

## Create Safe Operating Environments & Control Risks

Normal operations in a plant or facility can expose process equipment to corrosive environments, high temperatures, or cyclic operating conditions. Over time, these factors can lead to significant operational and maintenance costs. By proactively evaluating susceptibility to damage like metal loss and cracking, you'll identify the potential risk for creep, fatigue, general pitting/corrosion, stress corrosion cracking, brittle fracture, and many other damage mechanisms.

At E<sup>2</sup>G | The Equity Engineering Group, Inc., our team of metallurgy and corrosion experts leverage practical design, operation, and inspection considerations to maximize reliability and reduce maintenance costs for process equipment, including pressure vessels, tanks, heat exchangers, and piping. We combine our extensive experience with state-of-the-art technology to create safe operating environments while also guiding equipment design, material selection, inspection strategies, weld repair techniques, and process optimization.



**IMPROVE SAFETY AND RELIABILITY**



**DEVELOP INSPECTION PLANS**



**AVOID COSTLY EQUIPMENT DOWNTIME**



**IDENTIFY AREAS OF VULNERABILITY**



### PROACTIVE SERVICES

#### MATERIALS SELECTION & DAMAGE MECHANISMS ASSESSMENTS

Combined with Fitness-for-Service (FFS) and Risk-Based Inspection (RBI), identifying damage mechanisms helps predict an equipment's remaining life and potential risk for failure. During a Damage Mechanism Review (DMR), we work with you to identify active and potential damage mechanisms and use that data to identify plant or equipment-specific Integrity Operating Windows (IOWs) and create a long-term plan using Corrosion Control Documents (CCDs).

#### CORROSION CONTROL DOCUMENTS (CCDs) & INTEGRITY OPERATING WINDOWS (IOWs)

We develop thorough CCDs and customized limits for each process unit by analyzing the equipment's specific operation, stream chemistry, and metallurgy to minimize the likelihood of damage. CCDs document the specifics of managing the degradation of a unit for operations, technical, inspection, and integrity personnel. IOWs provide a recommended response or monitoring action when process units exceed the established operational limits. Our team follows a streamlined process that integrates API 970 and API 584 guidelines to develop your site-specific documentation.

#### BIOFUELS & RENEWABLE FUELS DAMAGE REVIEWS

The major damage mechanisms that affect sections of renewables processing and biodiesel units are very similar to petroleum refining. We consider feedstock source changes and identify the effect on damage mechanism susceptibility. During a DMR, we work with you to identify active and potential damage mechanisms and use that data to calculate the impacts on corrosion. We leverage our expertise in renewable fuels with our extensive knowledge of traditional refineries, petrochemical, chemical process, and ethanol production industries to provide optimal solutions.



### TECHNOLOGY BEST PRACTICES

#### HIGH-TEMPERATURE HYDROGEN ATTACK (HTHA)

HTHA is the progressive degradation of carbon and low-alloy steels exposed to hydrogen at elevated temperatures. Accurately predicting HTHA has proven to be one of the most elusive industry challenges. As leaders of the longest-running HTHA Joint Industry Project (JIP), we combine FFS rules with mechanistic damage modeling to estimate remaining life and develop practical inspection recommendations to help you make run, repair, or replace decisions.

#### HIGH-TEMPERATURE CREEP

Guide and optimize your equipment replacement timelines by determining current creep damage and accurately estimating remaining life. We combine our knowledge and experience with E<sup>2</sup>G's extensive database of high-temperature material properties for many alloys. We also routinely perform Omega creep tests on ex-service tube, plate, or pipe samples and provide accurate remaining life assessments based on test data. Our team specializes in fired heater tube analysis and considers heater-specific operating histories, material properties, and service environment.

#### IN-SERVICE WELDING & SPECIALITY WELDING GUIDANCE

In-service welding may be required when repairs or modifications are needed on operating piping and equipment. In-service welding can include addition of external sleeves or weld build-up (repairs) or installation of nozzles, tie-ins to existing lines, stopples and bypasses, or extraction of sample coupons (hot taps). However, if fluid dynamics aren't properly understood, the result can be catastrophic. We perform detailed in-service welding, or hot tap assessments, to provide optimized welding parameters that address the risks of burn-through, fluid decomposition, unintended chemical reactions, and delayed weld cracking. We help operating companies and service providers justify in-service welding in scenarios where the practice normally may not be allowed (high flows or stagnant lines, special services, etc.). We provide practical recommendations for local post-weld heat treatment (PWHT) layouts and heating parameters to mitigate the risk for weld cracking or distortion due to severe metal temperature gradients. Our team will review current company welding procedures and provide general repair guidance that complies with industry standards.



### REACTIVE SUPPORT

#### FAILURE ANALYSIS AND METALLURGICAL LAB INVESTIGATIONS

Unfortunately, equipment failures do happen, and unanticipated damage (corrosion, cracking) can occur. Fast, practical decision-making is needed for decisions of repair or FFS. Learning from these incidents is key to continuous improvements. With access to state-of-the-art analytical laboratory equipment for metallography/metallurgy, mechanical, and corrosion testing, E<sup>2</sup>G provides answers to understand the cause(s) of failures or damage. Every E<sup>2</sup>G failure analysis project includes a damage mechanism review and materials & corrosion engineering assessment to extract practical recommendations and mitigation strategies from the lab results. Where necessary, our resources are available to provide results, in as little as a week or even in some cases as quickly as next-day.

