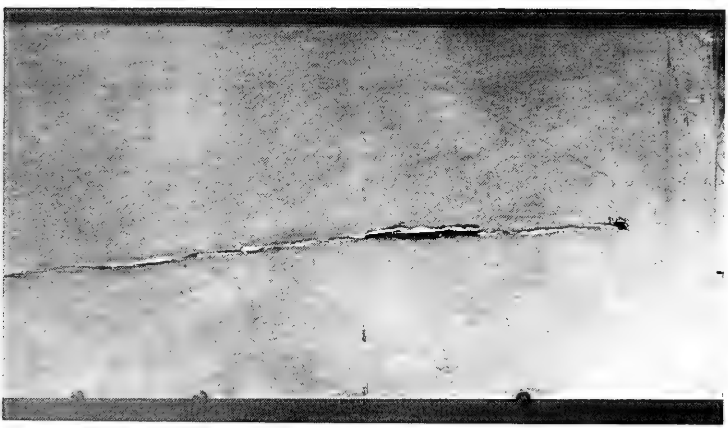

Figure 4. Tunnel corrosion extending almost the entire length of a 12 inch long specimen.

Figure 5. Crevice corrosion typical of that found in stainless steels.

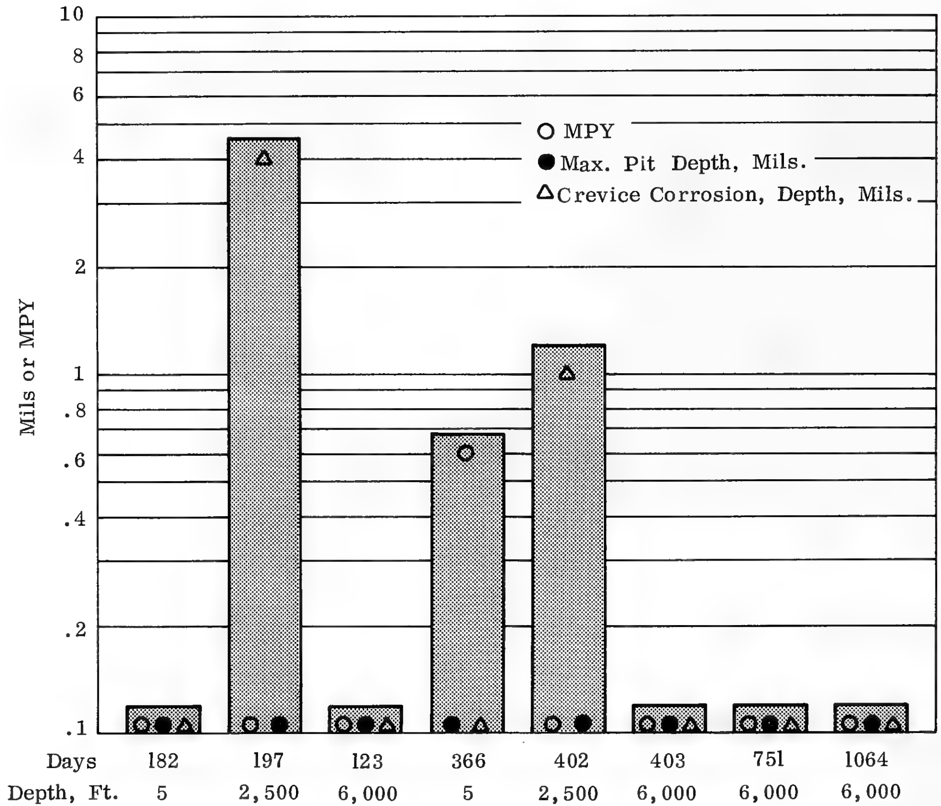

Figure 6. Corrosion rates, maximum pit depths and crevice corrosion of AISI 202 stainless steel in seawater at the surface and at depth.

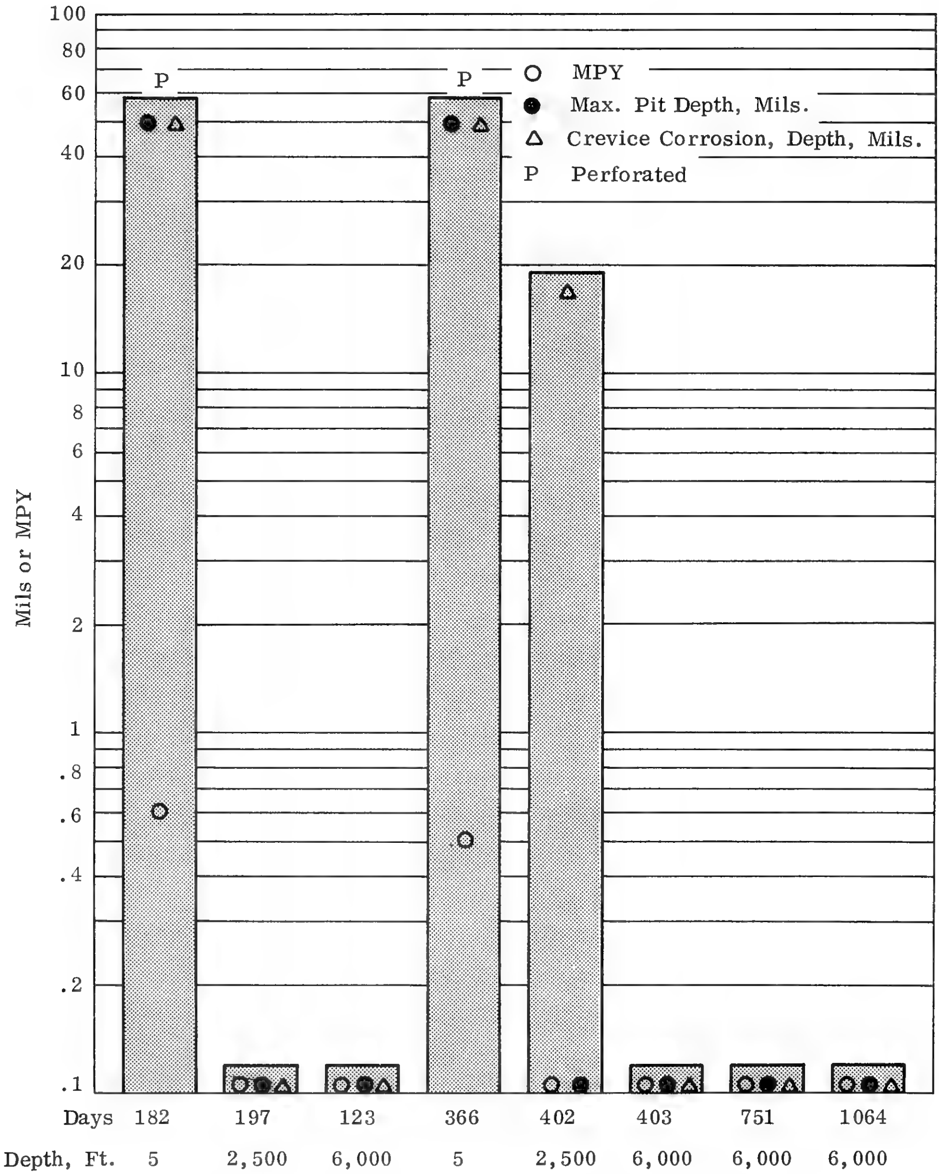

Figure 7. Corrosion rates, maximum pit depths and crevice corrosion of AISI 202 stainless steel in seawater at the surface and at depth.

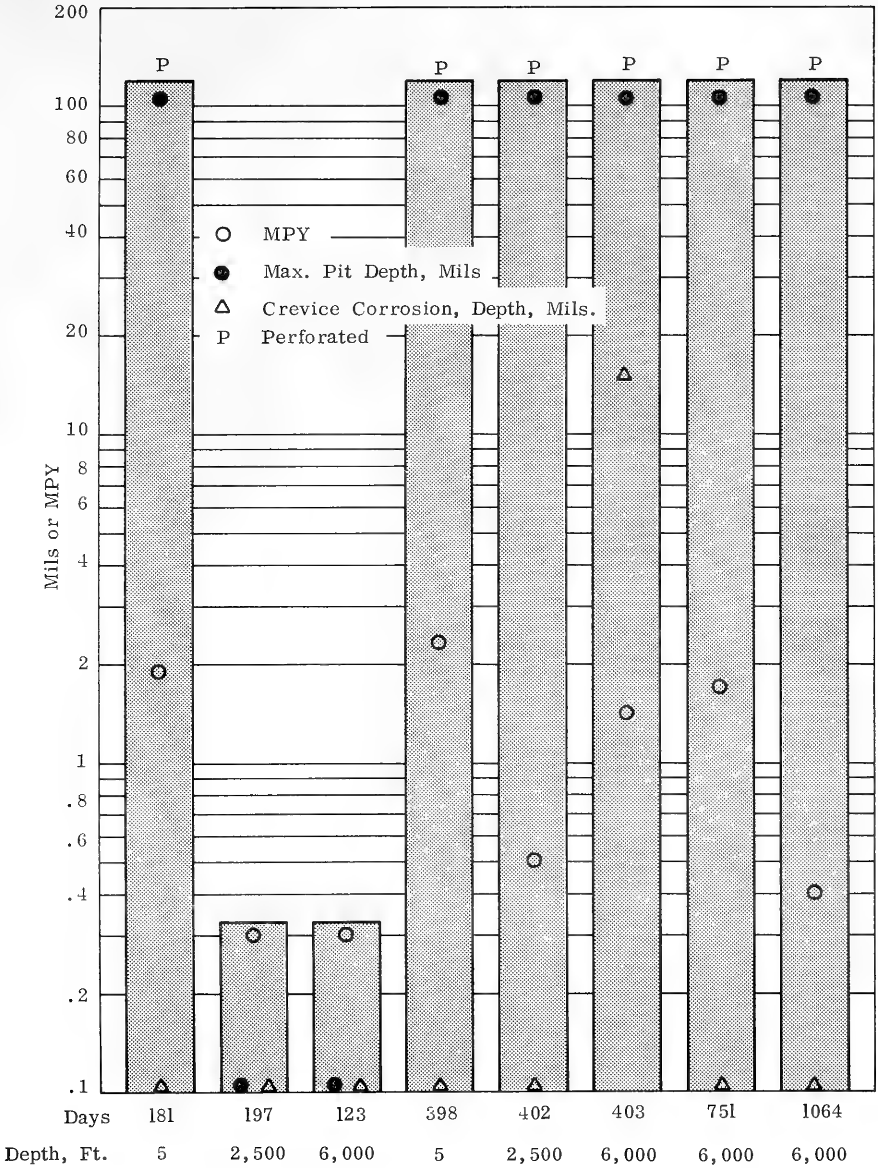

Figure 8. Corrosion rates, maximum pit depths, and crevice corrosion of AISI Type 301 stainless steel in seawater at the surface and at depth.

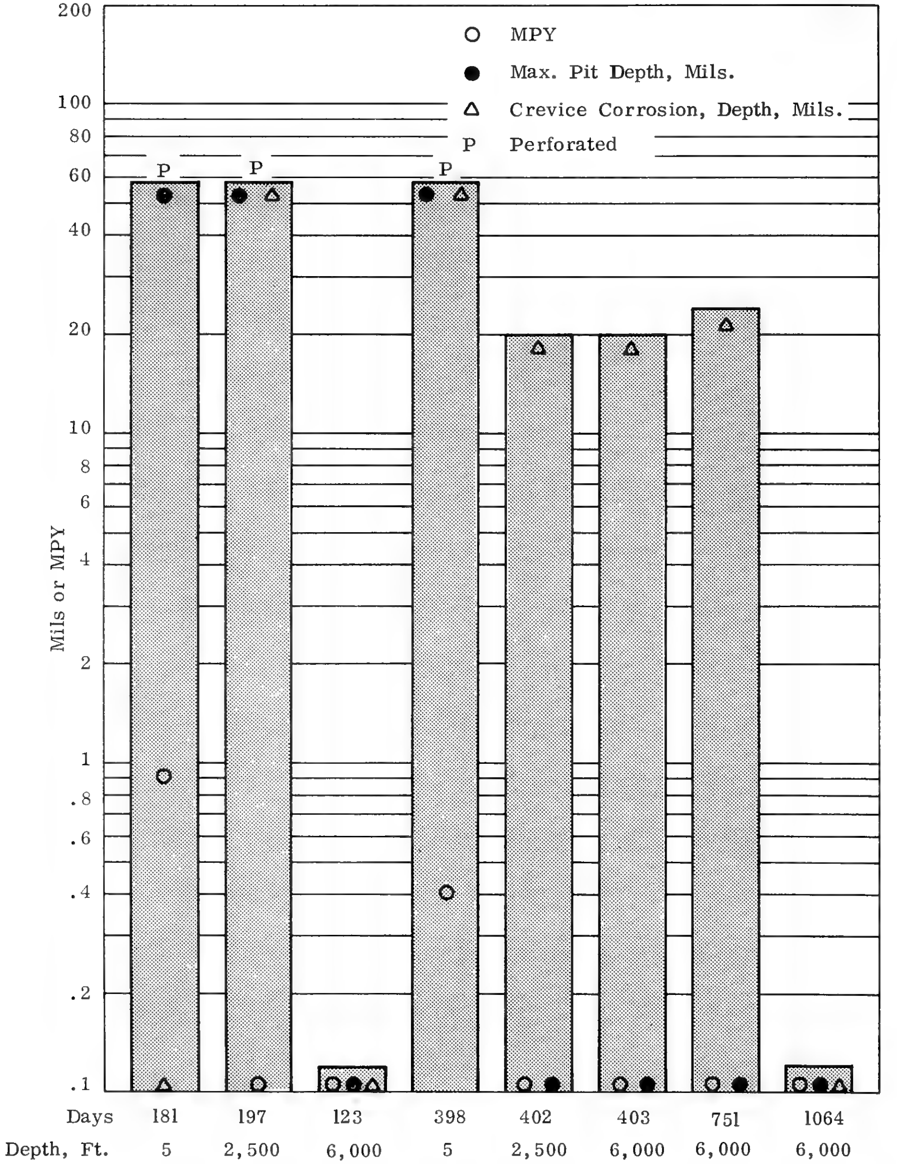

Figure 9. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 302 stainless steel in seawater at the surface and at depth.

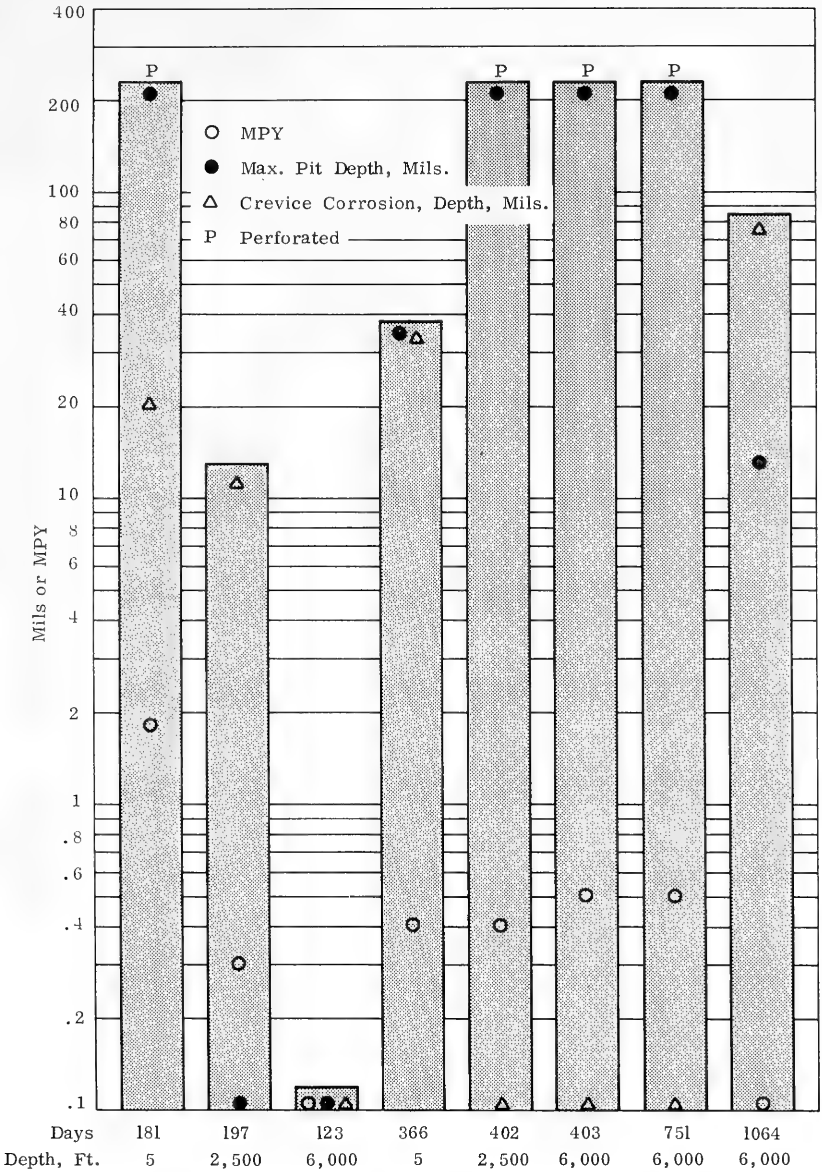

Figure 10. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 304 stainless steel in seawater at the surface and at depth.

