CORROSION RESISTANCE OF ELECTROLESS NICKEL FOR PETROLEUM PRODUCTION OPERATIONS

ABSTRACT

Recent experience has shown functional Electroless Nickel to have exceptional resistance to corrosion and erosion in petroleum production facilities. Details of test programs to establish the performance of these coatings in saline/CO_2/H_2S environments at temperatures up to 180°C are reported, together with actual experience with their use.

Data is also presented on the effect of heat treatment on the corrosion of Electroless Nickel and on galvanic corrosion in oil field services. The effect of deposit quality and defects is also discussed.

Ronald N. Duncan

Electroless Nickel is not a new product for the petroleum industry. The coating has been used for many different applications since its introduction twenty-five years ago. Today with the availability of functional, consistent Electroless Nickel and with the increased importance being shown equipment cost and reliability, these coatings are being considered for more and more uses. Electroless Nickel is now one of the fastest growing materials of construction for petroleum equipment.

PRODUCTION ENVIRONMENTS CAN CAUSE SEVERE CORROSION

Corrosion problems in petroleum production environments are usually complex, consisting of several corrosives, with the additive effect of temperature, pressure, velocity and abrasives(1). The most common corrodents in an oil field are salt water, carbon dioxide and hydrogen sulfide, although oxygen, nitrogen and sulfur compounds, and organic and inorganic acids may also be present.

The salt content of the water from production facilities can vary greatly, ranging from a few hundred ppm in the condensed water from some gas wells to over 10 percent TDS in the associated brine of many crude oils. The salts are usually mixtures of NaCl, $CaCl_2$, $MgCl_2$, $BaCl_2$, $NaHCO_3$ or $Na(CO_3)_2$, Na_2SO_4, etc. By themselves salt solutions are usually only mildly corrosive, even when concentrated. When acid gases or oxygen are also present, however, attack can become quite aggressive.

Carbon dioxide is often the most corrosive constituent in an oil or gas well. It results in "sweet corrosion" and causes severe thinning and deep pitting. The corrosion rate of steel in CO_2 containing condensate wells can exceed 35 mils per year (2). Sweet corrosion is controlled by the amount of gas dissolved in the water (the carbonic acid concentration) and in turn by the CO_2 partial pressure. Generally only mild corrosion will occur if the CO_2 partial pressure is less than 3 psi. Severe corrosion, however, can occur if the partial pressure exceeds 15 to 30 psi.

The hydrogen sulfide present in most production environments can cause damage in two ways. First, it produces sulfurous acid when dissolved in water and causes "sour corrosion". This type of attack results in general, deep pitting, and occasionally heavy fouling. In some sour installations, especially those where CO_2 is also present, corrosion can become catastrophic with rates greater than 100 mpy (3). Second, and often more important, the presence of even small amounts of H_2S can cause sulfide stress cracking and the failure of high strength steels. Often only lower strength

FIGURE 14

Brittle, highly stressed deposit from coating in Figure 11.

FIGURE 15

Porous, brittle deposit from coating in Figure 12.

FIGURE 16

Ductile, defect free, functional deposit from Figure 13.

