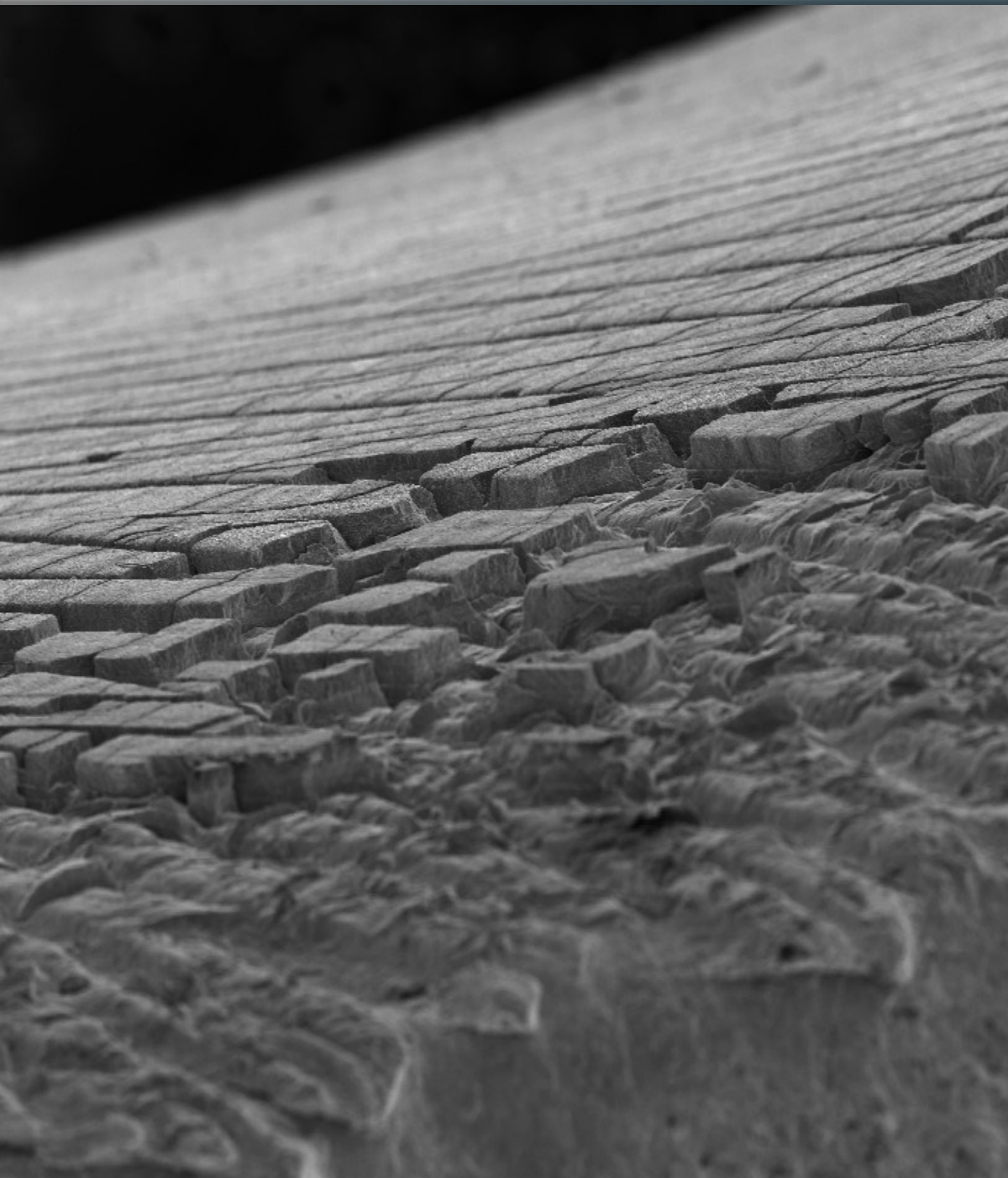
Summer 2018

The Metal Never Lies

the CONDUIT



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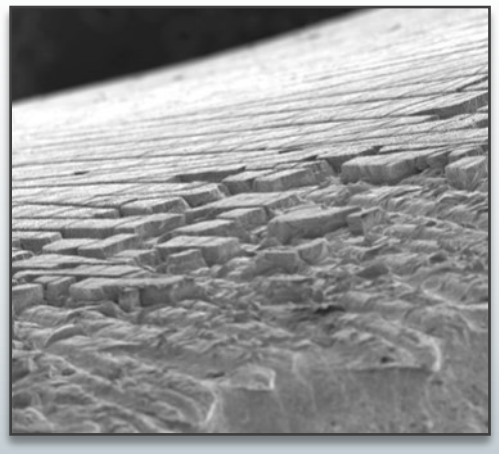
VOL 18, NO 2

COVER PHOTO



Crazed Oxide:

High-cycle thermal fatigue frequently results from intermittent wetting of a hot surface by liquid having a considerably lower temperature. In such instances, the wetted surface contracts rapidly, whereas the metal below the surface does not; this produces large biaxial tensile stresses in the wetted surface. As the water absorbs heat and evaporates, the temperature of the surface returns to its previous value, and surface stresses are relaxed. After a sufficient number of thermal cycles, a crazed pattern of cracks appears on the surface. Eventually, one or more of the surface thermal fatigue cracks may propagate completely through the section by fatigue or by another mechanism[1].

[1]*Metals Handbook, Ninth Edition, Volume 11, Failure Analysis & Prevention*

ABOUT the *CONDUIT*

For technical information please contact:

David Daniels
(512) 407-3752
david_daniels@mmengineering.com

Mark Tanner, P.E.
(512) 407-3777
mark_tanner@mmengineering.com

Karen Fuentes, P.E.
(512) 407-3778
karen_fuentes@mmengineering.com

We hope you enjoy reading **the *Conduit*,** our quarterly newsletter offering technical information, insight, and case studies.