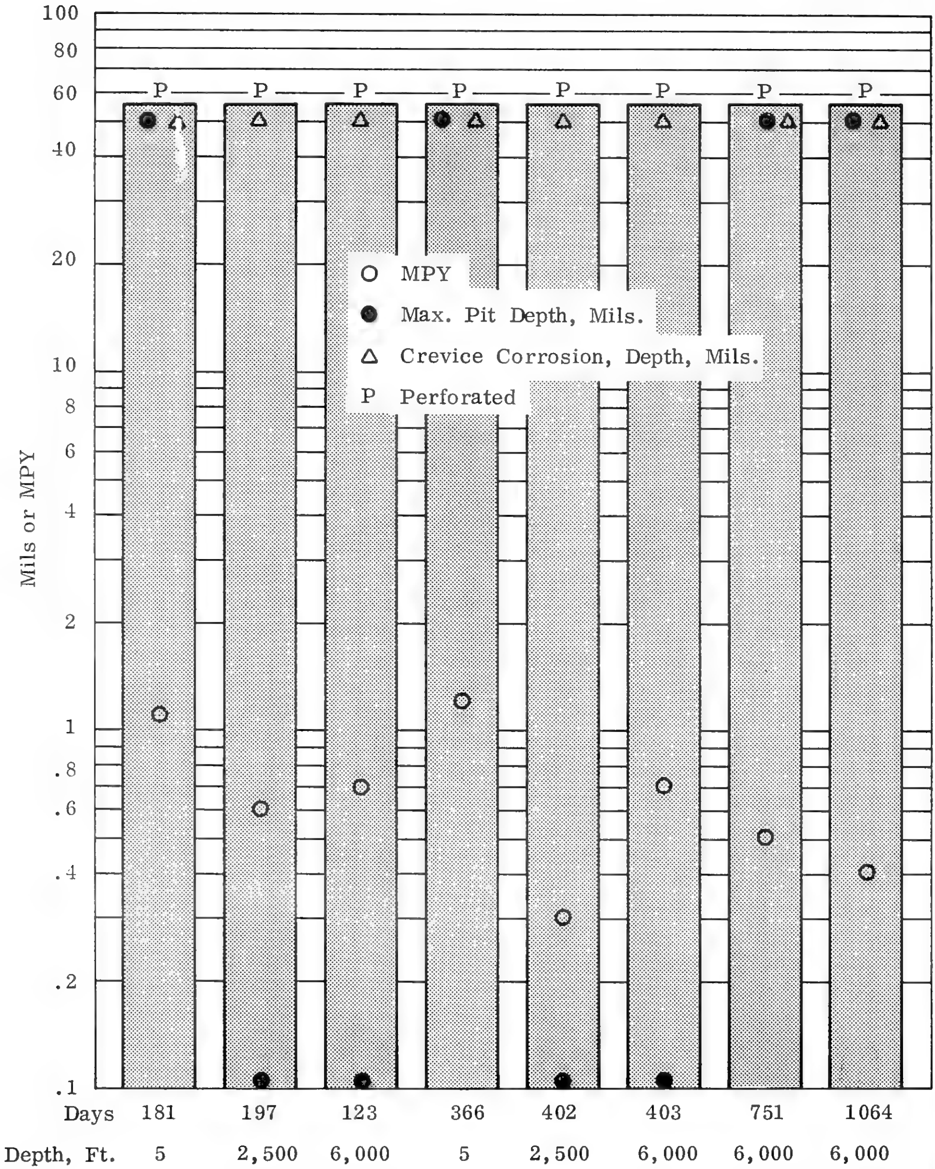

Figure 11. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 304 (sensitized) stainless steel in seawater at the surface and at depth.

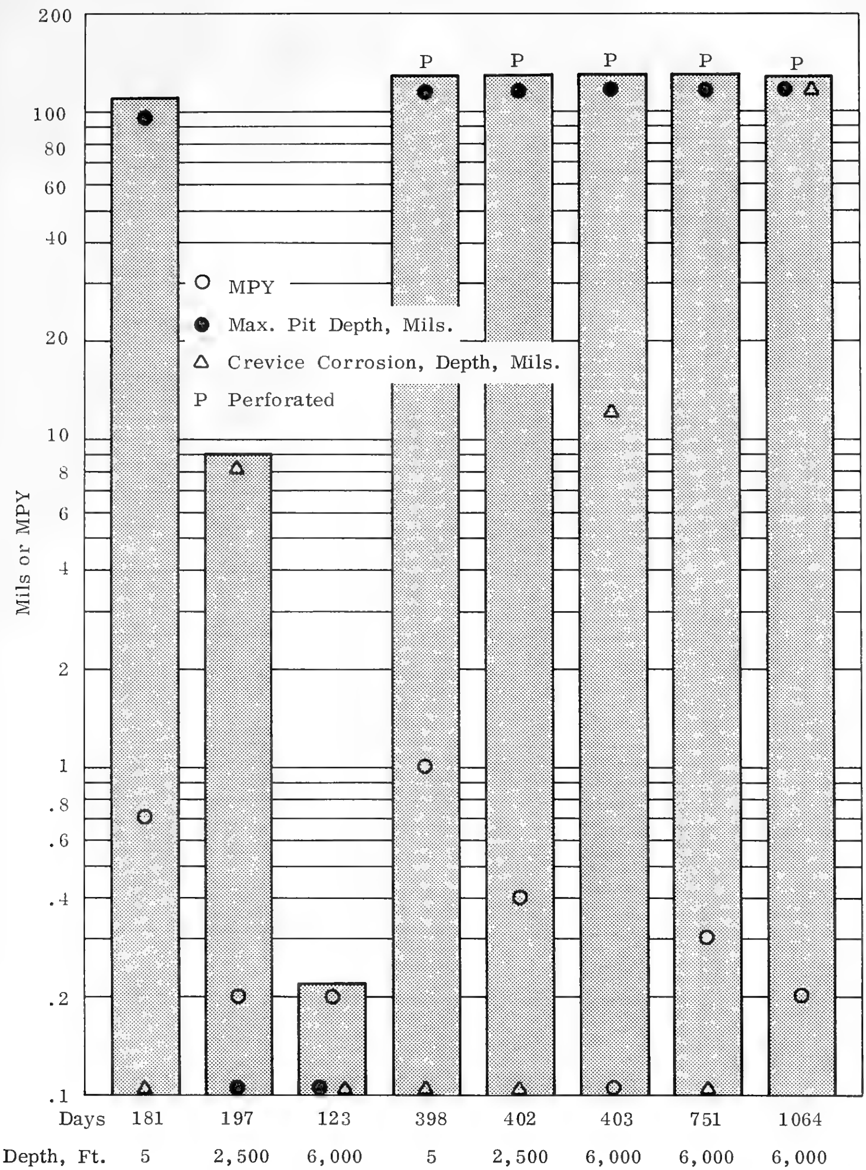

Figure 12. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 304L stainless steel in seawater at the surface and at depth.

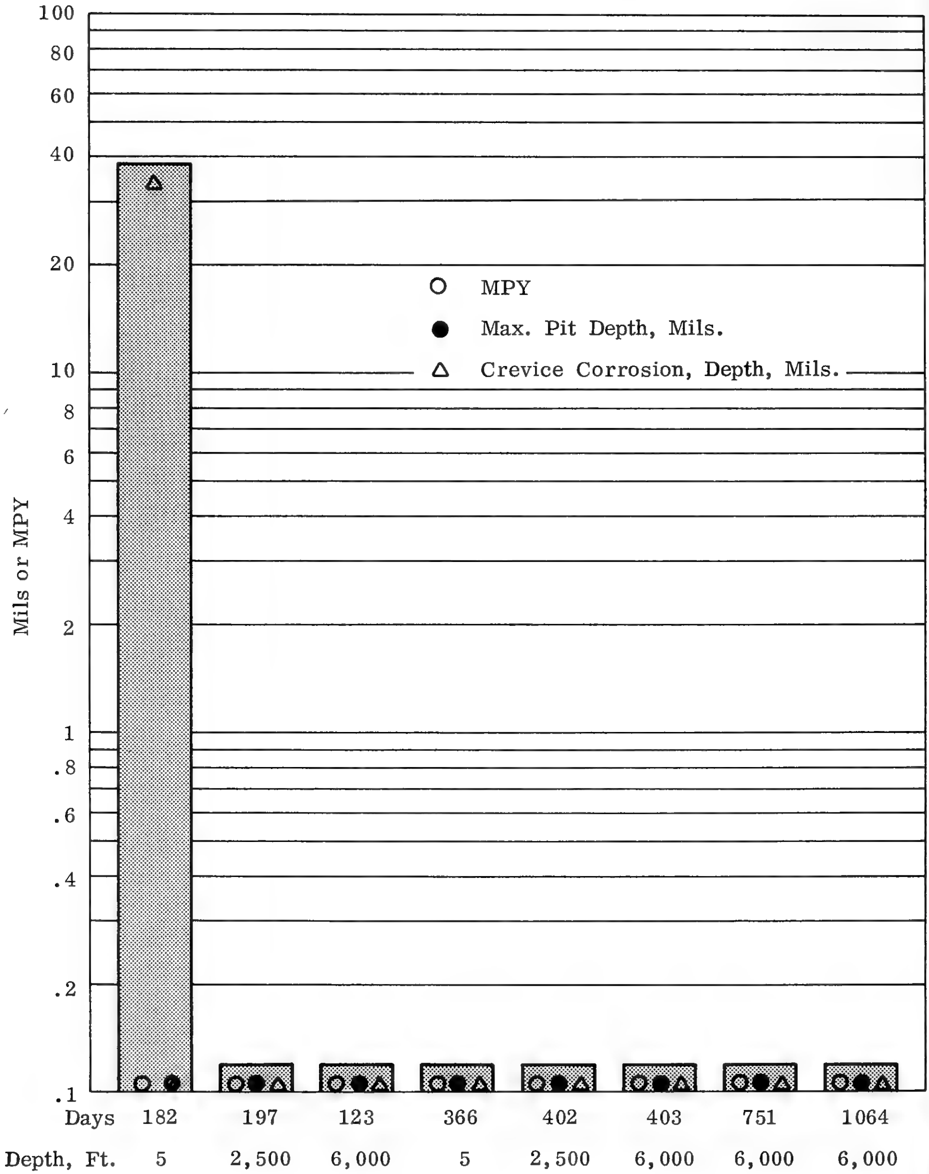

Figure 13. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 309 stainless steel in seawater at the surface and at depth.

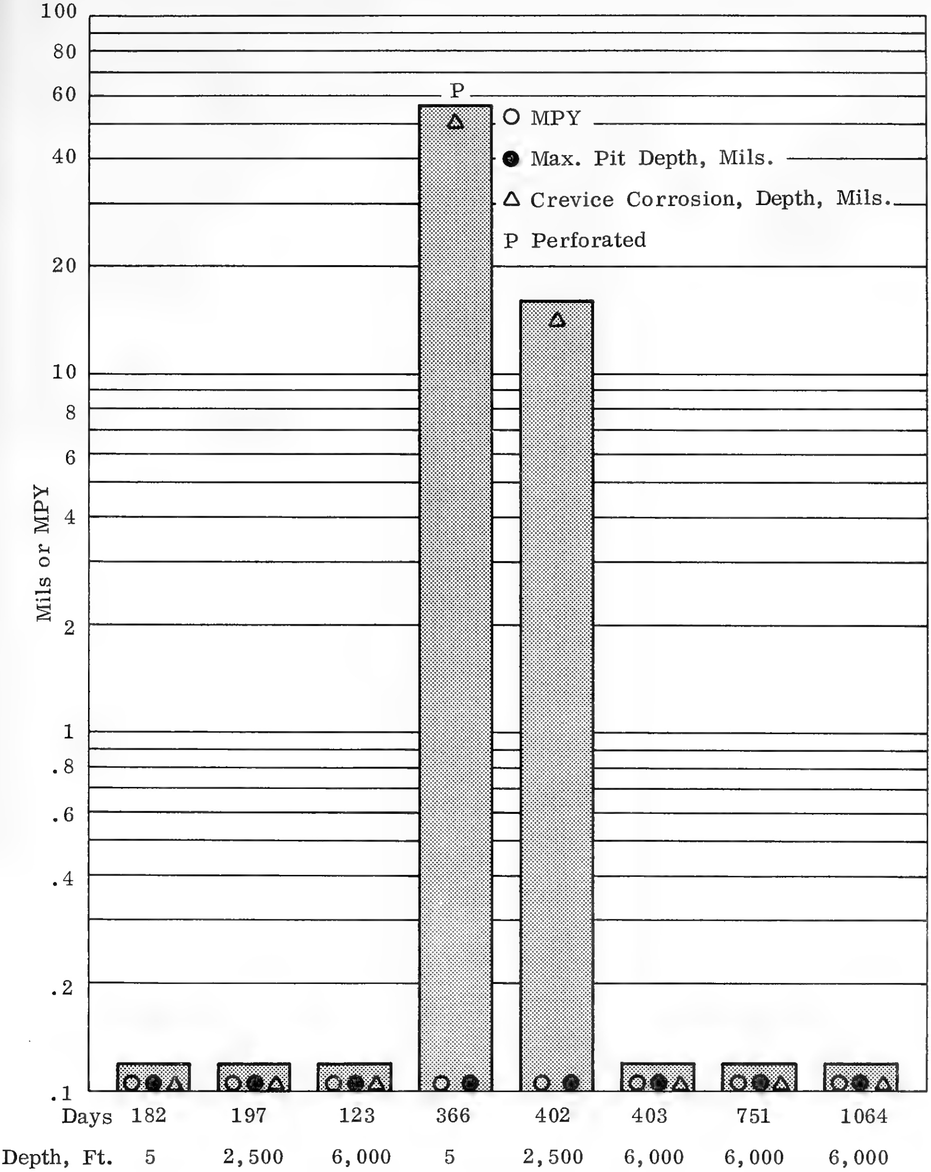

Figure 14. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 310 stainless steel in seawater at the surface and at depth.