#### FIRE DAMAGE & ON-SITE INCIDENT SUPPORT

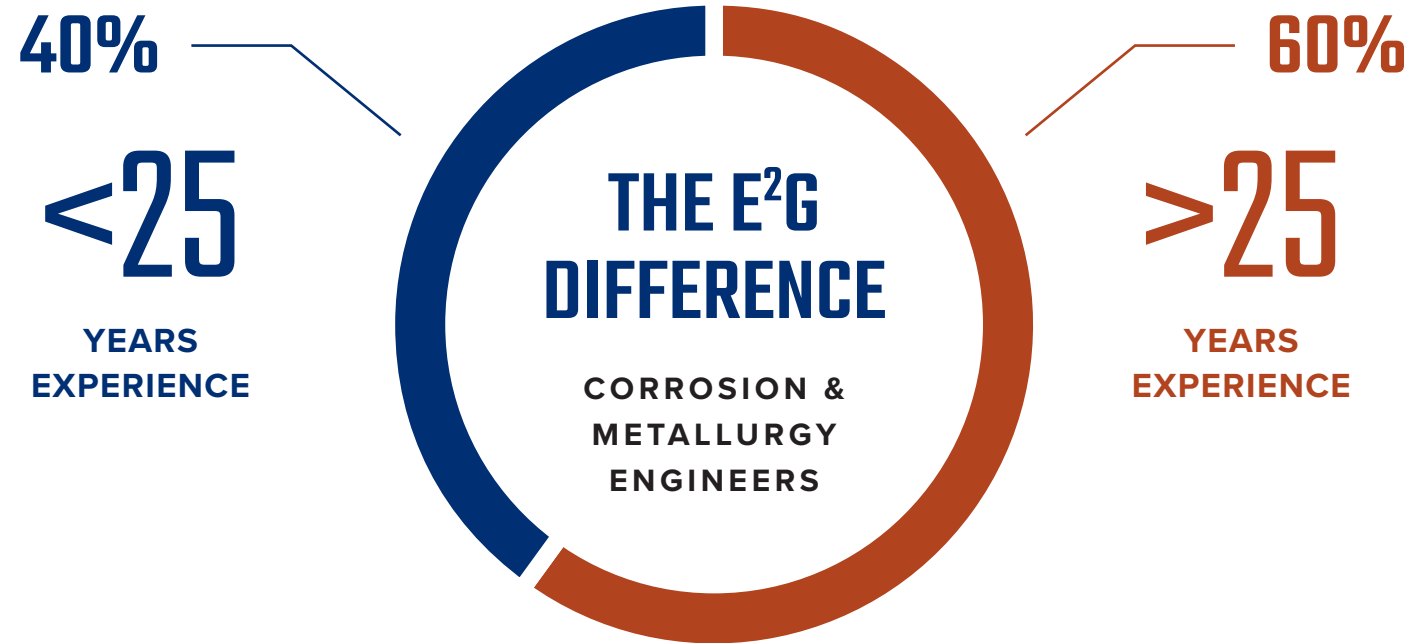
E<sup>2</sup>G's experts can be at most facilities the very next day after you contact us. We coordinate resources for inspection (replications, hardness, cracking inspections, etc.) to provide a turn-key API 579 Part 11 Fire Damage Assessment. We provide immediate support to investigate the causes and timelines of failures, incidents, or fires. We identify all equipment and piping affected by a fire or incident and provide clear "next steps" to be performed to return the equipment safely to service. We can facilitate incident or failure investigations using a formal root cause failure analysis (RCFA) or API 585 protocol if desired. Our team is available 24/7 for immediate/emergency support.

**IMMEDIATE OR EMERGENCY SUPPORT**

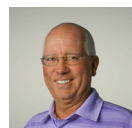
**Phillip E. Prueter, P.E.**

**PPrueter@E2G.com | 216.658.4767**

# Materials & Corrosion



## OUR METALLURGY & CORROSION EXPERTS



Kenneth K. Kirkham, P.E.  
**42** YRS EXP



Renée L. Downie  
**30** YRS EXP



Nathaniel G. Sutton, P.E.  
**8** YRS EXP



Richard J. Gaugler  
**41** YRS EXP



Anelsy Mayorga-Baker  
**27** YRS EXP



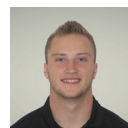
Paul J. Kowalski  
**7** YRS EXP



Brian L. Jack  
**40** YRS EXP



Phillip E. Prueter, P.E.  
**13** YRS EXP



Lucas A. Baldesberger  
**3** YRS EXP



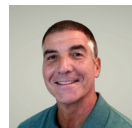
Kirk C. Baker  
**35** YRS EXP



Chris Aguayo  
**12** YRS EXP



Raj K. Patadia, E.I.T.  
**3** YRS EXP



Charles D. Buscemi  
**34** YRS EXP



Thomas Calko, P.E.  
**9** YRS EXP



Mindy Wu  
**2** YRS EXP



Positive experience, accountable, prompt, and inspires confidence in their field of expertise. Thank you for the quality service you provide.”

*Failure Analysis & Weld Procedures, February 2023*

- ▶ PIONEERED DEVELOPMENT OF **FFS & RBI**
- ▶ AUTHORED APPENDIX F OF **API 579-1/ASME FFS-1**
- ▶ LEADERS OF LONGEST RUNNING **HTHA JOINT INDUSTRY PROJECT (JIP)**
- ▶ EMERGENCY ON-SITE SUPPORT WITHIN **24 HOURS**