In The News

Catherine A. Noble, P.E., Senior Consulting Engineer for M&M Engineering Associates, has relocated to the Seattle area as of June 1st. If you are in the Pacific Northwest and need timely engineering assistance, a site visit can be arranged. Her contact information is the same: (512) 407-3771, Catherine_noble@mmengineering.com. Please contact her if you have any failure analysis, material assessment, on-site engineering evaluation, or litigation needs.

Contact Fran Pimentel
Telephone 780.405.3223
Email fpimentel@acuren.com
Website www.acuren.com

FOR IMMEDIATE RELEASE
July 4, 2018

Acuren, Inc. Acquires Skystone International

Acquisition brings specialized engineering and asset integrity capabilities to the pipeline and pressure equipment industries.

Edmonton, AB, July 4, 2018 – Acuren Inc., the global provider of nondestructive testing (NDT), inspection and related services, is pleased to announce the acquisition of Calgary-based Skystone International. With a focus on pipelines and pressure equipment, core segments of Acuren for over 40 years, the addition of Skystone deepens Acuren's engineering and technology-enabled asset integrity capabilities, and adds new services such as cathodic protection and emergency management. The entire management team at Skystone will join Acuren and continue leading the Skystone operation.

"I am excited to welcome the entire Skystone team to Acuren." states Talman Pizzey, COO of Acuren Canada. " Skystone is a well-respected service provider with talented professionals who have significant industry experience and technical competence. The addition of Skystone aligns with Acuren's mission of being a trusted partner that clearly reduces clients' cost to operate, while providing exceptional service. Acuren and Skystone clients will benefit from new, complementary, and scaled service offerings. I am also excited about the additional growth and career opportunities for our collective employees."

Hal Hamilton, President and CEO for Skystone states "On behalf of the Skystone team, we are proud and pleased to become part of the Acuren organization. We believe our combined service offering will greatly improve the breadth of services we can offer our clients, and the size and type of projects we can pursue. Other major considerations for us in making the decision was creating new opportunities for our staff, and ensuring the cultures are compatible. We truly feel this will be the case."

Acuren provides state-of-the-art nondestructive testing, inspection, engineering and rope access enabled industrial services delivered through over 80 locations and over 4,000 employees throughout North America and the United Kingdom. Committed to delivering a higher level of reliability, Acuren provides an unrivaled spectrum of services to support the safe operation of industrial assets. Services include conventional and advanced nondestructive testing and examination (NDT & NDE), inspection, engineering, rope access enabled services (industrial services and NDT), and condition based monitoring services to many of the world's largest industrial clients in the harshest environments.

Acuren Group, Inc.
Fran Pimentel
Vice President, Western Region
780.405.3223 / fpimentel@acuren.com

Skystone International
Hal Hamilton
President & CEO
403.630.4594 / hhamilton@skystone.ca

UNDERSTANDING AND PREVENTING FAILURES IN INDUSTRIAL POWER & STEAM GENERATING EQUIPMENT

AUGUST 14-15, 2018

TWO WEEKS REMAIN—Seating Limited!

Click the ticket and REGISTER TODAY!

Now in our seventh year, the M&M Engineering workshop previously known as "Preventing Failures in Steam Generating Equipment" is geared towards producers of steam, be it used in power or process applications. This two day workshop focuses on the issues most common in steam generating systems and is applicable to many industries including: power generation, refining, petro-chemical, pulp and paper, and industrial insurers. Our workshop covers the following topics:

- Equipment Associated with Steam Generation – A Primer
- Utility Feedwater Heaters and Damage Mechanisms
- Steam-Touched Boiler Tube Failure Mechanisms
- Water-Touched Boiler Tube Failure Mechanisms
- Introduction to Failure Analysis
- Introduction to Nondestructive Testing & Inspection Contracting
- Damage Mechanisms in Deaerators
- High Energy Piping: Damage Mechanisms and Corrections
- Failure Investigation Principles for Combustion Turbines
- Basic Steam Turbine Failures
- Condenser and Cooling Water Failures
- Water and Steam Chemistry-Influenced Failures in the Steam Cycle

Registration for this two-day event is $800 (continental breakfast and lunch included). The deadline for registration is August 1, 2018.

This event will be held at M&M Engineering Associates' headquarters located at 1815 S. Highway 183 in Leander, Texas 78641, just north of Austin.
Click the photo of our facility for a map of our location.

For more information, contact Lalena Kelly at Lalena_Kelly@mmengineering.com, or (512) 407-3775.

Case Study

Why is My New Stainless Clarifier Rusting?

Karen T. Fuentes, P.E., Senior Principal Engineer

A municipal utility was constructing a new water treatment facility (Figure 1). In the course of the construction of the clarifiers, they were filled with water and emptied a number of times. In one case, the water was in the clarifier for three weeks. When the clarifiers were empty, various stains and other signs of apparent corrosion were identified by the construction firm and municipal inspectors. Reportedly, inspections of the clarifiers were performed according to ASTM 380 and ASTM 967 specifications. The stains on the surface of the stainless steel were suspected to be active corrosion of the base metal, which meant that the clarifiers would not pass inspection. The project contractors spent several months attempting to clean and treat these stains, passivating the areas chemically and washing the areas with high pressure water. However, the stains continued to be observed shortly after cleaning.

M&M Engineering was contacted and asked to inspect the clarifiers, determine the cause of the apparent corrosion of the stainless steel, and provide recommendations for mitigating it.

M&M Engineering found that the majority of staining was superficial.

- The spots on the stainless steel were particles of iron that had settled and adhered to the surface of

Figure 1. Photograph shows the interior of a clarifier tank.

(Continued on page 6)

(Continued from page 5)

the stainless steel. These iron particles were actively corroding and causing visual stains on the surface of the stainless steel.

