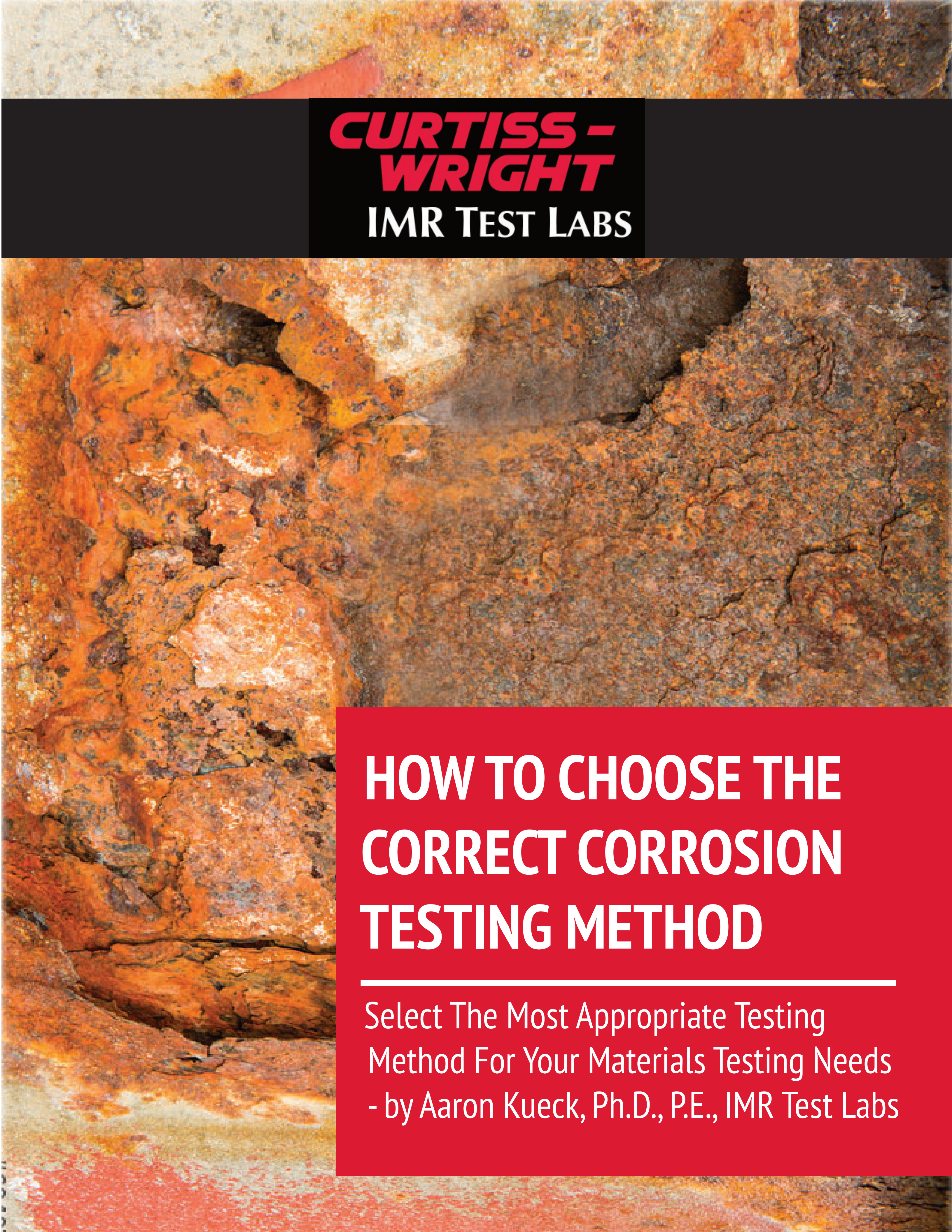

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HOW TO CHOOSE THE CORRECT CORROSION TESTING METHOD

Select The Most Appropriate Testing Method For Your Materials Testing Needs

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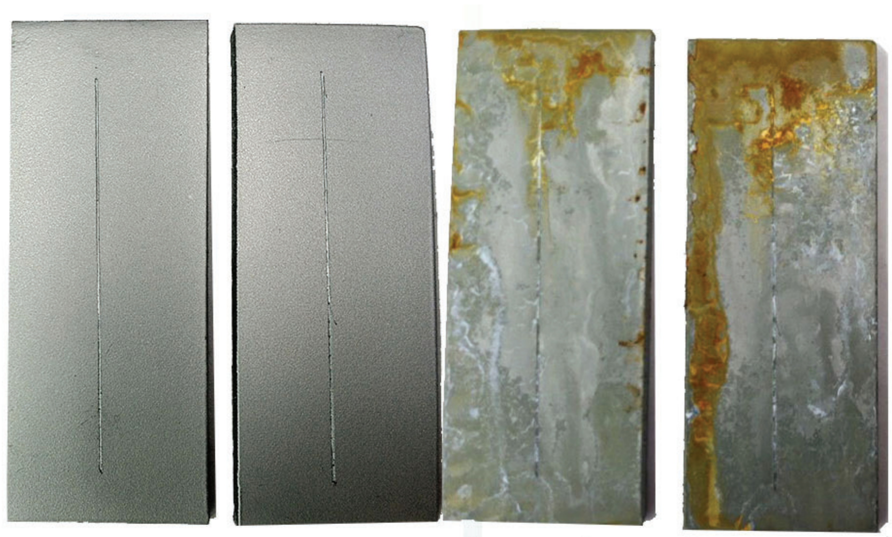
When designing a metal component, engineers have to consider how susceptible certain alloys are to corrosion in the final product's operating environment. In a recent study by NACE (National Association of Corrosion Engineers), it was estimated that the direct and indirect costs of corrosion in the United States is approximately 6.2% of the GDP. In 2016, that cost exceeded $1 trillion dollars for the first time.

While a range of corrosion types can affect your operation's metal components, the specific varieties that pose a risk to your parts are dictated by your particular application and the corrosive threats within your operation.



TYPES OF CORROSION

- **Uniform or General Corrosion**

While this type of corrosion is the most common, it is also the most preventable. Uniform corrosion occurs when widespread exposure to weather, chemicals, or other elements causes corrosion across the entirety of an exposed metal surface. The rate of corrosion is an important factor in selecting materials, but on occasion a manufacturer expects corrosion levels to be tolerable as opposed to preventable.

- ## High-Temperature Corrosion

Exposure to corrosive substances at high temperature in machines that experience combustion – furnaces or engines, for example – causes corrosion in specific types of metals that would normally be considered corrosion resistant.

- ## Local Corrosion