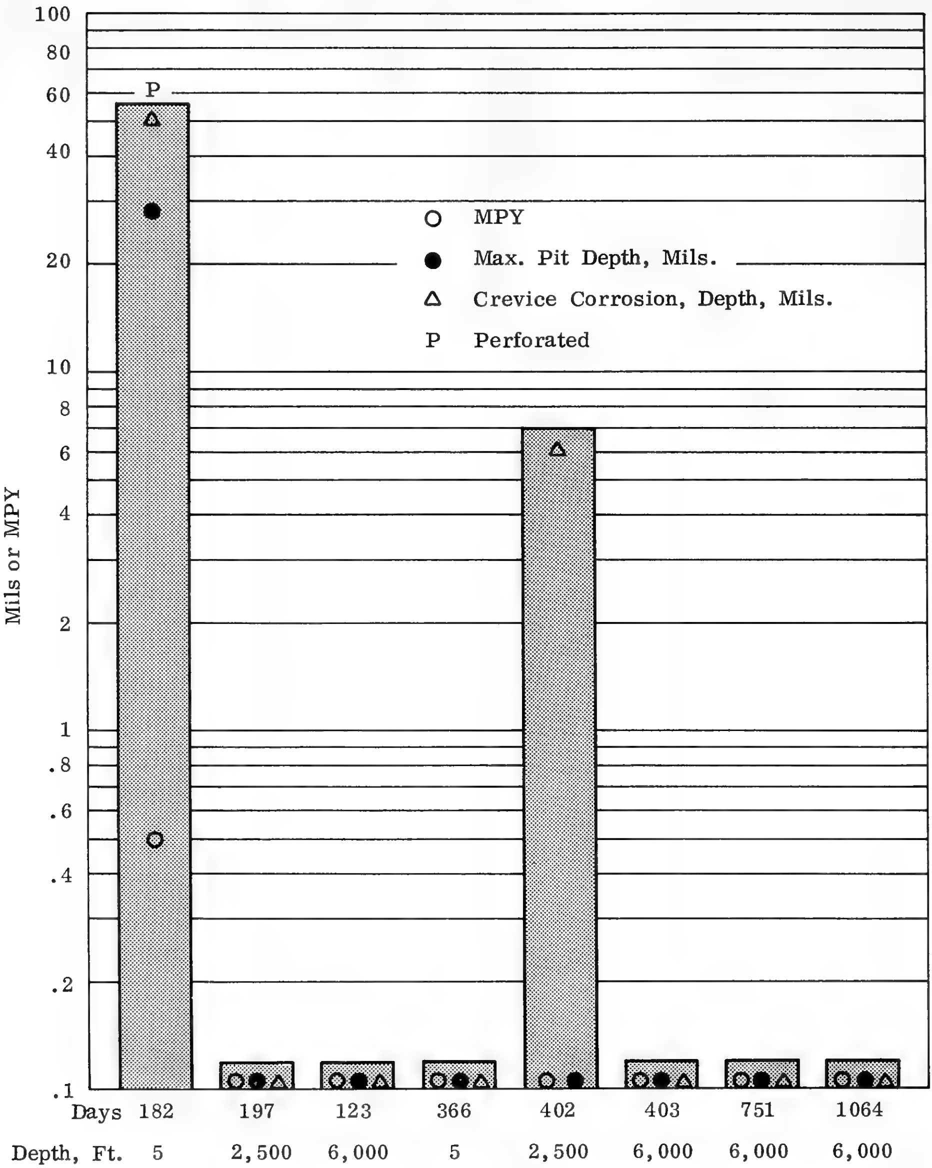

Figure 15. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 311 stainless steel in seawater at the surface and at depth.

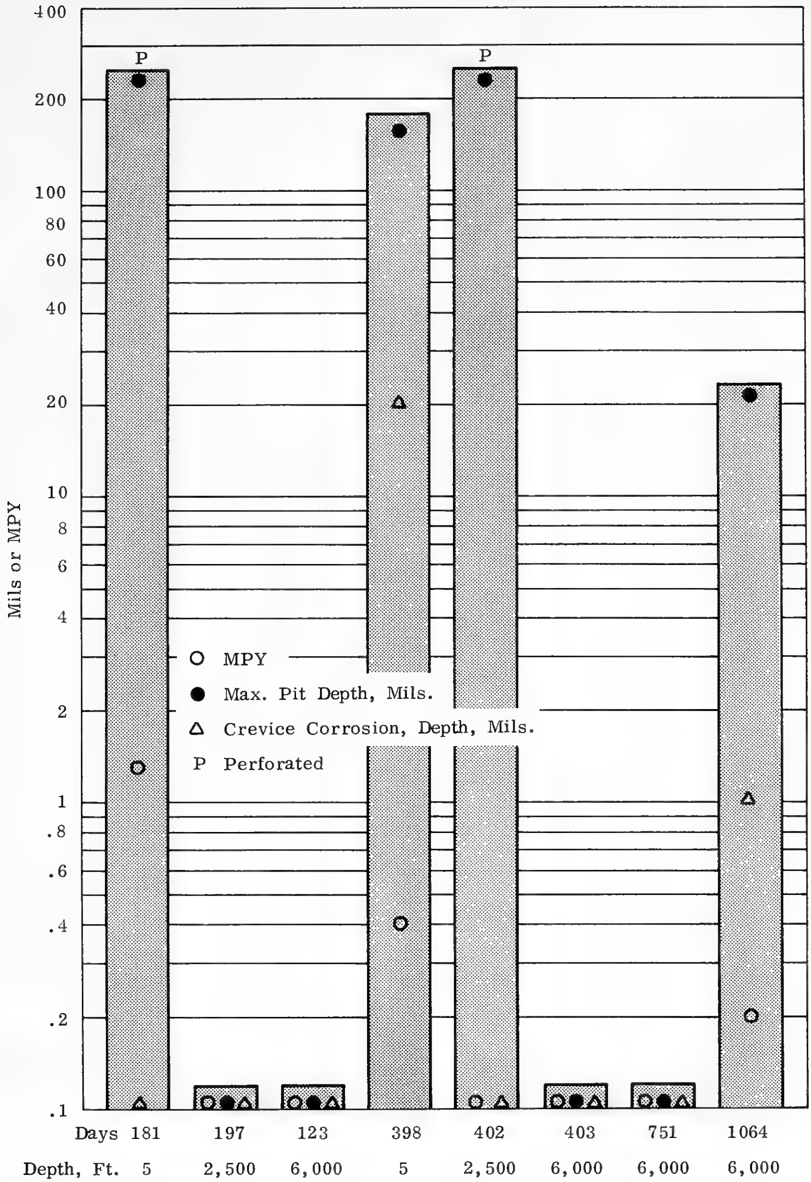

Figure 16. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 316 stainless steel in seawater at the surface and at depth.

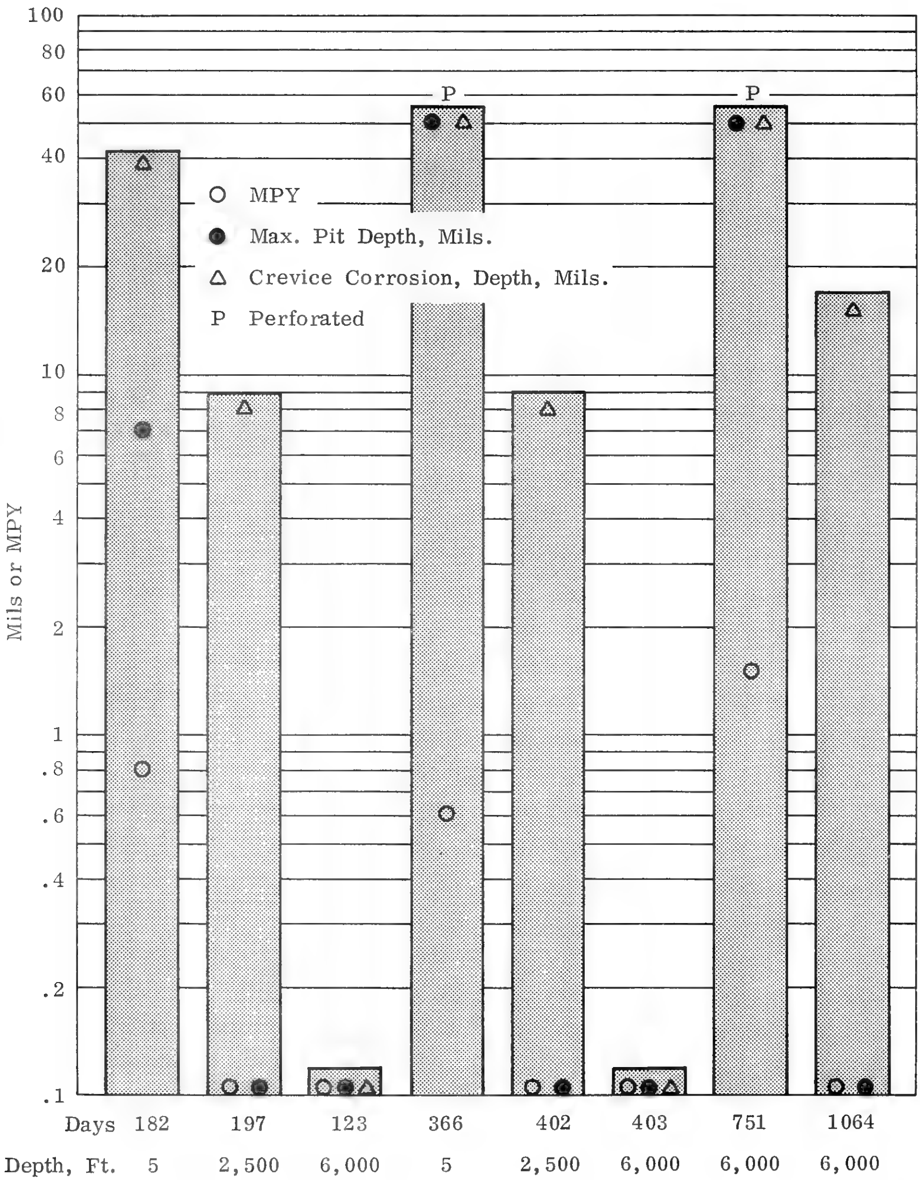

Figure 17. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 316 (sensitized) stainless steel in seawater at the surface and at depth.

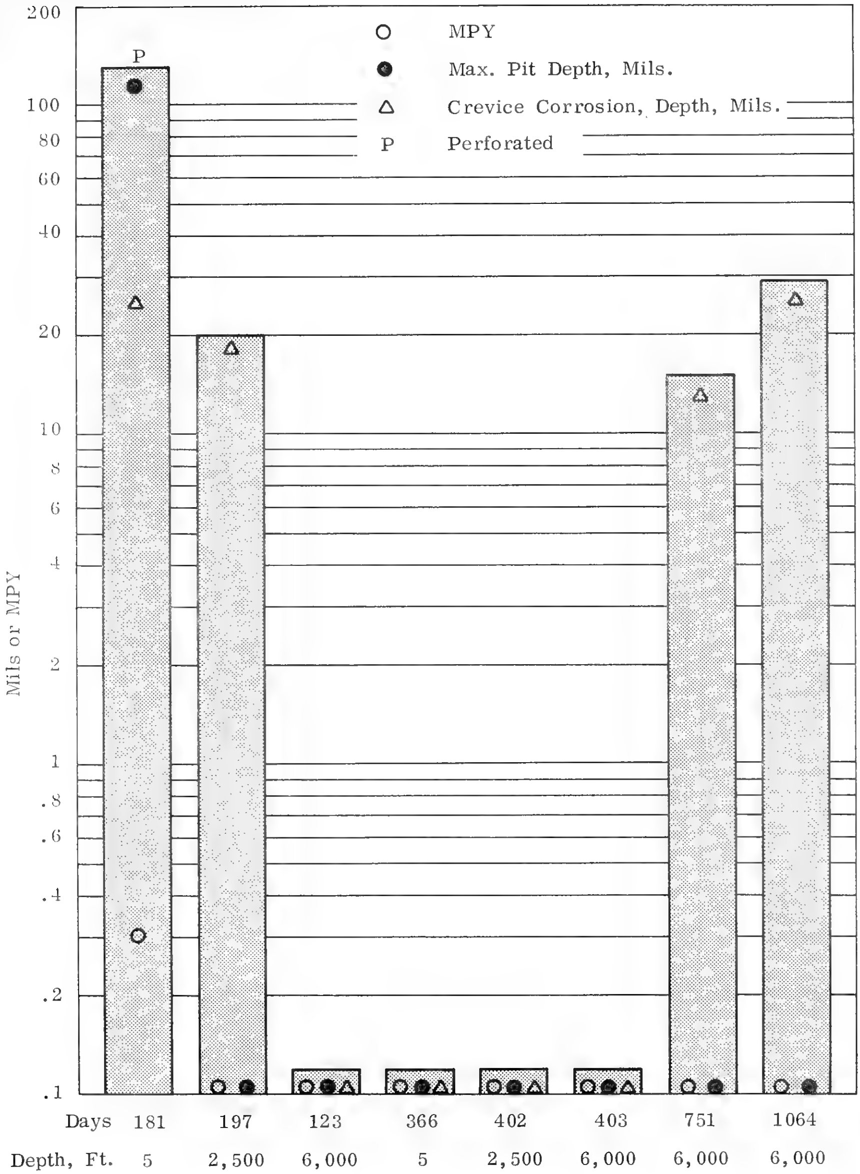

Figure 18. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 316L stainless steel in seawater at the surface and at depth.

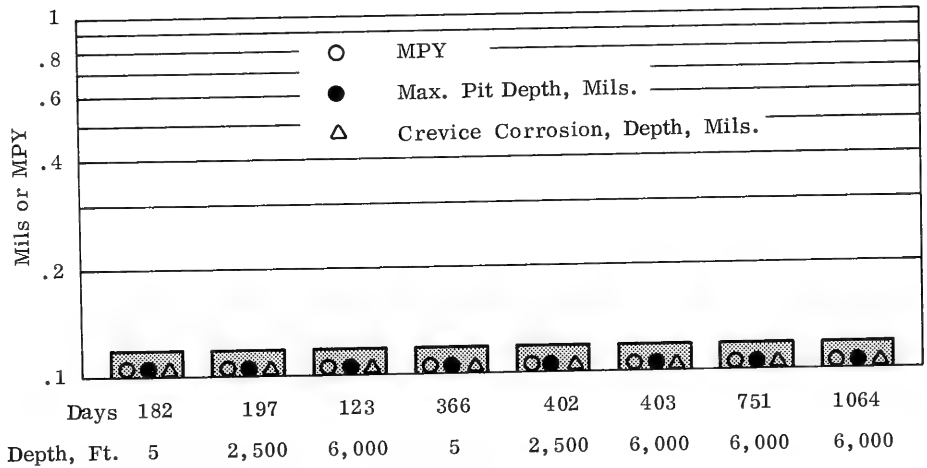

Figure 19. Corrosion rates, maximum pit depths and crevice corrosion of stainless steels AISI Types 317, 239 and 633, alloy 20Cb-3 and Ni-Cr-Mo-Si in seawater at the surface and at depth.