The location is shown untouched (Figure 2-left image) and after abrasive cleaning (Figure 2-right image).

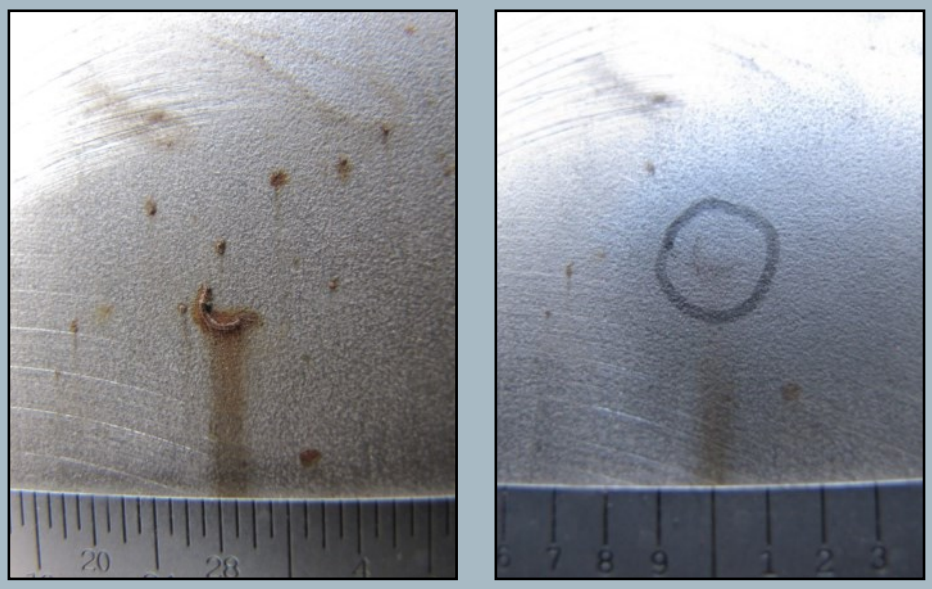


Figure 2. Photograph shows spots on the stainless steel were particles of iron that had settled and adhered to the surface. These iron particles were actively corroding and causing visual stains on the surface of the stainless steel.

- The stainless steel below the stains was not affected by the corrosion of the iron particles. The passive oxide layer was intact in every case. The stainless steel was not corroding.
- Other stains were caused by dirt and the organic matter in the water that was used to fill the clarifier.

Through the course of the investigation, corrective actions were recommended by M&M Engineering to address other areas of concern including:

- Some welds that were submerged in the water had areas of slag along the toe of the weld that were causing staining, but the weld itself was not compromised (Figure 3).
- Some rough spots caused by grinding needed to be smoothed to prevent an opportunity for crevice attack.
- The absence of seal welds presented the opportunity for crevice corrosion that was eliminated by adding seal welds.

M&M Engineering worked with the contractor who satisfactorily addressed all concerns and implemented all recommendations. All stainless steel in the clarifiers was found to be suitable for commissioning activities, startup, and operations.

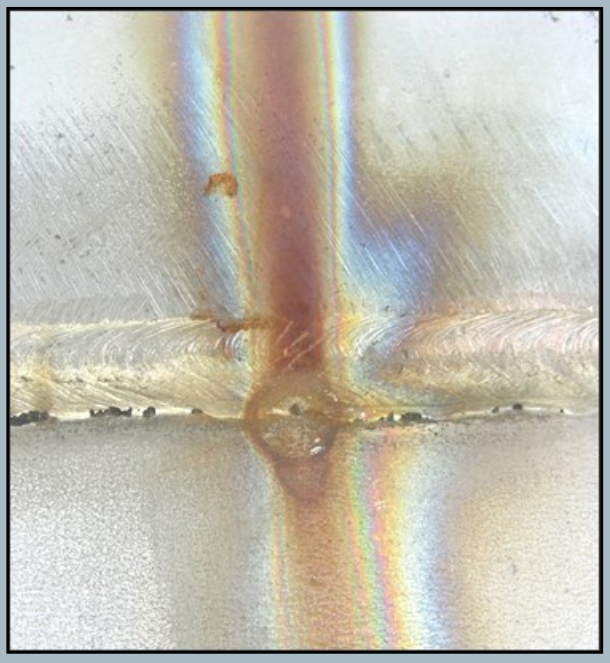
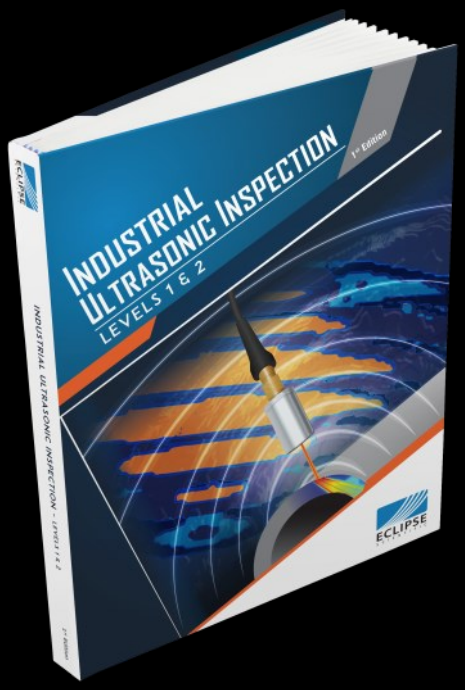


Figure 3. Photograph shows a weld that was submerged in the water where areas of slag along the toe of the weld were causing staining. The weld itself was not compromised.