Local corrosion occurs in a specific area of the metal where corrosion protection fails or is improperly applied – such as a crevice or hole – and threatens the integrity of the entire metal surface. This type of corrosion is sometimes difficult to detect until a component fails, making it especially dangerous. "Pitting" can occur even without an application failure of corrosion protectants. Its somewhat random and nonlinear corrosion patterns make it a very dangerous affectation, especially for alloys like 300 series stainless steel.

- ## Alloy Corrosion

When corrosive elements target one component of an alloy, it is referred to as de-alloying. Alloys are created to provide specific properties and corroding one portion of the material destabilizes the entire metal component.

- ## Galvanic Corrosion

When two distinct types of metal come into contact, one will act as the cathode while the other acts as the anode. This electrochemical reaction causes the anodic metal to corrode faster than normal.

- **Environmentally Assisted Cracking (EAC)**

Includes stress corrosion cracking (SCC), caustic cracking, environmental stress cracking (ESC), hydrogen cracking, and other subtypes of stress-environment interactions. Corrosion can occur due to a wide variety of environmental factors during original machining processes and exposure during operation. Stress, chemical exposure, pressure, vibrations, welding, machining, and a long list of other factors can interact with service environments and cause or accelerate problematic cracking and damage.

- **Flow-Assisted Corrosion or Erosion-Corrosion**

When surface protection (sometimes including protective scale) is eroded away by the flow of water or air, fresh metal becomes exposed to environmental factors and begins to corrode. Corrosion products are often less wear resistant, leading to increased erosion. This cycle is self-propagating and can rapidly degrade components.

- **Fretting Corrosion**

Most common in industrial machine components that experience intense and repeatable operation, fretting happens when surfaces wear down from constant friction caused by vibrations or rubbing.