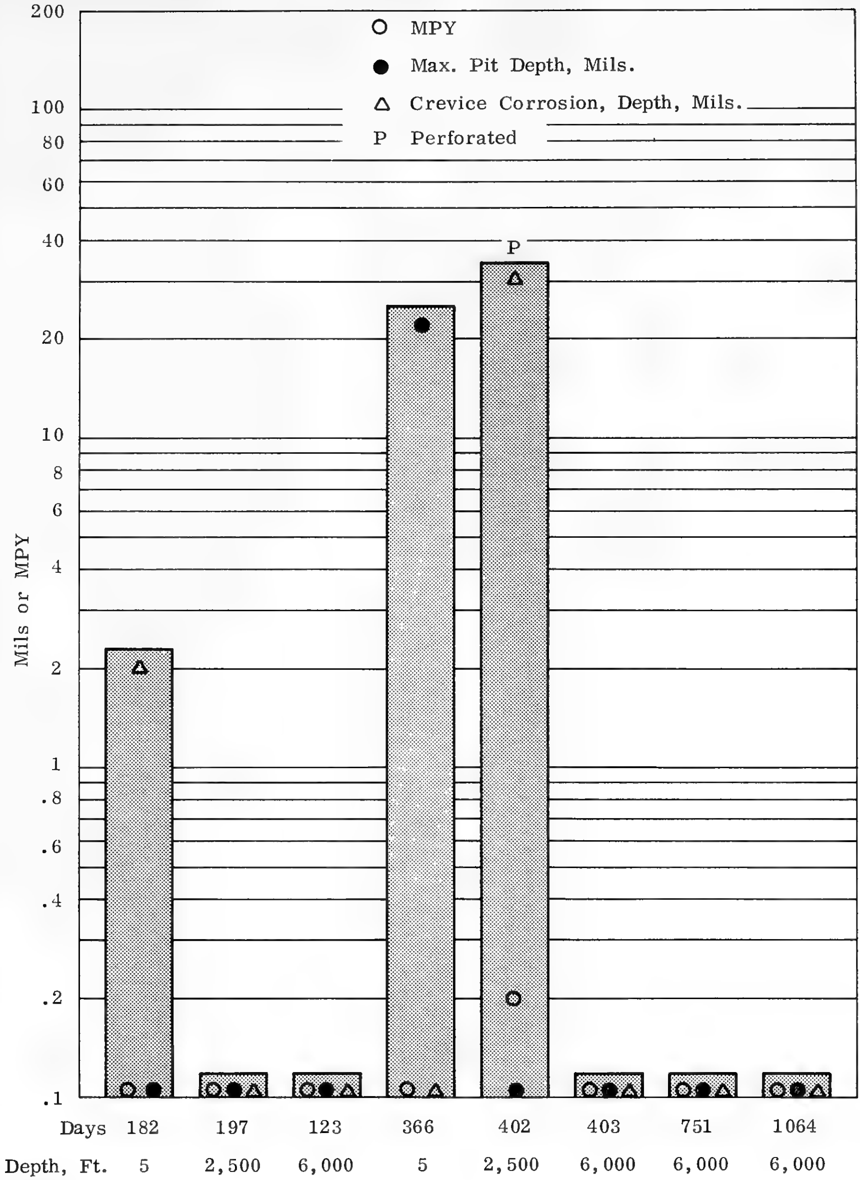

Figure 20. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 321 stainless steel in seawater at the surface and at depth.

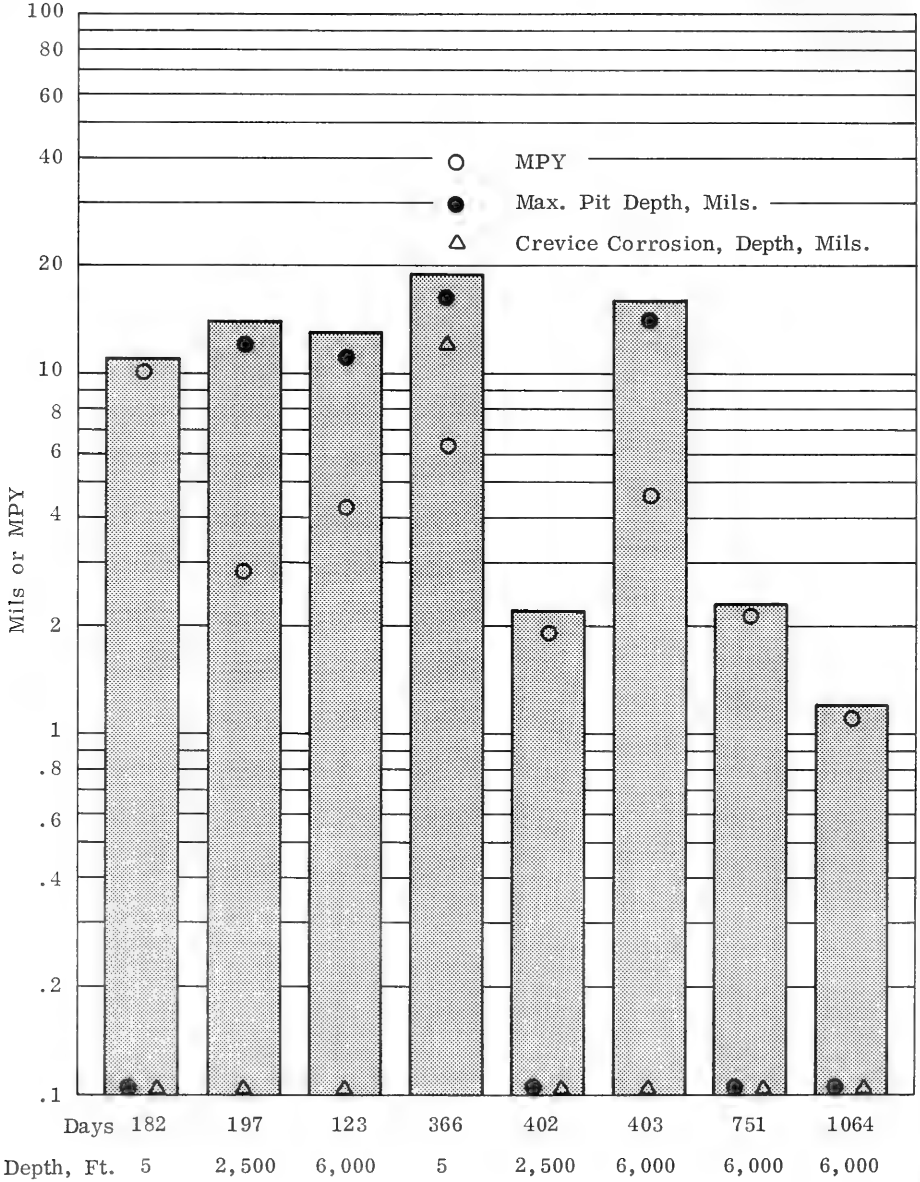

Figure 21. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 325 stainless steel in seawater at the surface and at depth.

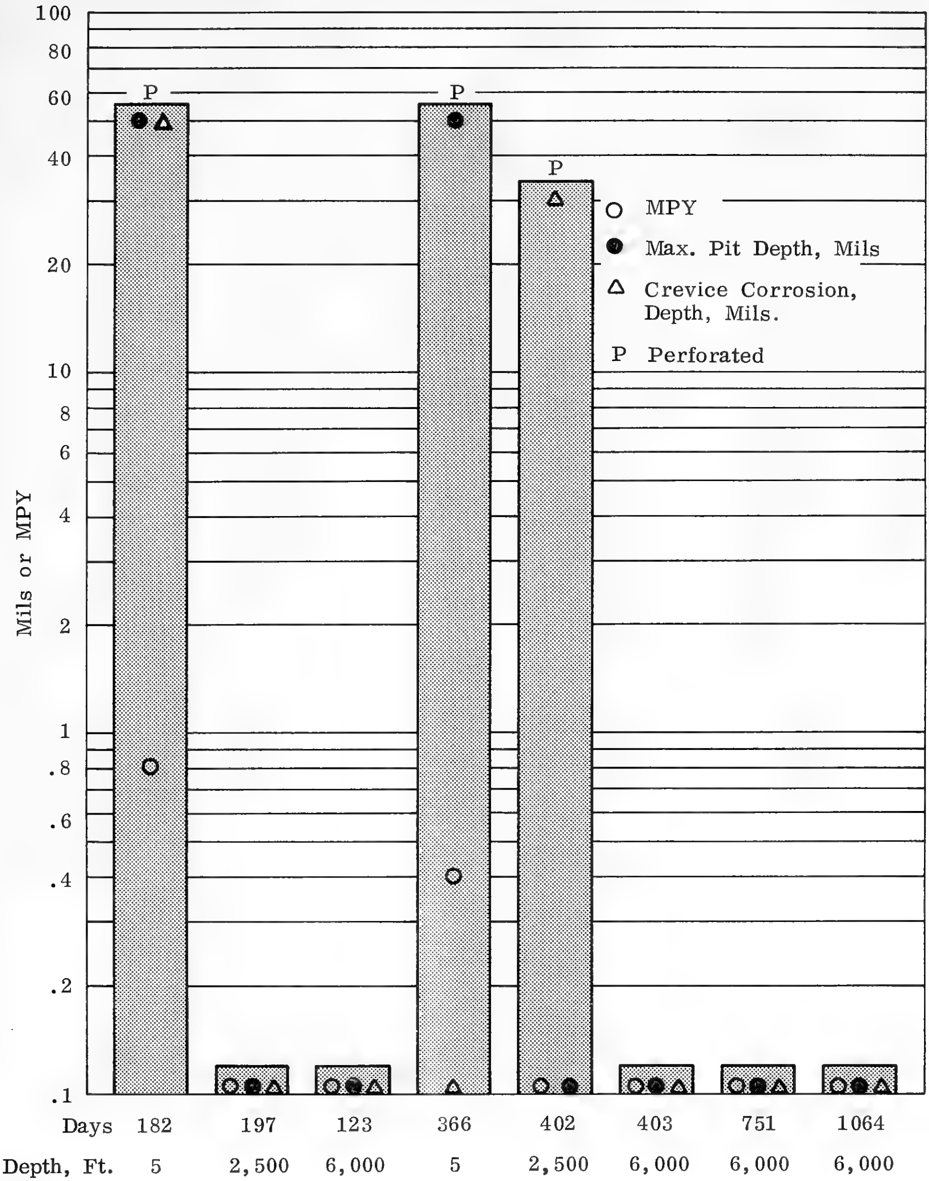

Figure 22. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 330 stainless steel in seawater at the surface and at depth.

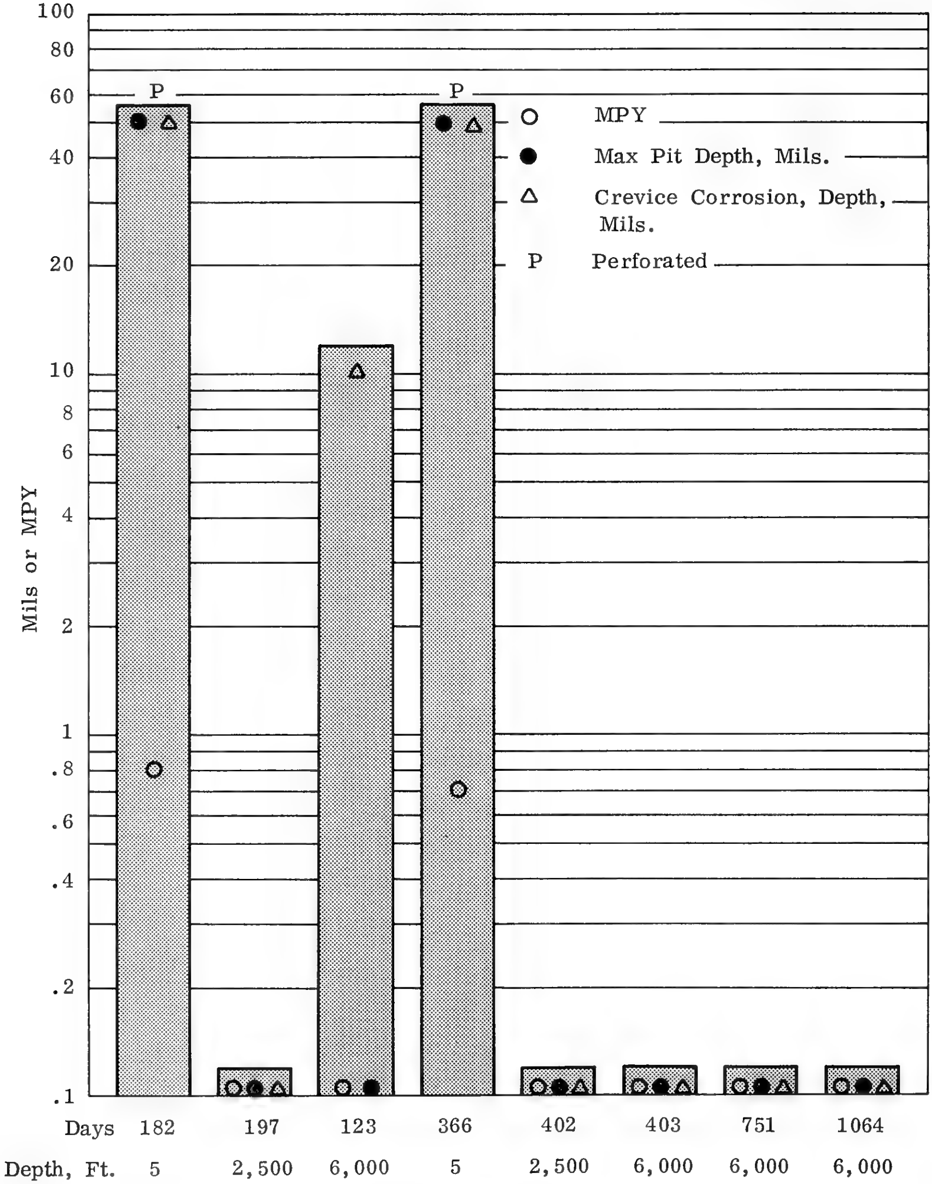

Figure 23. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 347 stainless steel in seawater at the surface and at depth.

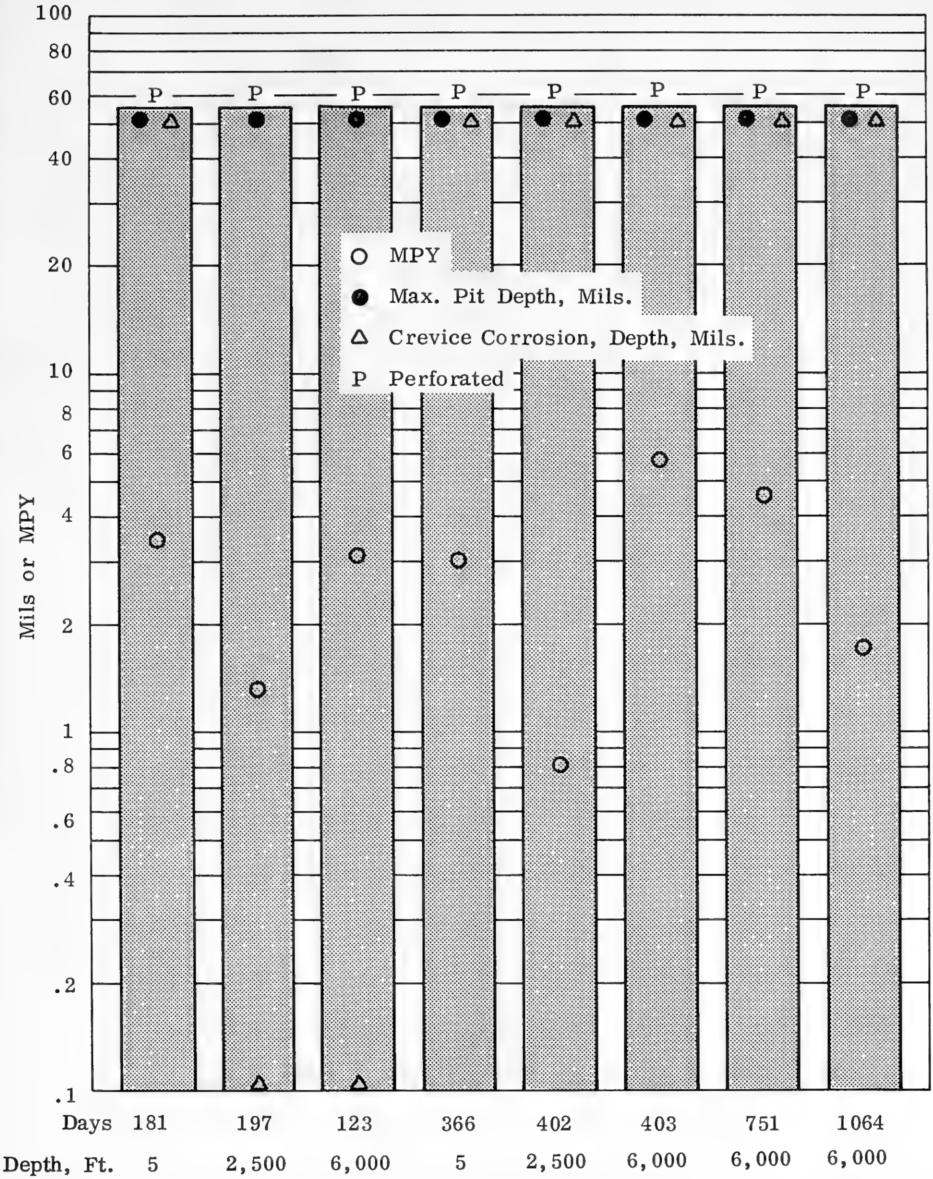

Figure 24. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 410 stainless steel in seawater at the surface and at depth.

