Cautionary Use of Test Data

The corrosion behavior of materials under conditions of service should be an important consideration during the design of a system. Although it is relatively straightforward to obtain quantitative information on physical and mechanical properties such as tensile strength, yield strength, impact values, fatigue limit, effect of temperature on properties, and so forth, truly representative corrosion data are often much more difficult to obtain. While reliable atlases characterize corrosion resistance of many materials, including metals and alloys, this information typically addresses concentrations of a single chemical in a uniform environment.

It is not always possible to anticipate the more complex environments in which a metal will actually operate. Even if initial conditions were known completely, often there is no assurance that operating temperatures, pressures, or even chemical compositions will remain constant over the expected life span of equipment.

Experience has shown, however, that even when unpredictable circumstances apparently are present, substantial cost savings are possible by intelligent use of corrosion data and good design practices.

Most published data have limited usefulness because the character of attack is often omitted. Another factor to keep in mind is that published data usually are obtained under carefully controlled laboratory conditions using high-purity, reagent-grade materials. This is very different than plant conditions using commercial-grade materials, which are less pure. Minor elements or impurities can play an important role in the stability of metals and alloys when they are exposed to service conditions. A classic example is the catastrophic influence on water-handling aluminum equipment even when only a minute amount of copper ions is present in the water.

If laboratory tests indicate that a given chemical is seriously corrosive to a particular material of construction, a decision can usually be made to eliminate this material from further consideration. Favorable laboratory or field test data, on the other hand, are not positive assurances of good performance of a material in service, unless the data were developed under precisely the same circumstances that will be encountered. Even conditions as seemingly similar as two different petroleum refineries belonging to the same oil company and using the same basic processes find differences in performance of materials traceable to differences in local conditions; for example, different source of crude, different mixtures of crudes, or different pretreatment because of different end products (lube oil, asphalt, fuel oil, etc.).

In another example, the use of aluminum heat exchanger tubes and shells was considered for the ammonia (NH₃) recovery condensers in a soda-ash plant. This is a standard aluminum application in many plants of this type. To verify suitability, sheet specimens of aluminum alloys were carefully mounted in the existing cast iron shells using brackets coated with electrical insulating material to avoid dissimilar metal attack.

After six months of exposure, examination of the specimens showed no discernable attack. Because this evidence seemed to confirm experience in other soda-ash plants, it was decided to build these larger, water-cooled condensers of aluminum alloys.

One week after being placed in service, the plant had to be shut down because the new condensers had failed. Although the walls of the condensers were unaffected by corrosion, the tubes were completely perforated from the condensate side (exterior).

The evaluation tests using aluminum coupons had not taken into account the influence of heat transfer on corrosion behavior. Unfortunately, the specimens had accurately simulated only the sidewall conditions. Further, in this particular plant, the ratio of carbon dioxide (CO₂) to NH₃ in the moist gaseous stream was lower than was customary in other soda-ash plants; consequently, the inhibiting effect of CO₂ was incomplete. This illustrates the importance of local situations that can complicate the task of material selection.

This article is adapted by MP Editorial Advisory Board Member Norm Moriber from Corrosion Basics—An Introduction, Second Edition, Pierre R. Roberge, ed. (Houston, TX: NACE International, 2006), pp. 559-561. MP