Corrosion risks can be largely mitigated through proper raw material and protective coating testing before incorporating them into your product's design and manufacturing processes. Testing laboratories can simulate most adverse conditions in your operational environment to see how various metals and coatings stand up to chemical exposure, environmental threats, stress, and more.

CORROSION CONSIDERATIONS

Some of the factors manufacturers must take into account when designing a component for production:
– material selection (choosing materials for improved corrosion control)
– corrosion allowance (increasing wall thickness to compensate for loss)
– protection technologies (including coatings, paints, sealants)
– corrosion prevention (application costs incl. labor, equipment, etc.)

The post-production costs of corrosion control include:
– corrosion-related inspection
– corrosion-related maintenance
– repairs that are required due to corrosion
– replacement of corroded parts found during inspections
– inventory and maintenance of backup components
– rehabilitation and refurbishment
– loss of productive time for operation

Corrosion's detrimental impact on a metal component's surface structure and functional integrity can often be mitigated by the application of coatings that are formulated to protect the metal's surface from corrosive elements. Coatings can also modify characteristics of the base metal by adding hardness, thermal resistance and increased durability.

Minimizing the direct and indirect costs of corrosion can be achieved by screening candidate materials through appropriate methods of corrosion testing. Depending on the component's application, there are two reliable, commonly used analytical methods that produces relevant data on corrosion resistance: Accelerated Weathering and Electrochemical Corrosion testing.

ACCELERATED WEATHERING CORROSION TESTING

Corrosion testing enables engineers to estimate component service life, compare candidate materials in your service environment, and screen materials for their suitability. Accelerated weathering testing also provides quality control by ensuring that your metal enhancement processes, such as coatings, anodizing and electroplating, are being applied in compliance with manufacturer specifications. If you're an OEM vendor, they usually require your test results are consistent with their standards before accepting your shipment.

Applications of Accelerated Weathering Corrosion Testing

- Analysis of finished products for pitting and crevice corrosion susceptibility
- Comparison of raw materials (screening) for corrosion characteristics
- Evaluating/comparing exposure effects on corrosion properties
- Evaluating bimetal combinations for galvanic corrosion behavior

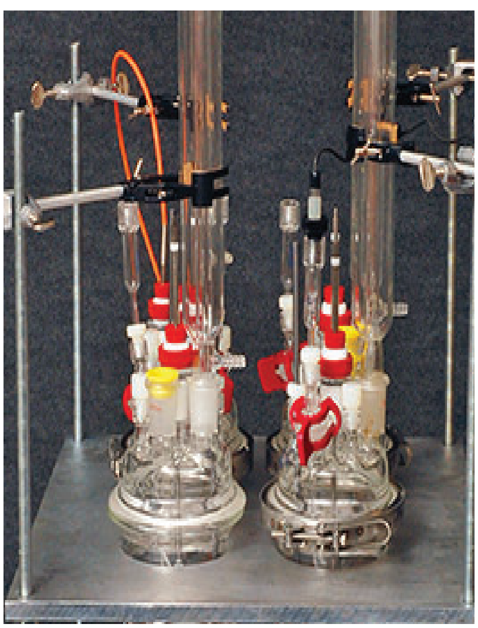
ELECTROCHEMICAL CORROSION EVALUATION

For service environments where standard pass/fail exposure testing is insufficient, electrochemical corrosion testing offers a more advanced analysis. Testing is performed through a controlled electrochemical reaction between two materials, or between an exposed surface and its surrounding environment.

The introduction of voltage or a current to the testing setup rapidly accelerates the effect of the aqueous solution on the material. Therefore, targeted electrolyte solutions can be used to simulate long-term conditions and predict and characterize the corrosive properties of metal materials and components.

Because the method greatly accelerates corrosions effects on the sample, it's particularly useful for gaining a quicker turnaround of results. This can produce a cost savings, as well as significant reductions in materials evaluation time.