If you have similar issues, please be sure to contact M&M Engineering Associates

Industrial Ultrasonic Inspection Levels 1 & 2 — First Edition

Author: Ryan Chaplin
ISBN: 978-1-4602-9567-0 *(Hardcover)*
ISBN: 978-1-4602-9568-7 *(Softcover)*
Hardcover and Softcover, Full Color, 277 Pages



Hardcover: $118.99 USD

Ultrasonic testing (UT) has been an accepted practice of inspection in industrial environments for decades. Our new textbook, titled Industrial Ultrasonic Inspection Levels 1 & 2, is designed to meet and exceed ISO 9712 training requirements for Level 1 and 2 certification. The material presented in this book will provide readers with all the basic knowledge of the theory behind elastic wave propagation and its uses through easy to read text and clear pictorial descriptors.

Discussed UT concepts include:

- General engineering, materials, and components theory
- Theory of sound waves and their propagation
- The general uses of ultrasonic waves
- Methods of ultrasonic wave generation
- Different ultrasonic inspection techniques
- Ultrasonic flaw detectors, scanning systems, and probes
- Calibration fundamentals
- General scanning techniques
- Flaw sizing techniques
- Basic analysis principles for ultrasonic, phased array ultrasonic, and time of flight diffraction inspection techniques
- Codes and standards
- Principles of technical documentation and reporting

It is the author's intention that this book is used for general training purposes and is the ideal classroom textbook.

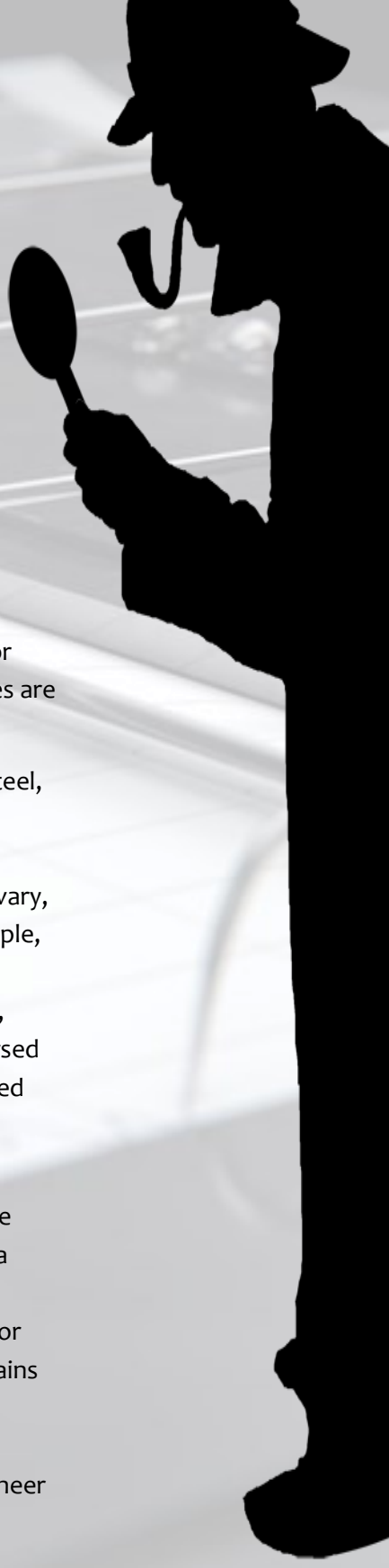
Softcover: $94.99 USD

For more information visit the Eclipse Scientific textbooks page at www.eclipsescientific.com/books.html

The Metal Doesn't Lie

Part 2 of 3: Metallography

G. Mark Tanner, P.E., Senior Principal Engineer



At M&M Engineering, we often tell clients that the metal doesn't lie. If we can metallurgically examine the part, it will tell us a wealth of information. It will tell us what the mode of failure was as well as what happened in the past (manufacturing and operation) that could have affected it. There are numerous parts to a metallurgical investigation, but it can be divided into three primary categories: fractographic, metallographic, and mechanical/chemical. For the first part in this 3-part series, we discussed fractography. This time we will take a look at metallography.

Metallography is the examination of a metal component's microstructure. Microstructure is the grain structure of a metal or alloy on a microscopic scale. Examination of a metal's microstructure is done by sectioning a small piece from the metal component, mounting it in a metallurgical media, and grinding the sample with finer and finer grits of sand paper. The sample is then polished using diamond media to create a polished mirror finish on the sample. The sample is etched with a chemical solution to bring out distinctive features of the alloy's microstructure. After the sample preparation is complete, it is then examined using a metallurgical microscope at magnifications typically ranging from 50X to 1000X.

Examination of the prepared sample can help determine if the component has the following features: the proper shape and size of microstructure, inclusion content and distribution, thermal degradation by operating temperatures (short or long-term), if it has been affected by various corrosion mechanisms (cracking or wastage), if it has been affected by operating environment (carburization, hydrogen damage, hydrogen cracking, oxidation, and sulfidation), plastic deformation, or if welds have porosity or lack of fusion and how many weld passes are present.

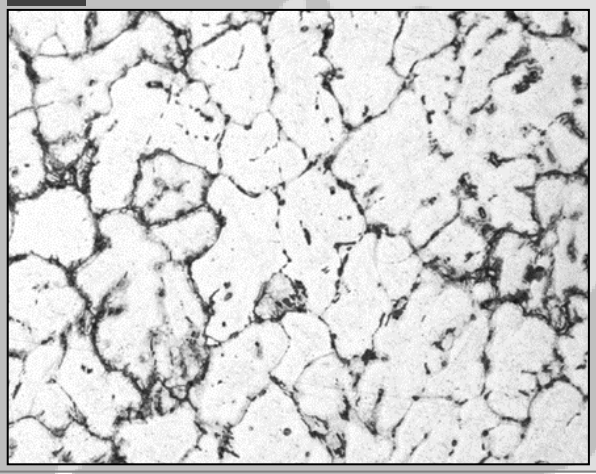
Based on the metal alloy (e.g., carbon steel, low alloy steel, stainless steel, nickel, aluminum, copper, titanium, etc.), the important microstructural features will vary, especially the primary matrix. For example, low carbon steel typically consists of colonies of pearlite in a matrix of ferrite, while a low alloy steel could have dispersed carbides in a matrix of ferrite or tempered martensite.