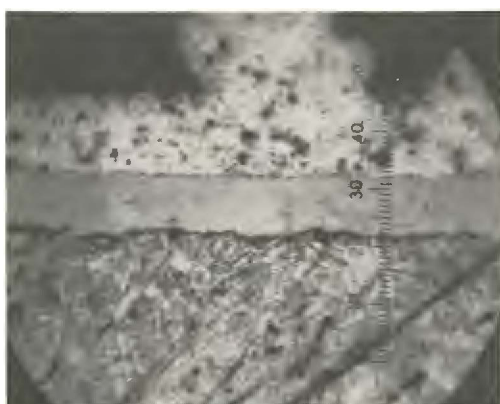
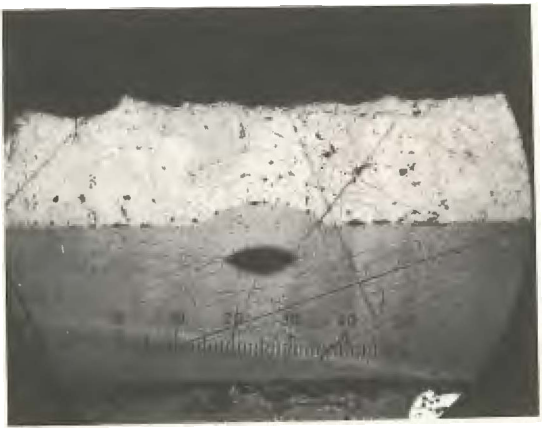
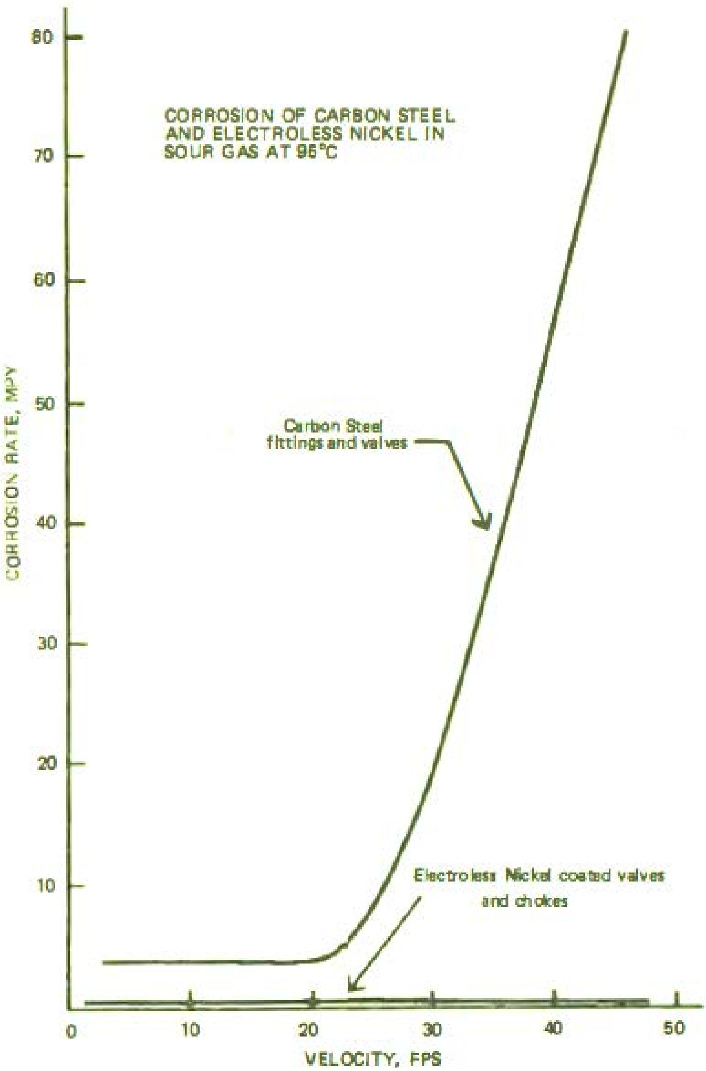


FIGURE 17



Roughness due to codeposition of
particles in the coating.

FIGURE 18



CORROSION OF CARBON STEEL
AND ELECTROLESS NICKEL IN
SOUR GAS AT 95°C
CORROSION RATE, MPY
80
70
60
50
40
30
20
10
Carbon Steel
fittings and valves
Electroless Nickel coated valves
and chokes
0
10
20
30
40
50
VELOCITY, FPS

Ronald N. Duncan

BIOGRAPHICAL SKETCH

In Memory of Ron Duncan

Ron Duncan served as Vice President of Palm International, Inc., where he led the company's technical and educational initiatives. Prior to joining Palm, he was Director of Research at Elnic, Inc., focusing on electroless nickel formulation and materials research.

Before entering the metal finishing industry, Ron spent 12 years in the oil sector with Exxon and Caltex Petroleum Corporations, tackling materials and corrosion challenges. His work took him across the globe—including the United States, Middle East, Europe, South America, and Africa—where he developed a reputation for his deep expertise and practical problem-solving.

Ron held a BE in Mechanical and Metallurgical Engineering from Vanderbilt University. He was a Registered Professional Engineer and a certified Corrosion Specialist through NACE. A leader in technical standards, he chaired NACE task groups T-1G-19 and T-6A-53, contributing to authoritative reports on electroless nickel and other metallic coatings. He also served on the AESF's Electroless Committee.

Throughout his distinguished career, Ron authored more than fifty technical papers on corrosion, coatings, and electroless nickel. His work appeared in Materials Performance, Plating and Surface Finishing, Metals Progress, Products Finishing, and Finishers Management, as well as in numerous industry conferences. He was the principal author of the electroless nickel chapter in Volume 5 of the Metals Handbook and was honored with the AESF Gold Medal in 1996 for the best paper published in Plating and Surface Finishing.

Ron also directed the Electroless Nickel School, a comprehensive four-day seminar presented by Palm, which educated professionals in all aspects of electroless nickel technology.

Ron Duncan passed away on December 15, 2006. He is deeply missed by his family, colleagues, and the broader surface finishing community. His legacy of innovation, mentorship, and integrity continues to inspire all who had the privilege of working with him.