A Study of Steel Aerobic Cariseean Fatigue Life as Related to the PH Level

F. J. RADD and L. H. WOLFE, Continental Oil Company Development and Research Department, Central Research Division, Ponca City

The object of this study which is largely abstracted herein, was to determine how a normal and a high pH level affect steel aerobic corrosion fatigue life. This study was indicated because most of our oil wells are drilled in such conditions and because a high pH environment is known to have a corrosion inhibition effect upon steel. While the data are directly useful in the drilling industry, by no means are the results restricted in their applications to the petroleum cases.

The statistical type experiments were accomplished on R. R. Moore fatigue machines using wick-type feeding of the corrosion liquids upon the steel specimens. The essential experimental data are given in Fig. 1 as derived from our statistical corrosion fatigue measurements in aerobic electrolytes of pH 7.0 and 13.2. The air fatigue properties of the A.I.S.I. 1036 normalized steel (1.07×10^5) psi tensile strength; 7.14×10^4 psi yield strength; 27.5% (in 2″) elongation) are also summarized in the same figure. The data show the existence of a real, effective endurance limit for the pH 13.2 case, this with an estimated increase of working life of a factor of 100 times over that of the pH 7.0 case. We believe that our data are fully explained by the substantial reduction of the solubility of ferrous hydroxide, the critical step in the atmospheric rusting mechanism, by the caustic added to obtain the higher pH levels. Fig. 2, taken from the literature, shows how this critical solubility varies. The theoretical developments in this report outline why dissolved oxygen and oxygen pressure are factors secondary to the pH levels employed. Apparently this is true because the dissolved oxygen acts upon the ferrous hydroxide formed and if its solubility is restricted the oxygen effects are also restricted. Fig. 2 shows how ferrous hydroxide solubility varies with the pH level.[1]

From these experiments we concluded that aerobic corrosion fatigue environments should be pH controlled to at least a pH 12.0 level, particularly for drilling muds. If for other reasons low pH environments must be used then the oxygen dissolved in the electrolyte system should be removed by a suitable method. We believe our data suggests that the aerobic corrosion fatigue life of a steel is quite dependent upon the sulphide impurity content thereof, that copper additions in the steel of the order of two copper atoms per one sulphur atom should help the aerobic corrosion fatigue resistance. Finally, it is evident that the data have immediate economic implications in the petroleum drilling industry where less than 5 per cent of the wells are currently drilled with pH 12.0 or higher muds and which industry has a U. S. A. volume of approximately one billion dollars per year.

[1] W. G. Whitman, R. P. Russell, G. H B. Davis, Jr., American Chemical Society, 1925, 47, 70-79.

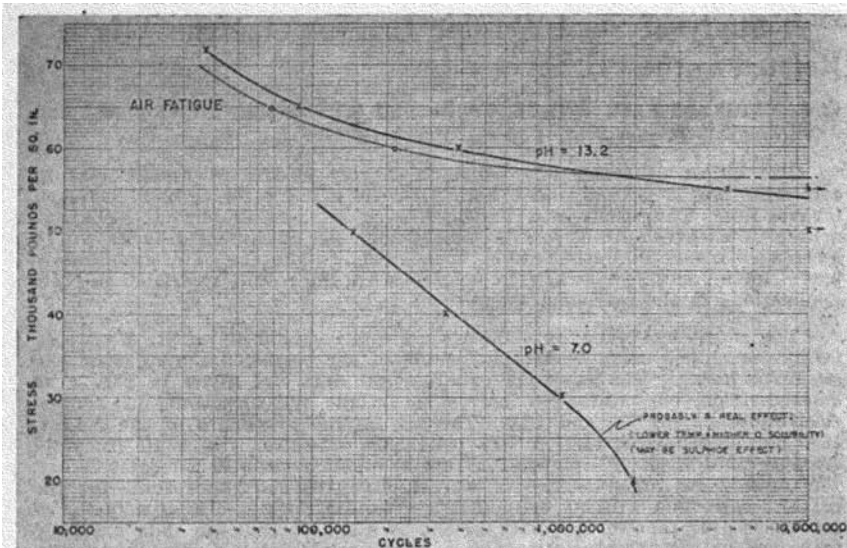

FIGURE I AEROBIC CORROSION FATIGUE LIFE vs pH LEVEL OF AN A.I.S.I. STEEL

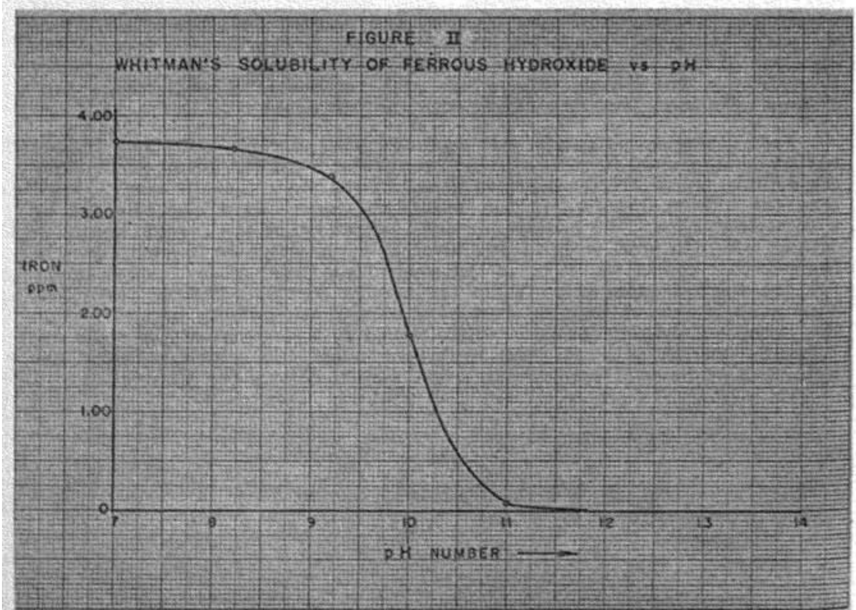

FIGURE II
WHITMAN'S SOLUBILITY OF FERROUS HYDROXIDE vs pH