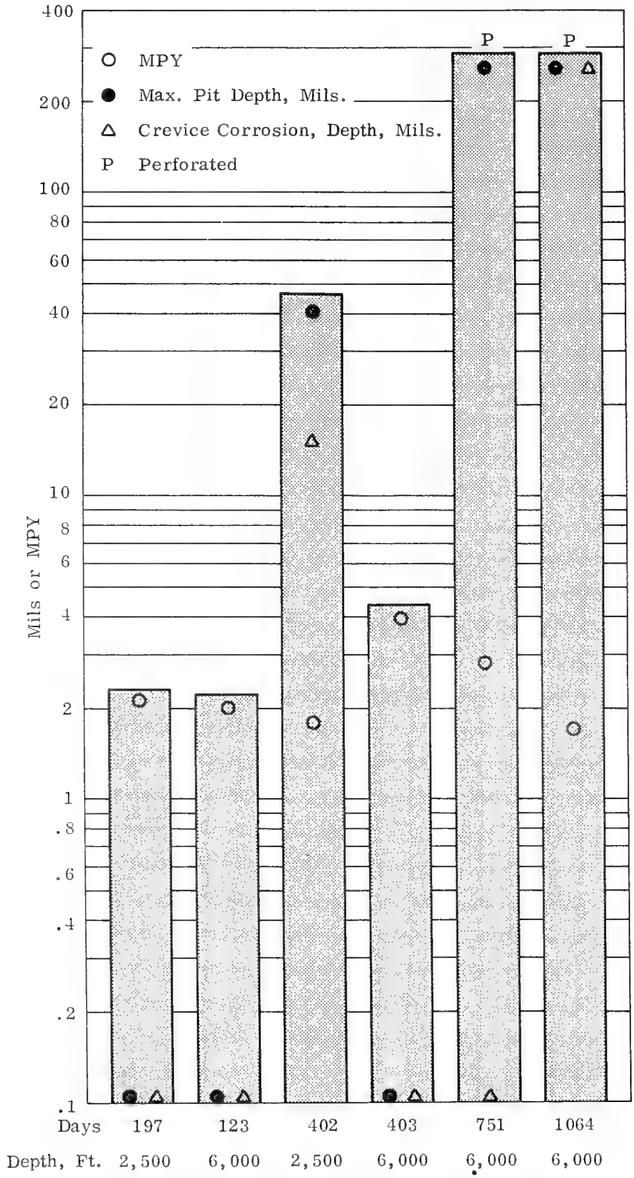

Figure 25. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 405 stainless steel in seawater at depth in the Pacific Ocean.

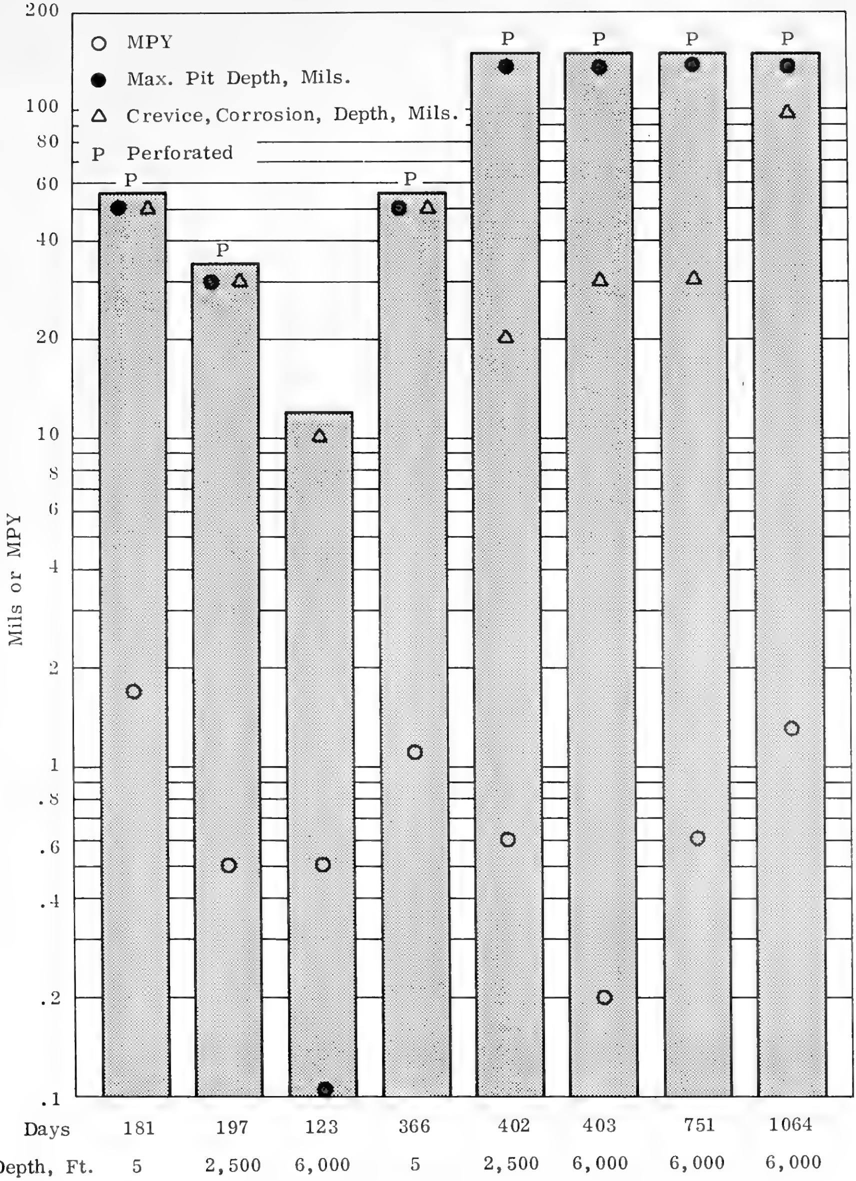

Figure 26. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 430 stainless steel in seawater at the surface and at depth.

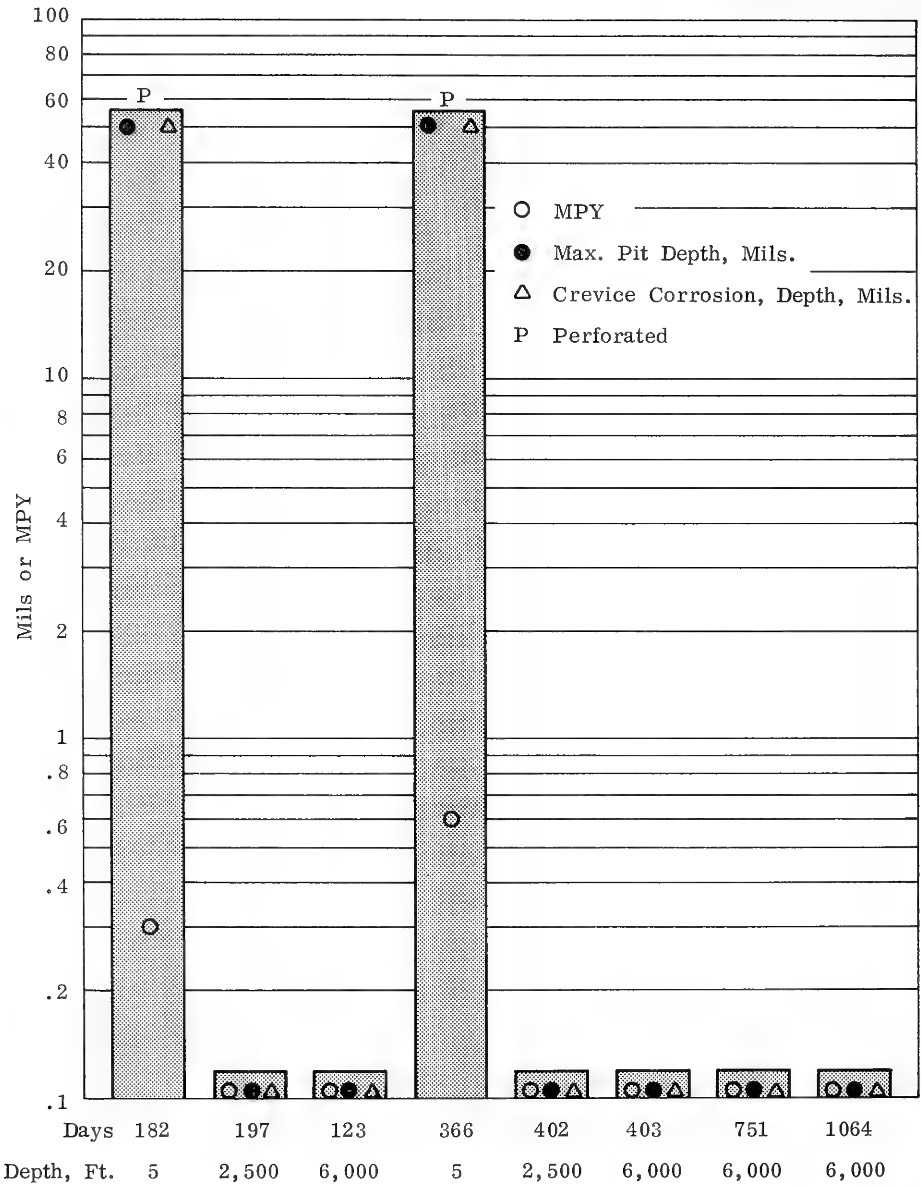

Figure 27. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 446 stainless steel in seawater at the surface and at depth.

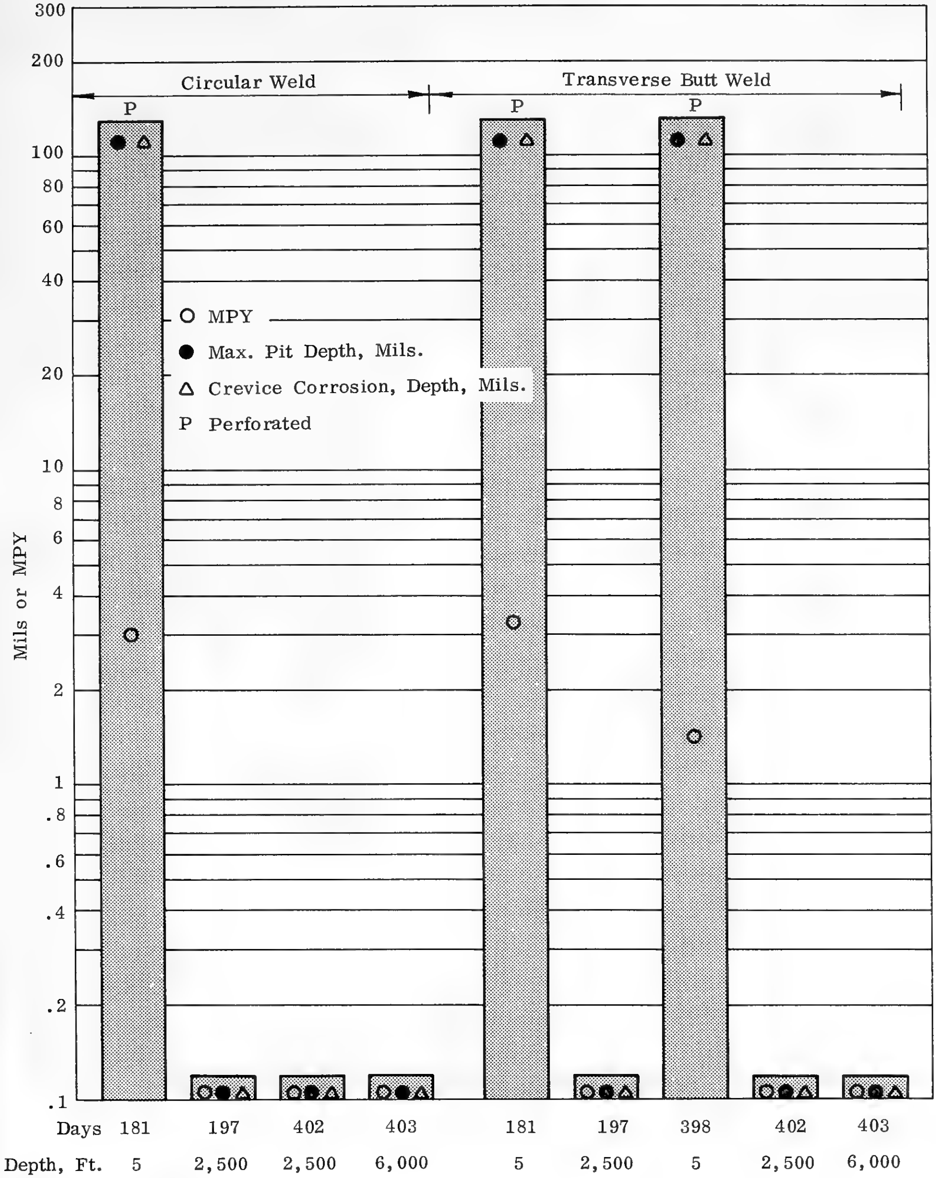

Figure 28. Corrosion rates, maximum pit depths and crevice corrosion of welded AISI Type 630-H925 precipitation hardening stainless steel in seawater at the surface and at depth.