In addition, to the general material condition, damage or failures can also be examined. If a component has a crack, a cross-section of the crack will allow the engineer to see if the crack is branched or not, and whether it runs through the grains (transgranular) or around the grains (intergranular). The morphology of the cracks in specific alloys will help an engineer identify the cracking mechanism. A branched, transgranular crack in an austenitic stainless steel is likely stress corrosion cracking from chlorides, while a branched intergranular crack would be from caustic induced stress corrosion cracking. Thus, the experience of the engineer as well as their access to metallographic literature

(books and articles) is very important.

Now that we have explained some metallography basics, let's examine some photomicrographs taken with a metallurgical microscope at high magnifications that allow us to see the fine metallographic features of various metals. Here are six examples of microstructures. Can you guess the alloy? Your choices are low alloy steel, nickel alloy, aluminum alloy, duplex stainless steel, caustic and chloride induced stress corrosion cracking. The answers are on page 16.

1



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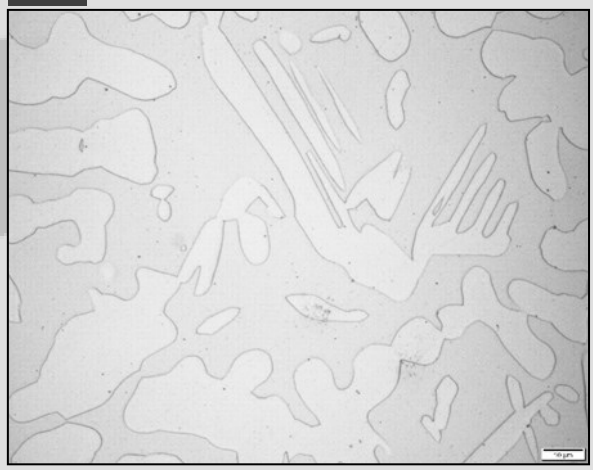

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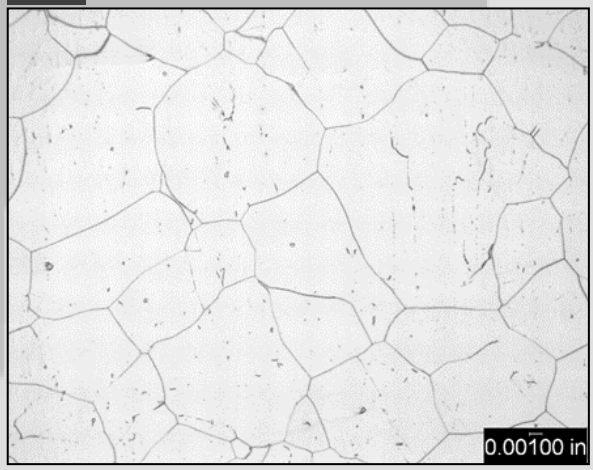

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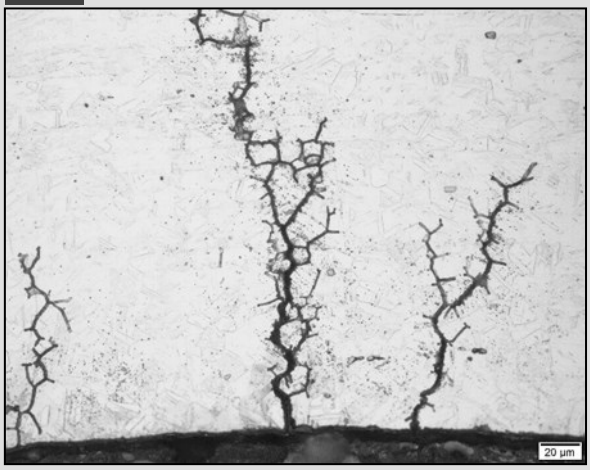

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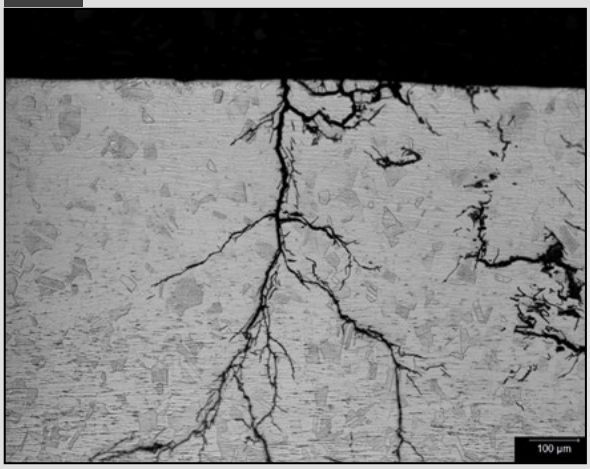

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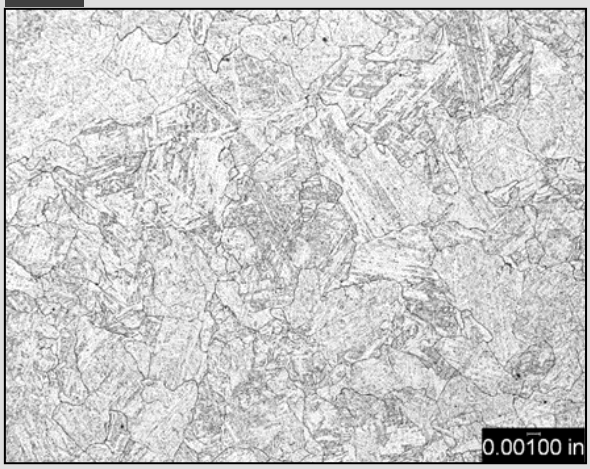
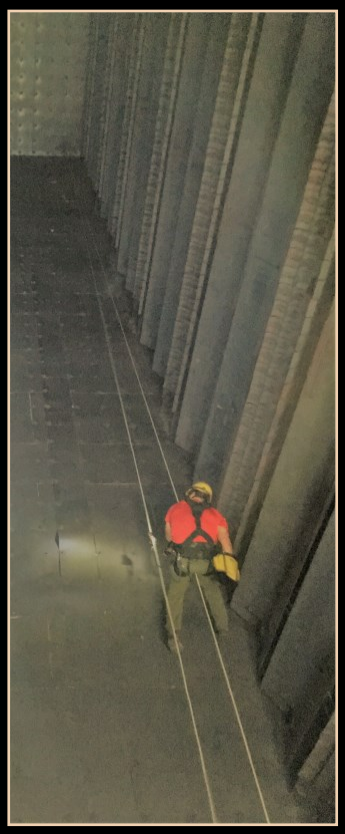