Applications of Electrochemical Corrosion Testing



- Evaluation of finished medical devices for pitting, crevices, and corrosion susceptibility
- Comparison of raw materials (screening) for corrosion characteristics
- Evaluating passivation effects or surface modifications on corrosive behavior
- Evaluating/comparing processing effects on corrosion properties
- Evaluating bimetal combinations for galvanic corrosion behavior

CORROSION TESTING SERVICES BY INDUSTRY

Corrosion testing, used throughout many industries to ensure that the raw materials employed will perform safely with a long service life, is often heavily relied upon in applications related to:

- **Aerospace**

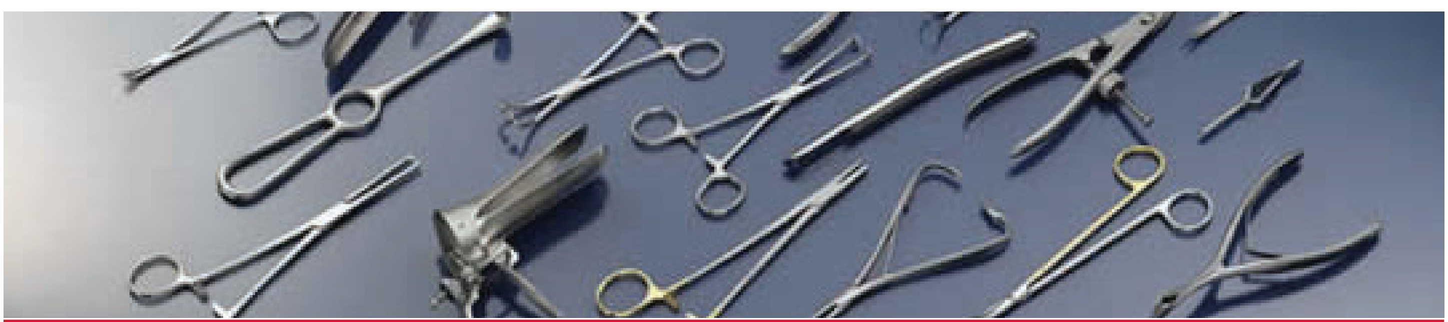
The aerospace sector requires corrosion testing to ensure that aircraft components remain reliable throughout their expected service life. Environmental simulations of temperature, humidity, and corrosive atmospheres help engineers guarantee durability and safety in the equipment they manufacture.

- **Automotive**

Automotive parts must withstand temperature extremes, inclement weather, deicing compounds, impact by hard materials, and exposure to fuel, oil, and other chemicals. Components for automobiles undergo extensive testing to ensure resilient functionality in a variety of adverse conditions.

- **Medical**

Given the high reliability standards of the medical sector, there is zero room for error on medical devices and equipment. Materials used to build this equipment must withstand harsh disinfectants, biological elements, and other corrosive risks. Implants must resist attack by substances within the body. Electrochemical potential studies are often used to assess the likelihood that devices may fail due to unexpected corrosion.



- ## Pipeline Integrity

In 2017, the Pipeline and Hazardous Materials Safety Administration (PHMSA) issued a final rule that mandates several preventative and documentation processes designed to standardize the measurement, testing and assessment of pipeline inspection procedures.

Line inspections look for dents, metal loss, significant stress corrosion cracking (SCC) and metal loss defect with predicted failure of less than 1.1 times maximum operating pressure.

Operators are required to submit annual safety-related condition and incident reports.

- ## Other Industries

While the aerospace, automotive, and medical fields may be the most dependent on corrosion testing, other industries such as energy, industrial processes, marine, and defense also rely on such testing to ensure their equipment operates reliably when exposed to environments that may be hazardous, vary in temperature, or include frequent exposure to salt water, sand, dust, chemicals, or other corrosive elements.

HOW IMR CAN HELP

At IMR Test Labs, our highly trained staff of chemists, engineers, PhDs, and lab technicians have conducted hundreds of material analyses where the potential for any of the many varying types of corrosion was present. In addition to electrochemical corrosion testing capabilities, we possess the equipment and expertise to simulate most corrosive environments using a comprehensive array of aqueous and accelerated weathering methods, such as:

- Salt spray testing
- Cyclic corrosion
- Humidity exposure
- Exposure testing

ABOUT US

We're an ndependent, accredited lab offering a complete scope of materials testing services, including chemical analysis, cleanliness testing, corrosion testing, mechanical testing, metallurgical analysis, fatigue testing and more.

We have five facilities, located in Ithaca, NY; Louisville, KY; Portland, OR; Singapore and Suzhou, CN. IMR demonstrates an on-going commitment to serve our clients' analytical needs, wherever they may be.

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