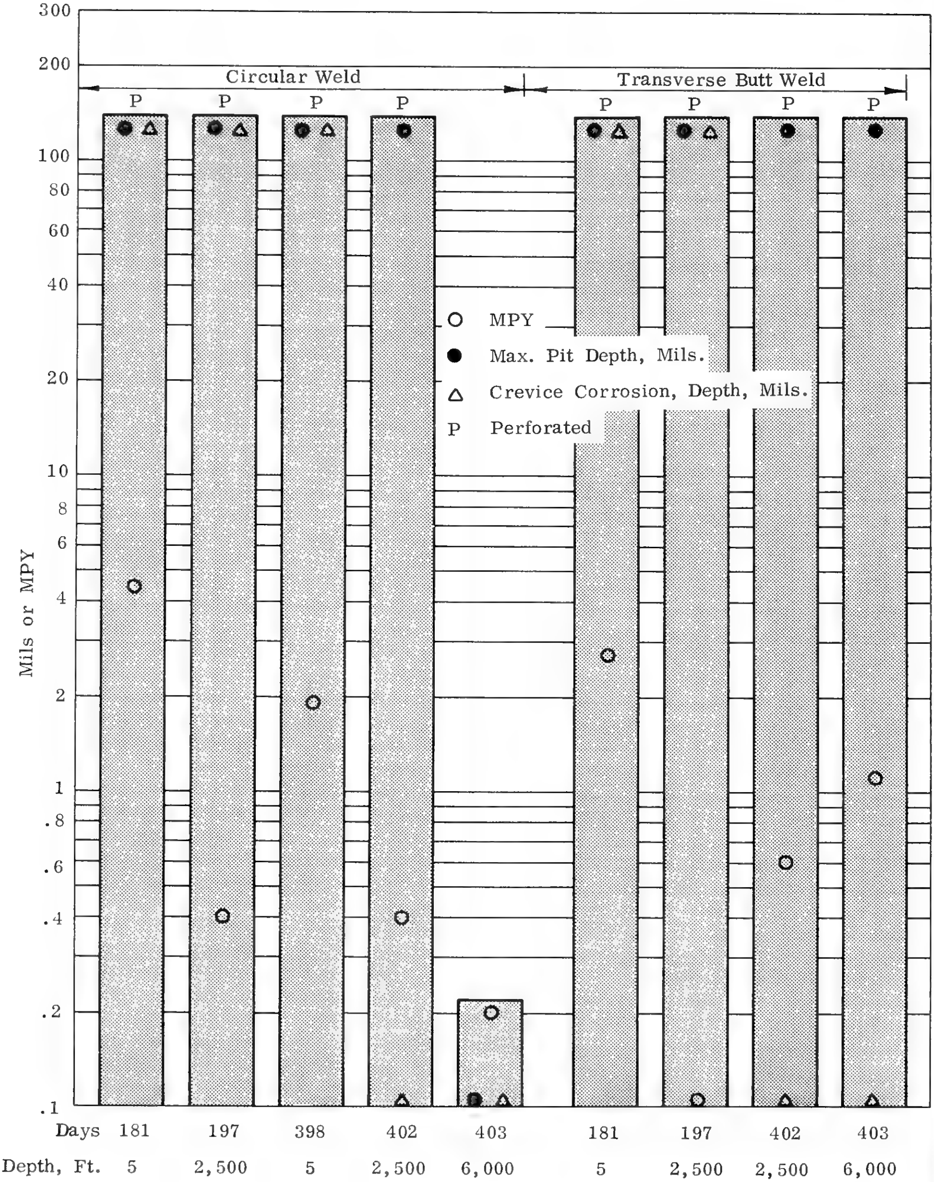

Figure 29. Corrosion rates, maximum pit depths and crevice corrosion of welded AISI Type 631-TH1050 precipitation hardening stainless steel in seawater at the surface and at depth.

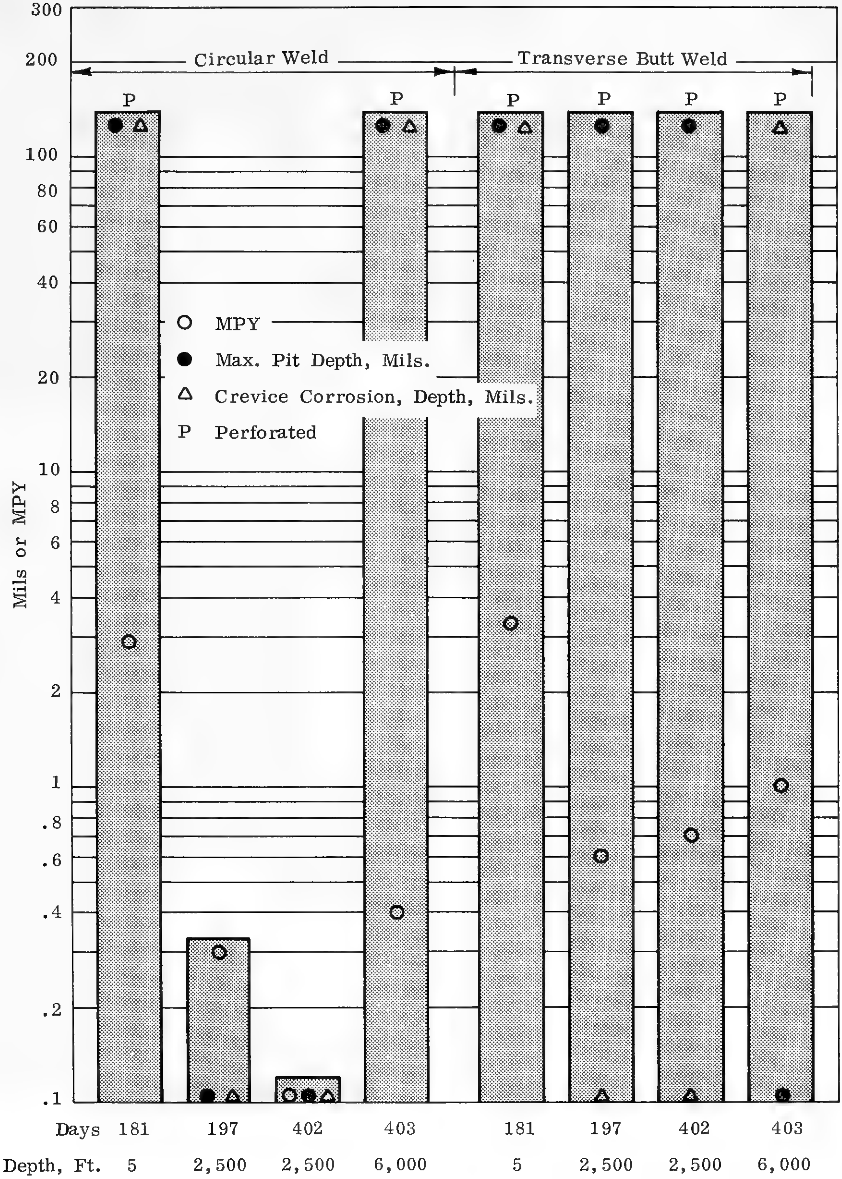

Figure 30. Corrosion rates, maximum pit depths and crevice corrosion of welded AISI Type 631-RH1050 precipitation hardening stainless steel in seawater at the surface and at depth.

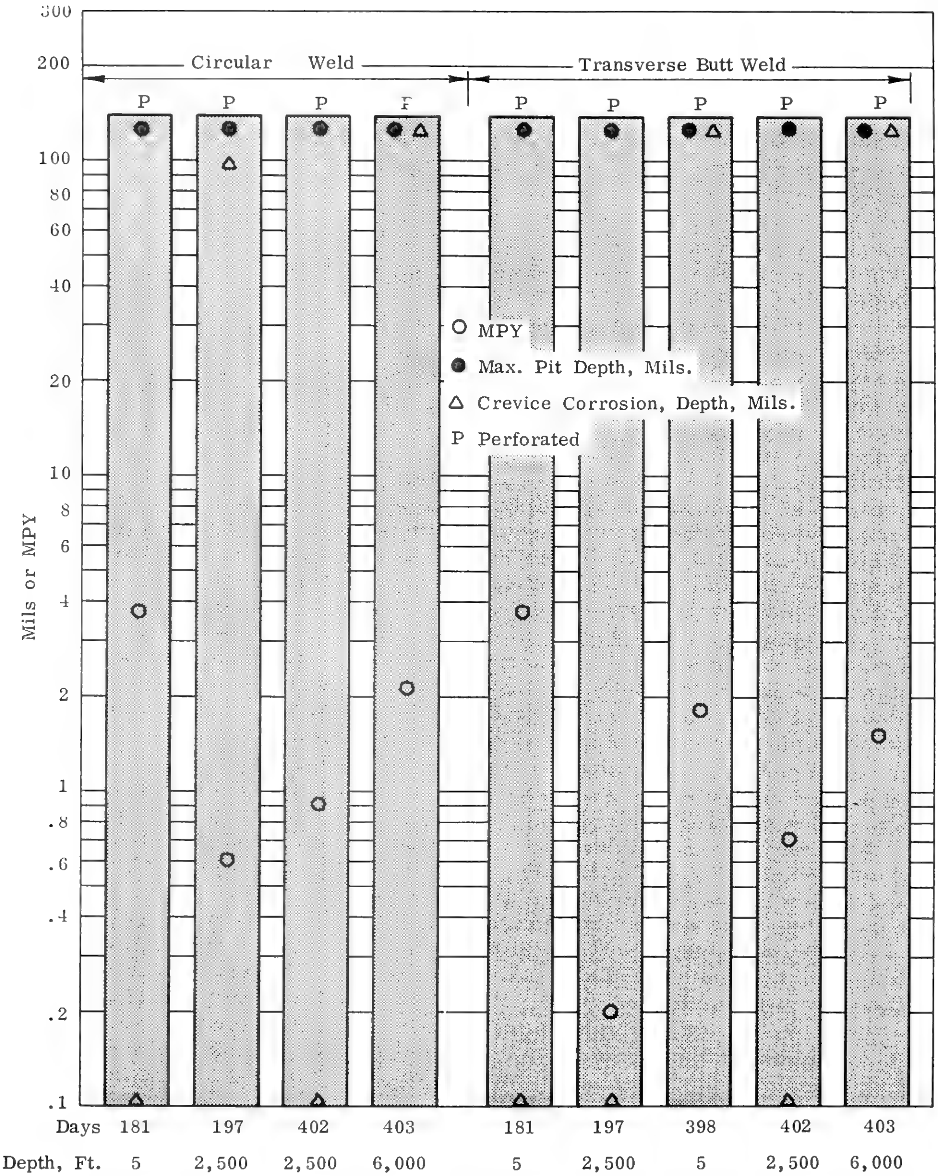

Figure 31. Corrosion rates, maximum pit depths and crevice corrosion of welded AISI Type 632-RH1100 precipitation hardening stainless steel in seawater at the surface and at depth.

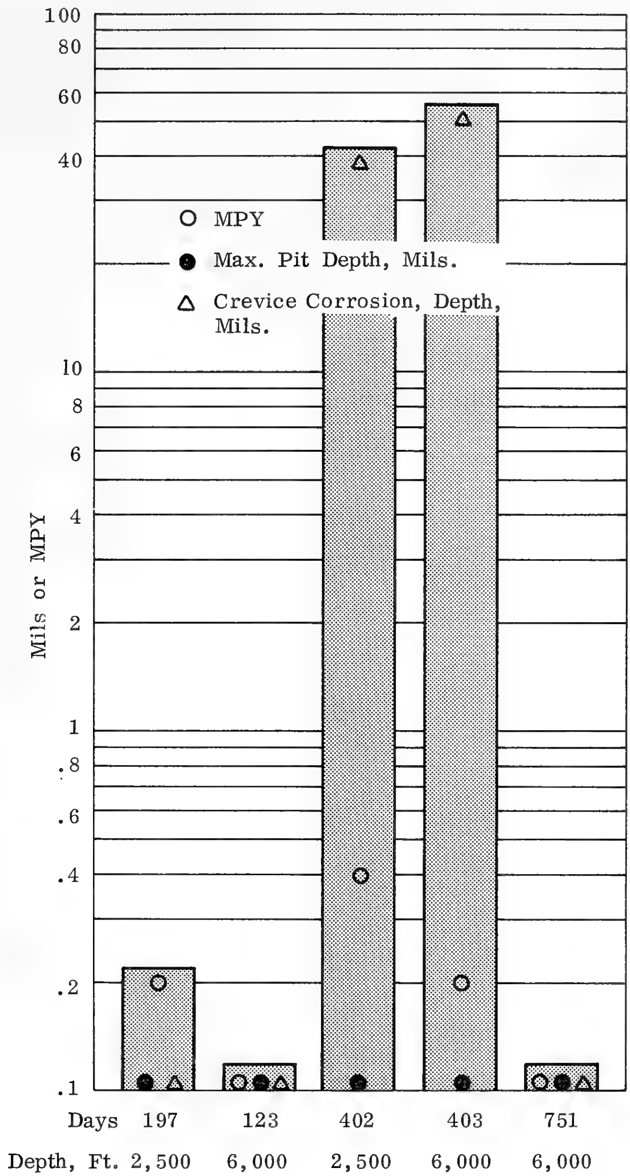

Figure 32. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 634-CRT precipitation hardening stainless steel in seawater at the surface and at depth.

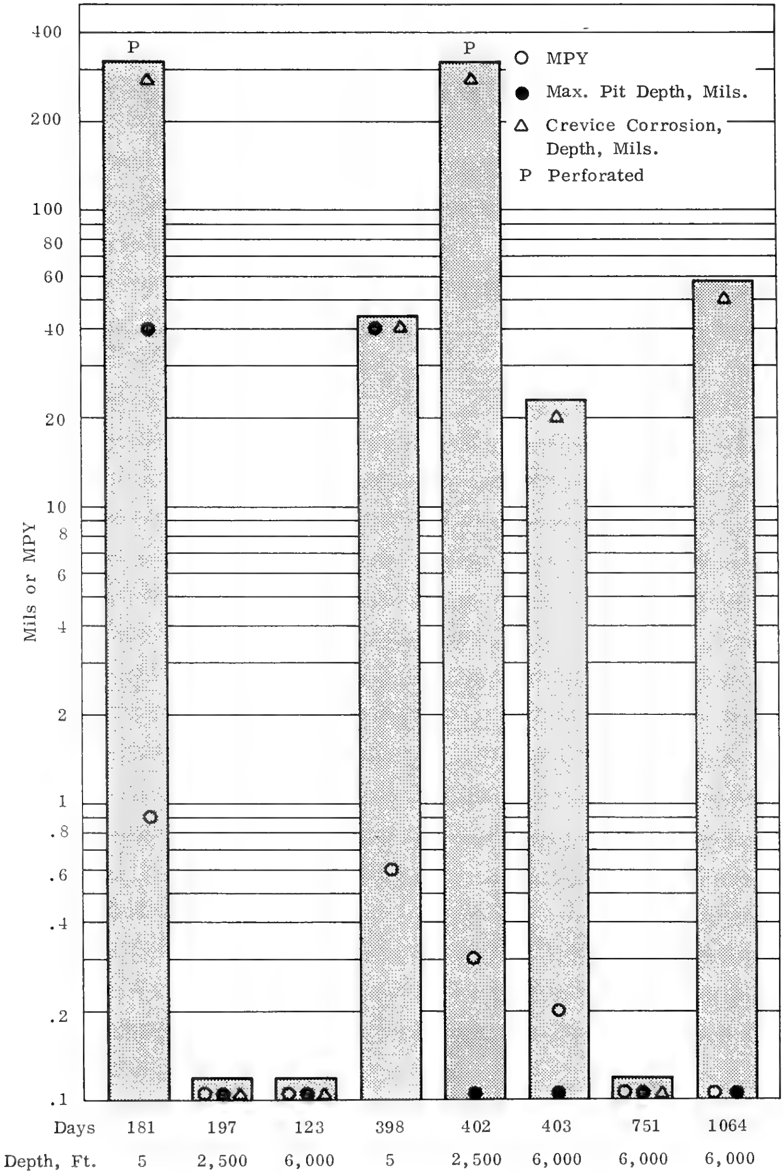

Figure 33. Corrosion rates, maximum pit depths and crevice corrosion of AISI Type 635-TH1000 precipitation hardening stainless steel in seawater at the surface and at depth.

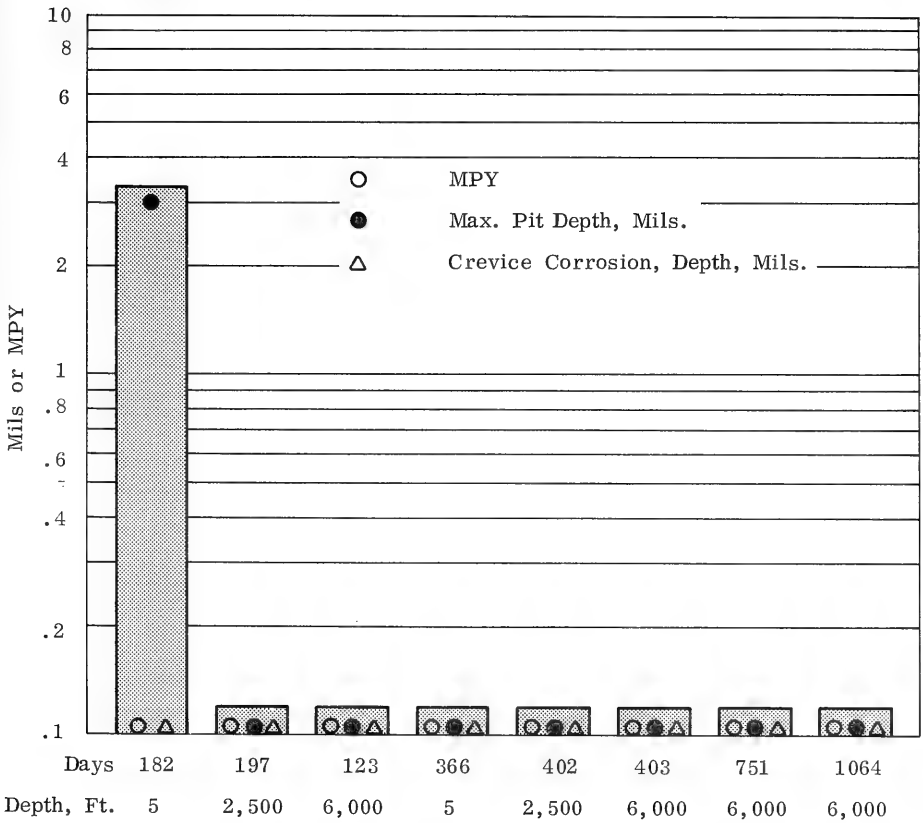

Figure 34. Corrosion rates, maximum pit depths and crevice corrosion 17Cr-14Ni-3Cu-2Mo precipitation hardening stainless steel in seawater at the surface and at depth.