Employee Spotlight

Jonathan McFarlen, Consulting Engineer



Jon McFarlen started his career at M&M Engineering in 2002. Like most engineers, he was involved in the failure analysis of a wide range of components including piping, pressure vessels, boiler components, and rotating equipment. This gave him a large "vocabulary" of the various damage mechanisms that plague industrial equipment and subsequently led to larger field investigations, root cause analyses, and condition assessments.

Prior to joining M&M Engineering, Jon worked as a government defense subcontractor performing detailed finite element analysis (FEA) of rocket components. With this background, performing Piping Stress Analysis on High-Energy Piping (HEP) systems was a natural segue along with hanger inspections and development of a Risk-Based methodology to prioritized inspection locations. Eventually, clients asked Jon to project manage post analysis inspections that afforded the opportunity to learn more about non-destructive testing (NDT) specific to HEP.

Currently Jon serves as a project manager for M&M Engineering's HEP team and often conducts system walkdowns, hanger surveys, piping stress analysis, and recommending appropriate remediation methods including recommendations for non-destructive testing (NDT), hanger testing, hanger replacement, or the addition of pipe supports.

Recently, Jon completed his Level 1 Rope Access certification allowing him to expand his inspection offerings.

When not talking HEP, Jon enjoys smoking meat on his BBQ pit and riding local trails on his mountain bike.

Contact information:

Jonathan D. McFarlen, Consulting Engineer

Jon_McFarlen@mmengineering.com

Direct: (512) 407-3773

Fax: (512) 407-3766

UPCOMING EVENTS

ACUREN ECLIPSE WORLDSPEC M&M ENGINEERING HELLIER

Understanding and Preventing Failures in Industrial Power & Steam Generating Equipment

August 14-15, 2018

M&M Engineering—Leander, Texas

This two day workshop focuses on the issues most common in steam generating systems and is applicable to many industries including: power generation, refining, petro-chemical, pulp and paper, and industrial insurers.

ONLY TWO WEEKS LEFT!

Seating is very limited—

Click the ticket and REGISTER TODAY!

October 28-31, 2018

George R. Brown Convention Center—Houston, TX

Be sure to visit Acuren Inspection, Inc. and Eclipse Scientific in BOOTH 903 and 905, respectively.

November 4-8, 2018

Talking Stick Resort—Scottsdale, AZ

David G. Daniels, Principal Scientist with M&M Engineering Associates, will be presenting a paper at a workshop during the IWC event. Registration for this event Is now open.

November 27-29, 2018

Sheraton Seattle Hotel—Seattle, WA

NACE INTERNATIONAL WESTERN AREA CONFERENCE

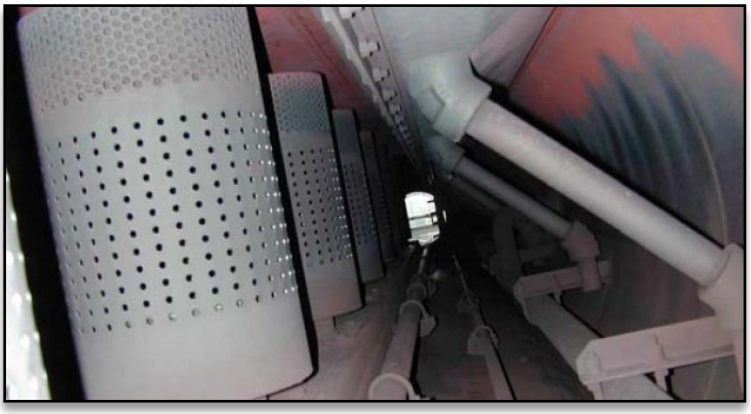
Catherine A. Noble, P.E., Senior Consulting Engineer with M&M Engineering Associates, will attend the NACE International Western Area Conference.

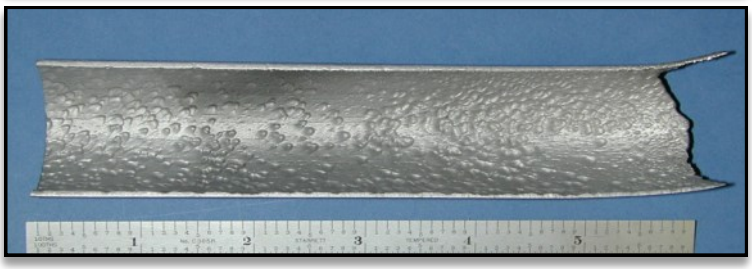
HRSG Condition Assessment

- **Gas Side and Water Side Inspections**
- **Visual Inspections, NDE and Metallurgical Analysis**
- **Rope Access for Inspections**
- **Water/Steam Chemistry Review and Troubleshooting**
- **Failure Investigations**

M&M Engineering Associates provides an experienced set of eyes to examine the health of the gas side and water side of your Heat Recovery Steam Generator (HRSG). We provide you with an independent assessment of the HRSG condition to assure you of reliable future operation whether you are an owner, operator, or insurer.