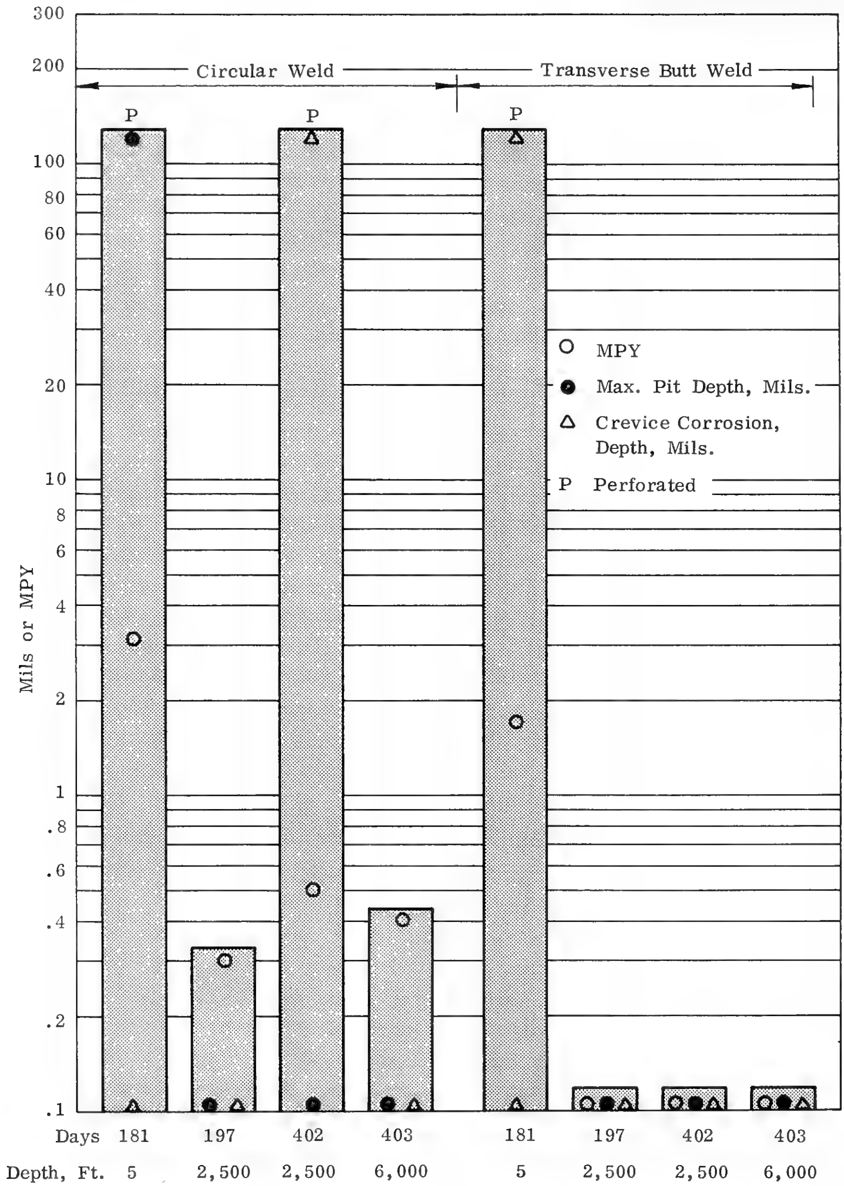

Figure 35. Corrosion rates, maximum pit depths and crevice corrosion of welded PH14-8Mo-SRH950 precipitation hardening stainless steel in seawater at the surface and at depth.

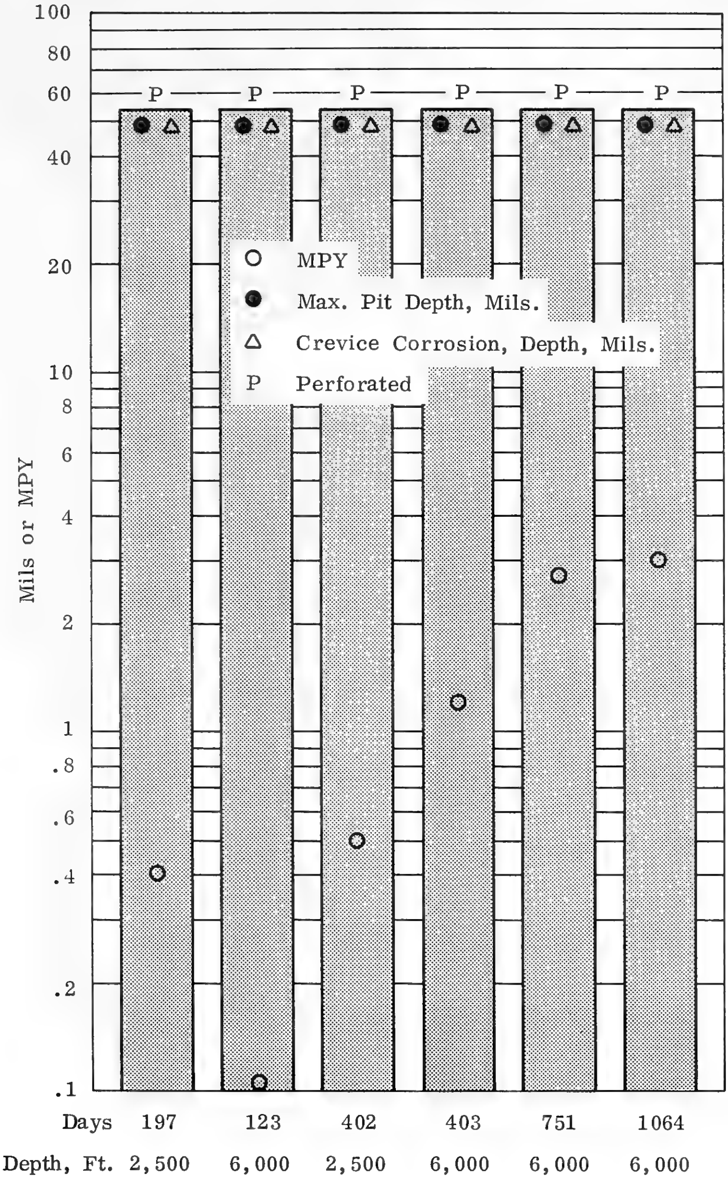

Figure 36. Corrosion rates, maximum pit depths and crevice corrosion of 15-7AMV, annealed precipitation hardening stainless steel in seawater at depth.

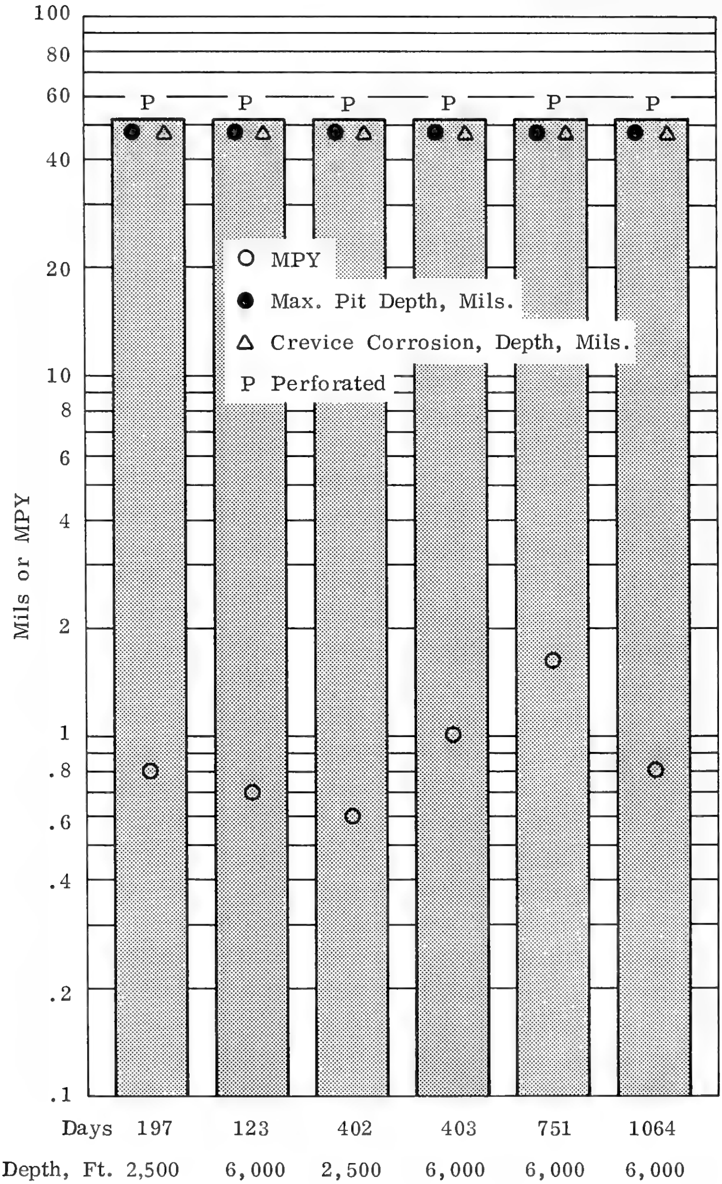

Figure 37. Corrosion rates, maximum pit depths and crevice corrosion of 15-7AMV-RH950 precipitation hardening stainless steel in sea-water at depth.

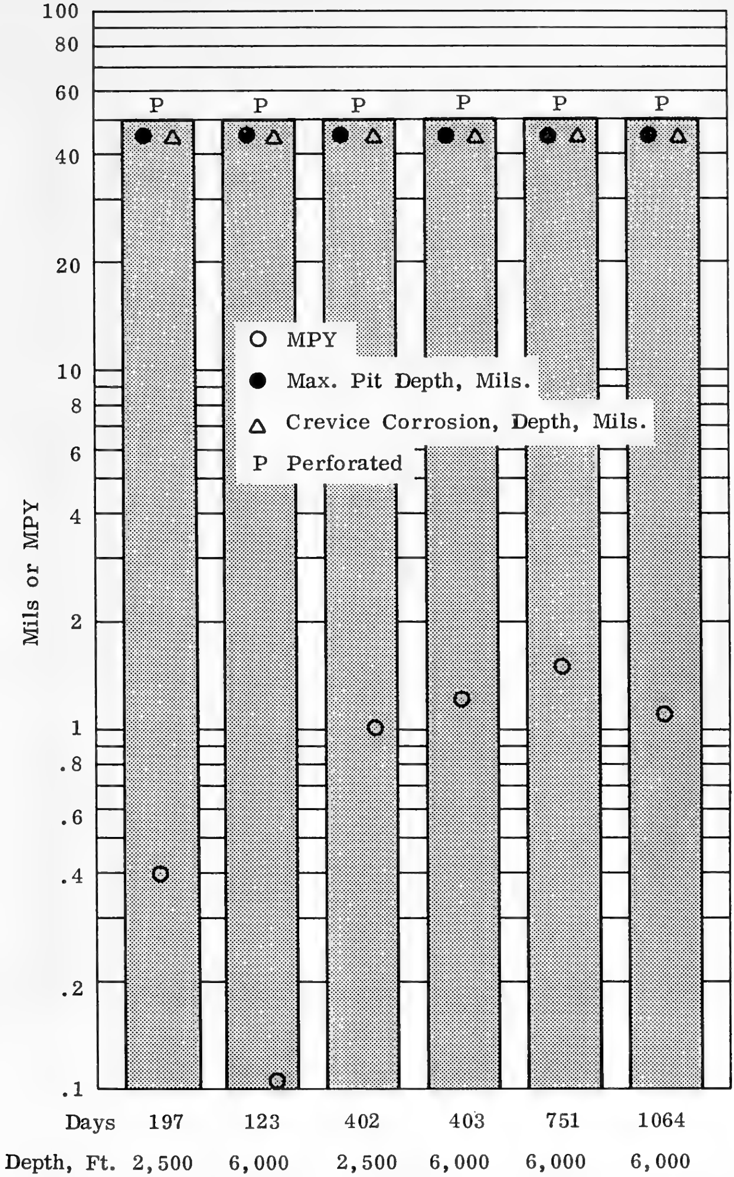

Figure 38. Corrosion rates, maximum pit depths and crevice corrosion of 15-7AMV-RH1150 precipitation hardening stainless steel in seawater at depth.

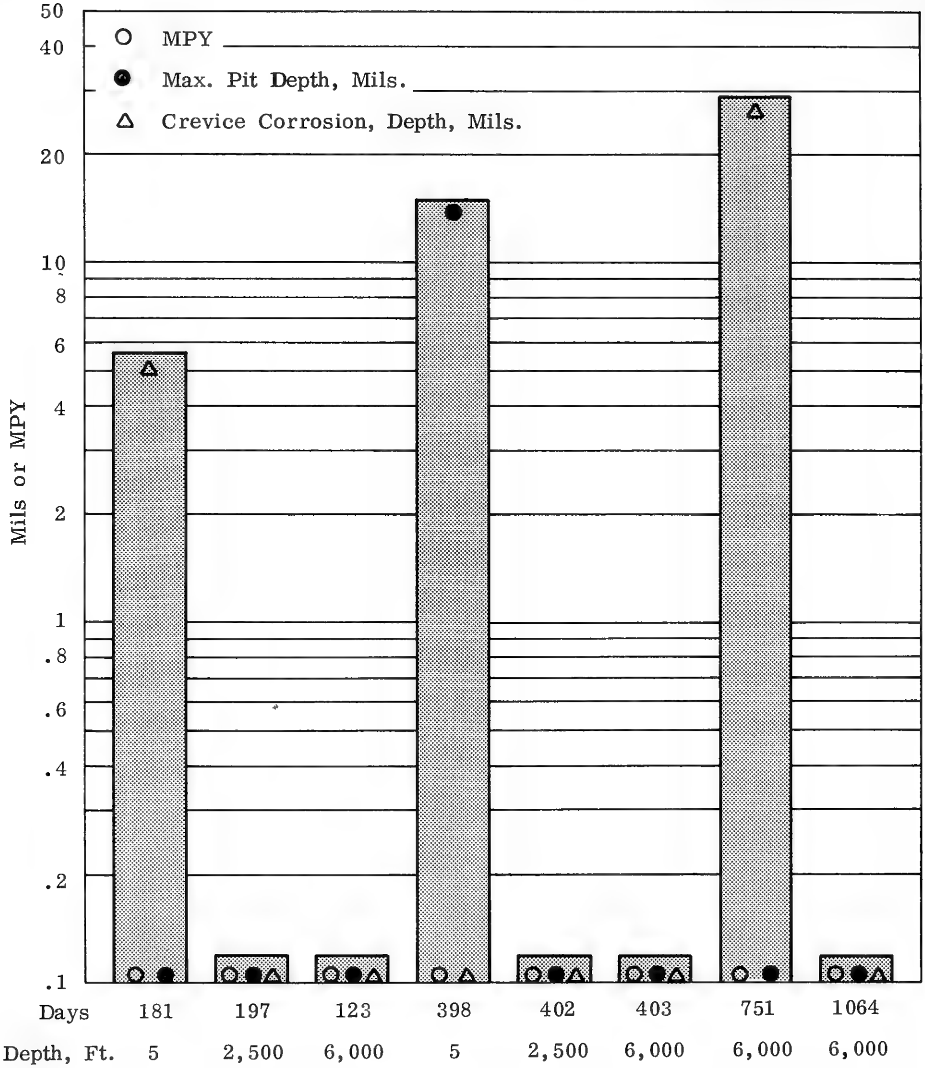

Figure 39. Corrosion rates, maximum pit depths and crevice corrosion of 20Cb stainless steel in seawater at the surface and at depth.