- We examine the gas side of duct burners, ductwork, tube banks, headers, the ammonia injection grid, and the support structure for signs of deterioration from corrosion, cracking, and wear.
- We examine the water side headers, steam drums, and risers for corrosion, cracking, FAC, or other damage mechanisms.
- We provide skilled nondestructive examination (NDE) technicians to provide a full condition assessment of your HRSG using the most advanced equipment and methods., including the use of Rope Access* (remote access technology) instead of scaffolding.
- When problems or failures occur, we provide on-site or in-laboratory metallurgical testing and engineering to get the unit back on line fast.





We Take a Closer Look

Gas path inspections from the floor are incomplete and using scaffolding or sky climbers to access upper components is costly both time-wise and financially. Utilizing rope access, we can inspect all of the gas path components up close , in person, for a fraction of the typical inspection cost. Don't assume that the lower burners look the same as the upper burners.

During the outage, our engineers, water chemists, and technicians provide recommendations for immediate repair, as well as focused testing and inspection strategies. Following our inspection, a detailed report of our findings will be provided electronically, in hard copy, or both. We can also recommend water treatment programs that will prevent waterside corrosion problems and provide recommendations for future repair, replacement, and inspection.

Water Chemistry is Critical

While HRSGs typically lack the heat flux of a standard fossil-fired unit, they are by no means problem-free when it comes to chemistry-related corrosion. In fact, experience has shown that these units seem to have more tube failures than their fossil-fired counterparts. Common causes include flow accelerated corrosion (FAC), under-deposit corrosion (hydrogen damage, gouging, and pitting), and corrosion fatigue. The complex flow patterns, quick starts and stops, and extended lay-up periods all combine to make proper chemical treatment of HRSGs different than the equivalent pressure fossil-fired boiler.

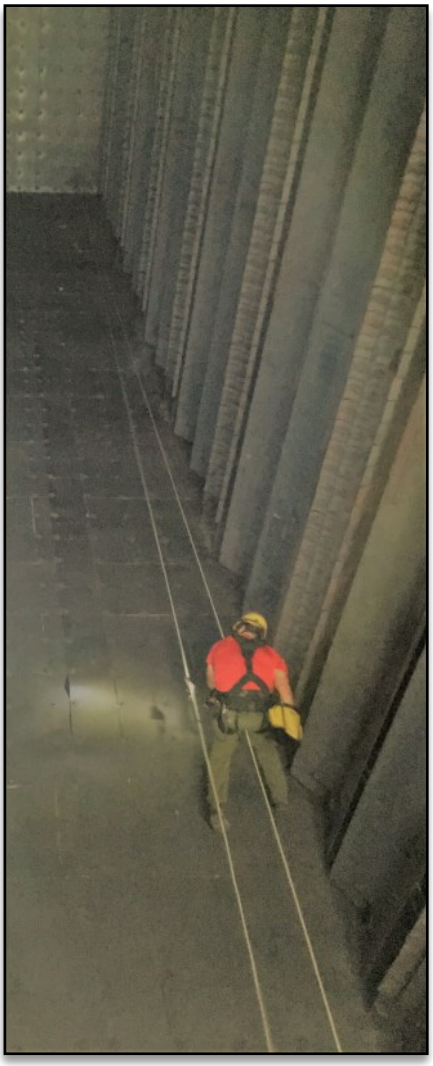
Don't Patch It — Fix It

When failures do occur, it is tempting to plug the tube and move on, but understanding the failure mechanism (the "why") is critical to understanding the potential for additional failures. A true root cause analysis of the failure is essential to solve the problem completely.

M&M Engineering has over 30 years of experience in failure analysis for all types of power and industrial boilers, as well as steam and gas turbines. We are experts in the analysis of steam and combustion turbine blade failures. We also understand the process, materials, and operational conditions in combined cycle plants and can work with you to find a way to eliminate failures in the future.

Training

Personnel at many combined cycle plants wear many hats. They operate, maintain, troubleshoot , and treat their units. To do it right, they need to know more than just what to do. They need to know the "why to do it." M&M Engineering can provide on-site training, tuned to your personnel and plant, for a number of areas including water and steam chemistry, nondestructive testing, materials and corrosion issues, and damage repair options.



In December 2017 our 300MW combined cycle unit at Stanton Energy Center started its Fall outage. Acuren's scope was to inspect burners, SCR lances, HP Superheat #4, and the Economizer # 4. This traditionally has been done from scaffold which requires time and sometimes very limited access. With the expertise of Remote Access Technology (RAT) they were able to perform the inspection in a timely manner with minimal support. When comparing the inspection via traditional scaffold there was both a significant time and money savings realized. It would have required approximately two days to erect scaffold for the inspection in which RAT performed, as well as at least a day to demo. Estimated cost for the scaffolding would have been approximately double of what RAT was to perform the same work.*

Acuren/RAT was able to handle dimensional checks, looking for abnormal wear or corrosion, etc. We were able to confirm that the burners, SCR lances, and HP Superheat #4, and Economizer # 4 were all in acceptable condition. Using RAT is a highly effective supplement to a traditional boiler inspector. In short, we will continue to look for other cost savings opportunities with Acuren/RAT in the future.

Wade Gillingham of Orlando Utilities

M&M ENGINEERING

For additional information contact:

David Daniels
(512) 407-3752
David_Daniels@mmengineering.com

Jon McFarlen
(512) 407-3773
Jon_McFarlen@mmengineering.com

Metal Sample Preparation Guidelines

Sampling Methods for Laboratory Analysis

The recommended sampling methods for metal parts being submitted for analysis are saw and torch cutting, metal nippers, drilling and filings, and scraping. The table on the following page shows the type of sampling method we suggest for different suspected problems or information gathering tasks that you may need. Also shown are the sample sizes needed to perform laboratory tests and analyses.