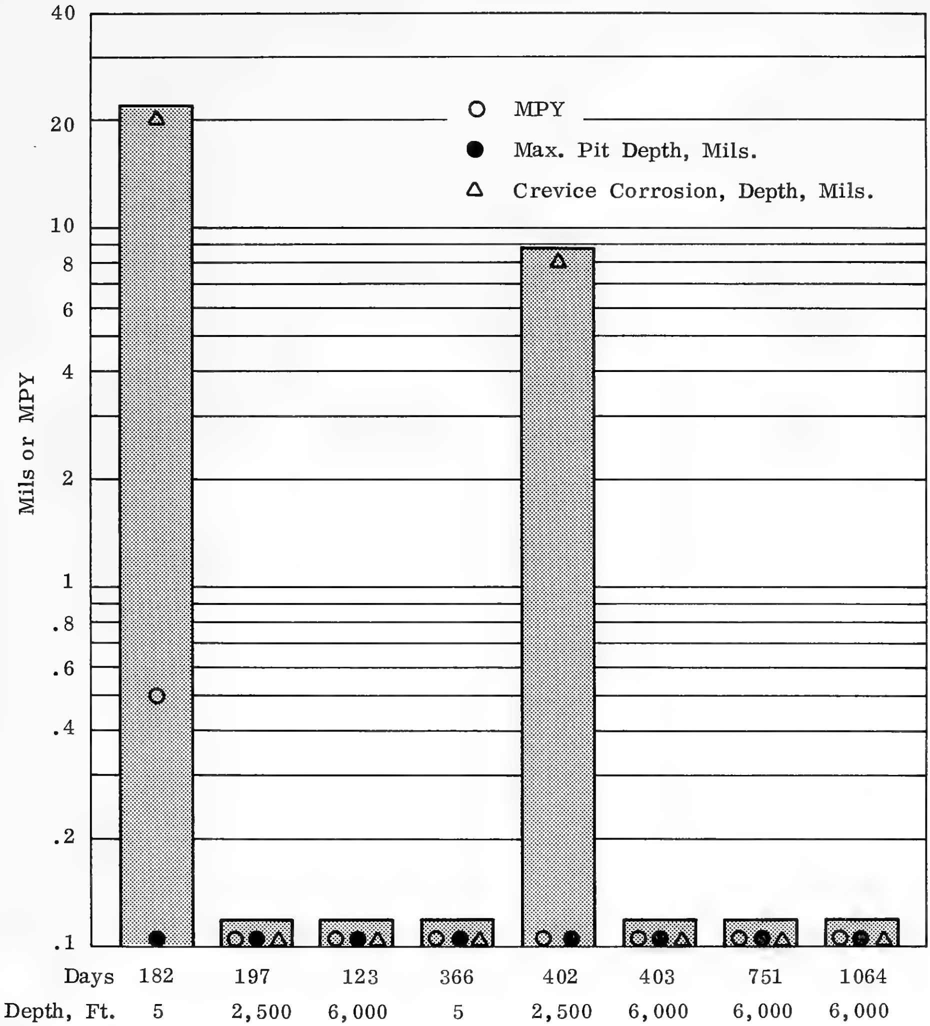

Figure 40. Corrosion rates, maximum pit depths and crevice corrosion of Ni-Cr-Cu-Mo#1 stainless steel in seawater at the surface and at depth.

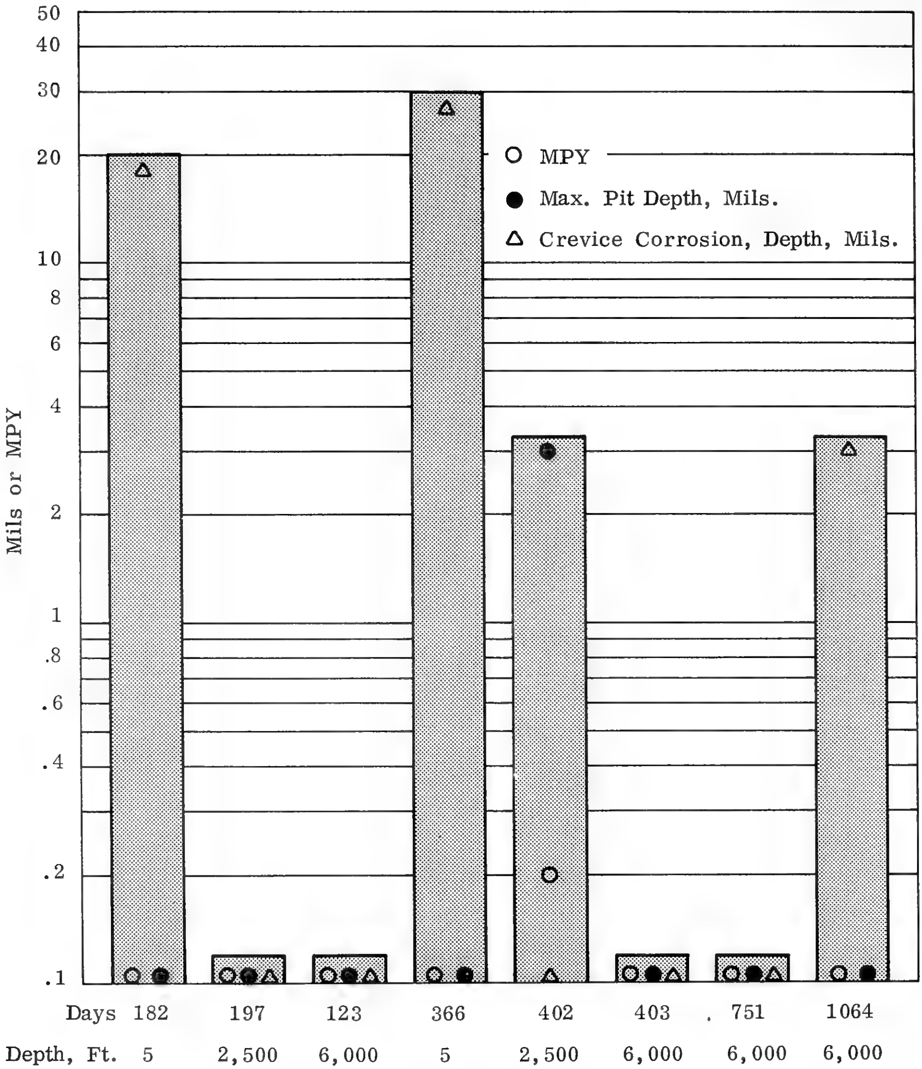

Figure 41. Corrosion rates, maximum pit depths and crevice corrosion of Ni-Cr-Cu-Mo#2 stainless steel in seawater at the surface and at depth.

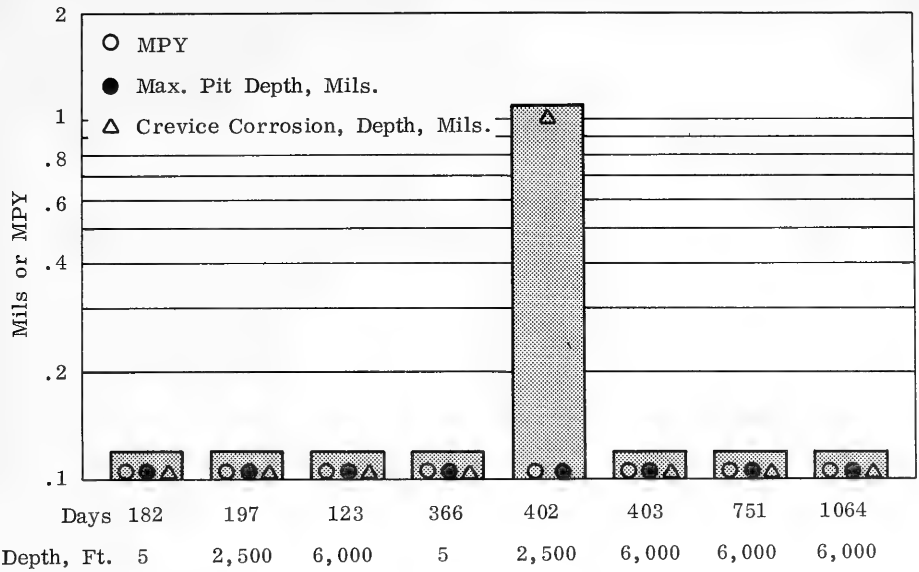

Figure 42. Corrosion rates, maximum pit depths and crevice corrosion of Ni-Cr-Mo stainless steel in seawater at the surface and at depth.

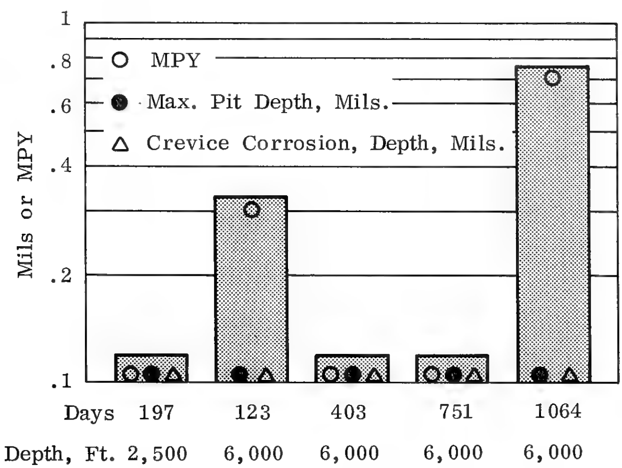

Figure 43. Corrosion rates, maximum pit depths and crevice corrosion of RL-35-100 stainless steel in seawater at depth.

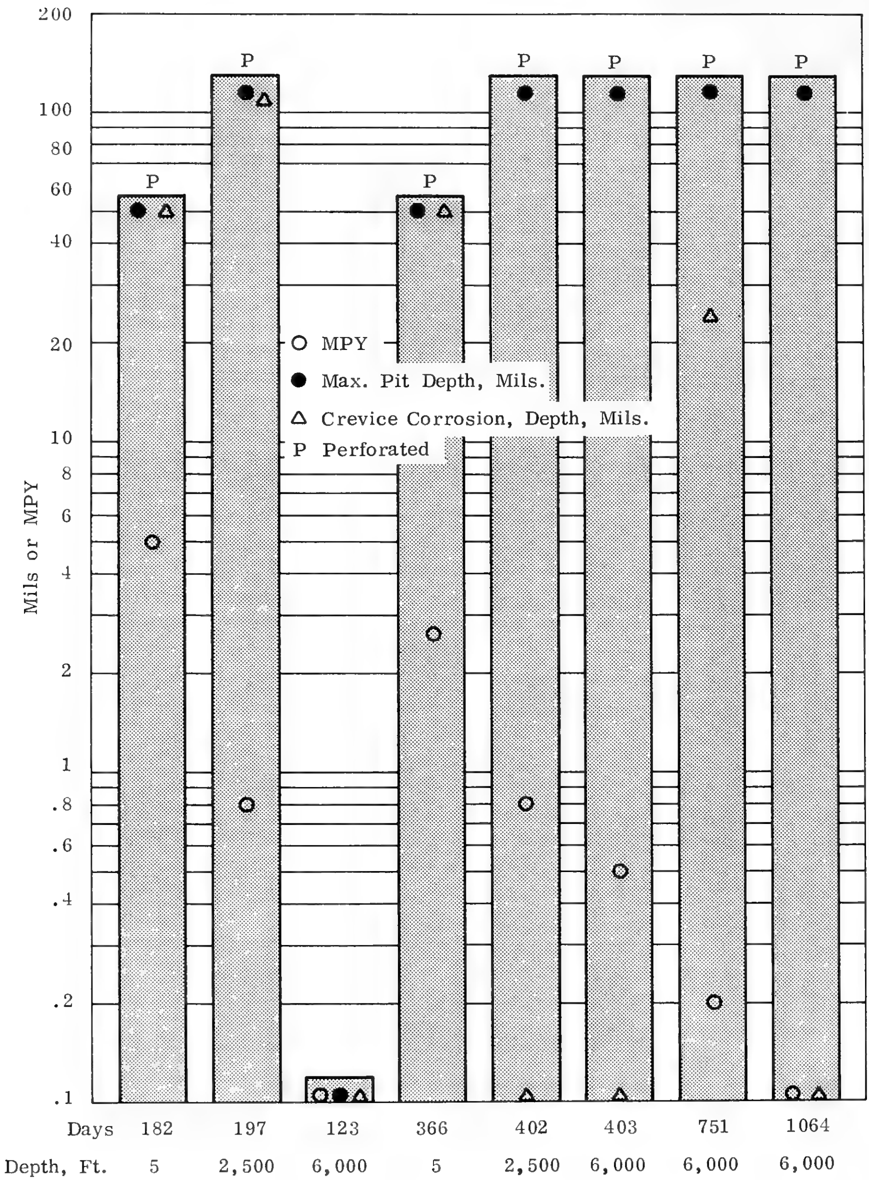

Figure 44. Corrosion rates, maximum pit depths and crevice corrosion of 18Cr-14Mn-0.5N stainless steel in seawater at the surface and at depth.

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13. ABSTRACT

A total of 1,750 specimens of 57 different stainless steels were exposed in seawater at the surface and at depths of 2,500 and 6,000 feet in the Pacific Ocean for periods of time varying from 123 to 1,064 days in order to determine the effects of the seawater environments at different depths on their corrosion resistance.

Corrosion rates, type of corrosion, pit depths and stress corrosion cracking resistance are presented.

Cast stainless steel, Ni-Cr-Mo-Si, was uncorroded.

AISI Types 317 and 329 stainless steels were attacked by incipient (less than 1 mil deep) crevice corrosion. Stainless steel 20Cb-3 was attacked by both incipient crevice corrosion and incipient pitting corrosion. Most of the corrosion on AISI Type 325 stainless steel was of the general surface type.

All the other stainless steels, AISI Types 200, 300, 400 and 600 series and miscellaneous alloys, both cast and wrought, were attacked by pitting, tunneling and crevice types of corrosion varying in intensity from depths of 1 mil to complete perforation of the thickness of the material and tunnels to 12 inches long.

Continued

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Corrosion						
Stainless steels						
Sea water						
Sa						
Shallow water						
Deep water						
Ocean environments						
Corrosion environments						
Stress corrosion						
Sea water corrosion						
Environmental tests						

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Unclassified

Security Classification

In general, corrosion in surface seawater was more severe than in the deep seawater and in the bottom sediments at depths of 2,500 and 6,000 feet for equivalent periods of exposure.

Sensitization decreased the corrosion resistance of AISI Types 304 and 316 stainless steels.

Stainless steel wire ropes were also attacked by the pitting and crevice types of corrosion.

Precipitation hardening stainless steels 630-H925, 631-TH1050 and RH1050, 632-RH1100, 15-7AMV-annealed, RH950 and RH1150 and PH14-8Mo-SRH950 failed by stress corrosion cracking.