⇒ Saw cutting is usually the best method for general sample removal. Always make saw cuts away from the area of interest or concern; 6 inches on either side of the area of interest is sufficient.

⇒ Torch cutting (flame or air arc), when necessary, must be done far enough away from the area of interest or concern to avoid over-heating damage; 12 to 18 inches or more on either side of the area of interest is recommended.

⇒ Metal nippers, drill bits, files or scrapers used for small sample removal should be clean (alcohol wipe is best) before using.

⇒ IMPORTANT: Fractured Sample pieces should never be "matched" back up, rubbed together, or cleaned before shipping. Carefully protect "fracture faces" and the surrounding edges for lab analysis.

Identification and Information for Samples

⇒ Use a clear and logical numbering or naming label on the sample or a tag/bag with the sample to assure that the analysis you later receive from the lab is correctly connected with the sample.

⇒ When writing on the sample, avoid covering the area of concern (crack, corrosion products, fracture surface, stampings, etc.).

⇒ Also, if appropriate, use arrows or direction words to orient the sample with the equipment/component it represents. Use terms such as "top", "flow direction", "plant North" or "fire side" to do this.

⇒ Use a lead-free, indelible marker such as a "Sharpie®" for marking samples.

⇒ For bagged or bottled small samples, apply identification to the container directly. If labels are used, try to cover the label with clear tape to prevent smearing of the information during shipment.

Packaging Samples for Shipping

⇒ Cap openings (such as tube ends) with tape or cardboard/plastic plugs.

⇒ Wrap the sample securely so loose deposits or pieces stay intact if possible. Make sure that sharp edges are padded from cutting the packaging.

⇒ Bag or bottle small samples (snips, drillings/filings or scrapings) in tightly sealed bags/containers.

Shipping

⇒ Include written description of the sample identification and problem of concern with a sketch for orientation if possible. Also, send photos and descriptions via email, or include our Incoming Sample Form located on our website.

⇒ Contaminated samples may need special packaging and paperwork; please contact your shipper for more information.

⇒ Large samples are usually shipped by truck.

⇒ Samples less than 75 lbs. can usually be shipped by a package service (e.g., FedEx, UPS, DHL, etc.).

⇒ Small samples can be shipped overnight by envelope.

Note: On a routine basis, M&M Engineering is able to safely receive and handle samples 1 ton and under when received on a pallet or in an appropriate shipping container. We are also able to receive items eight (8) feet in length, height, width and/or diameter. If you anticipate shipping a sample over 1 ton or with a dimension over eight (8) feet, please contact us prior to shipping the sample so the appropriate arrangements can be made to receive the item.

Metal Sample Preparation Guidelines

Sampling Methods for Laboratory Analysis

SAMPLE TYPE	SUSPECTED PROBLEM	SIZE	CUTTING METHOD
Whole	All Types (Particularly Fractures and Cracking)	1 ton and/or 8 feet in diameter, height, or width	___
Partial	All types	50 lbs. (express delivery limit)	Saw or Torch Cut
Cores	Cracks, Corrosion, Damage, Heat Treatment, Subsurface Material Identification	1/4 inch diameter and above	Hole Saw
"Boats"	Shallow Surface Features: Alloy ID, Weld ID/defects, Corrosion Damage, Heat Treatment	Approximately 1/2 x 3/4 x 3 inches	Carbide Cut-off Saw Angled Hole Saw
Plate	Cracks Fractures, Alloy ID, Weld ID/defects, Corrosion Damage, Heat Treatment, Tensile or Bend Testing	6 inch and greater from area of interest 12 inch and greater from area of interest	Saw or nipper cut (NO Torch Cutting) Torch cut
Snips	Alloy ID	½" x ½" or as small as available	Saw or nipper cut
Drillings or Fillings	Alloy ID	1 ounce or more	Clean drill or file
Scrapings	Corrosion Damage Products	From a 2 square inch area, or more	Clean metal scraper

CONTACTS

1815 S. Highway 183
Suite 100
Leander, Texas 78641
MAP

info@mmengineering.com
Main: 512.407.8598
Toll-free: 800.421.9185
Fax: 512.407.3766

Our Business

Our History: http://mmengineering.com/about-us/

Facilities: http://mmengineering.com/about-us/facilities/

Acuren: https://www.acuren.com/about/

Our Team

Credentials: http://mmengineering.com/about-us/our-credentials/

People: http://mmengineering.com/about-us/people/

Our Services

http://mmengineering.com/services/

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Accident Investigation
Boiler Tube Assessment
Failure Analysis
Finite Element Analysis and Computational Mechanics
High Energy Piping Assessment
HRSG Condition Assessment
Independent Third-Party Laboratory
Materials Science Laboratory
Metallurgical Condition Assessment
Smart Non-Destructive Testing
Steam Cycle Chemistry Services
STRAP – Steam Turbine Risk Assessment Program
Support for Industrial Insurers and Independent Adjusters
Water Treatment Technologies Services

Publications

By Author: http://mmengineering.com/publications-reports/publications-author/

Boiler Tube Failure Handbook: http://mmengineering.com/boiler-tube-failure/

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CREDITS/Answers

Banner image Page 3: https://www.flickr.com/photos/62693815@N03/6276688407

Background image, Pages 8: https://www.psffirm.com/blog/are-lie-detector-tests-accurate-and-can-they-be-used-in-court/

Background image, Pages 8-9: http://suppersleuths.com/resources/sleuth-school/

Answers from page 5: Photograph 1 - aluminum alloy, Photograph 2 - duplex stainless steel, Photograph 3 - nickel alloy, Photograph 4 - corrosion austenitic stainless steel – caustic stress corrosion cracking, Photograph 5 - austenitic stainless steel – chloride stress corrosion cracking , Photograph 6 – low alloy steel