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Standard Guide for Corrosion-Related Failure Analysis¹

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1. Scope

1.1 This guide covers key issues to be considered when examining metallic failures when corrosion is suspected as either a major or minor causative factor or contributory to the failure in some manner.

1.2 Corrosion-related failures could include one or more of the following: change in surface appearance (for example, tarnish, rust, color change), pin hole leak, catastrophic structural failure (for example, collapse, explosive rupture, implosive rupture, cracking), weld failure, loss of electrical continuity, and loss of functionality (for example, seizure, galling, spalling, swelling).

1.3 Issues covered include overall failure site conditions, operating conditions at the time of failure, operational and exposure history, corrosion product sampling, environmental sampling, metallurgical and electrochemical factors, morphology (mode) or failure, and by considering the preceding, deducing the cause(s) of corrosion failure.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*²

[E3 Guide for Preparation of Metallographic Specimens](#)

[E1459 Practice for Physical Evidence Labeling and Related Documentation](#)

[E1492 Practice for Receiving, Documenting, Storing, and Retrieving Evidence in a Forensic Science Laboratory](#)

[G1 Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens](#)

[G46 Guide for Examination and Evaluation of Pitting Corrosion](#)

[G193 Terminology and Acronyms Relating to Corrosion](#)

3. Significance and Use

3.1 This guide is intended to assist those encountering corrosion or possible corrosion as a potential causative or contributory factor in a failure analysis.

3.2 This guide is not an absolute plan that will identify the cause of corrosion in all failure analyses or the role of corrosion in an investigated failure.

3.3 This guide is intended to help an investigator identify significant sources and types of corrosion information that may be useful in failure analysis investigations.

3.4 [Appendix X1](#) contains a checklist that is intended to assist in corrosion-related failure evaluations of industrial equipment.

4. Organizing the Analysis

4.1 Early recognition of corrosion as a factor in a failure analysis is critical to any such investigation. Therefore, it is generally desirable to conduct the analysis as soon as possible after the apparent failure. It is *always* desirable to protect the physical evidence until the analysis can begin. Much important corrosion information can be lost if a failure scene is altered or changed before appropriate observations can be made.

4.2 Preservation of evidence can take a variety of forms and options for physical preservation may be limited due to the size of the failed components and the nature of the operational environment, among other issues. At a minimum, photographic documentation of the failure situation should be prioritized to occur as close in time to the failure event as practicable.

4.3 A written plan for the detailed analysis should be prepared. The plan may include methods of documentation (photographs before and during analysis, sketches, statements), responsibilities of parties, reporting needs, and scheduling.

¹ This guide is under the jurisdiction of ASTM Committee G01 on Corrosion of Metals and is the direct responsibility of Subcommittee G01.05 on Laboratory Corrosion Tests.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

4.4 If the capability (corrosion knowledge and experience) of in-house personnel and availability of resources are inadequate to make the analysis in a timely manner, it may be expedient to seek third party services. This includes access to the appropriate analytical equipment necessary to conduct a metallurgical evaluation of the components at issue and chemical analysis of residues, deposits, or corrosion products that might be present in association with the failure being investigated.

5. Failure Site Conditions

5.1 When possible, an overall examination of the conditions at a failure site prior to cleaning, moving, or sampling debris should be conducted. Impressions as to physical arrangements, odors, colors, textures, and conditions of adjacent structures can provide important clues as to active (or previously active) corrosion processes.

5.2 Photographs or video recordings serve as documentation of the observations. It is helpful to include labels and indications of size, location, and orientation in the photographs. Photographs before, during, and after sampling are recommended. Given the nuances of discoloration associated with corrosion and tarnishing, attention to appropriate lighting for photography can benefit the interpretation of the photographic record at a later date. Since ideal lighting can be difficult to achieve outside of a laboratory environment, the use of an in-frame color bar can be a useful tool for capturing this information.

5.3 Sketches and drawings with notes as to detailed observations can be beneficial for later evaluations. Locations of samples and photographs may be shown.

5.4 Interviews with those who were present or nearby when the failure occurred would be appropriate. Information on time, sights, sounds, and conditions can be gained during such interviews.

6. Operating and Exposure Conditions at Time of Failure

6.1 Ascertain the operating or exposure conditions, or both, from operator's logs, recorders, and data loggers (verify the accuracy of time records). Special attention should be given to the stability of the operating conditions, for example, were they stable or variable. Conditions of corrosion concern could be temperature, pressure, flow rate, velocity, process stream pH and chemical composition, time, and weather.

6.2 Special attention should be given to out-of-specification or other abnormal or unusual upset conditions.

6.3 It may be necessary to plot or track operating conditions for an indefinite period of time prior to the detection of failure to more clearly identify any unusual, contributory operating conditions.

6.4 If similar, parallel equipment at the same or other location was operating at the time of the corrosion-related failure, note the operating conditions as a reference point. Such information could be useful in judging the normalcy of the operating conditions associated with the failure.

6.5 Corrosion monitoring instruments and coupons, if present, should be examined to help document operating or exposure conditions, or both, at the time of failure.

7. Historical Information

7.1 Historical information, when available, is extremely useful in understanding some situations. In the present context, historical refers to the time frame from which the subject equipment or structure was manufactured up to the failure event. This may be expanded to include experience with the use of similar equipment or structure regardless of make, model, mode of assembly, or materials of construction. All of the types of information noted may not be useful. Often in cases of older equipment, historical information may be nearly impossible to find because of lost files or retired personnel. Based on cost, time, and anticipated benefit, a judgement must be made as to the effort one should expend in retrieving historical information.

7.2 Useful details regarding original constructions may include, but are not limited to, design drawings and specifications, material specifications (composition, thermal treatments, surface treatments), joining (bolts, rivets, welds, adhesives), and surface treatments (coatings, pickling, etching, anodizing, plating, peening, grinding, insulation, or refractories).

7.3 Details regarding modifications made subsequent to original fabrication and prior to the corrosion-related failure may be extremely important because they often reveal less-than-optimum field work. Modifications may have been made for one or more reasons, including, but not limited to, problems with original design, changed service requirements, corrected earlier failures, and correction of safety and environmental concerns. The same types of details suggested in 7.2 should be considered regarding modifications.

7.4 Details regarding operating history may be important. Three types of operating information that may require documentation are original design parameters, chronology of nominal operating parameters, and anomalous operating parameters, including out-of-specification periods and significant downtime periods. Information about shut down and start up procedures may be useful in an investigation, regardless of whether the failure event is closely connected in time to a shut down or start up event.

7.5 Maintenance, cleaning, and repair histories may be important and should be documented.

7.6 For structures, site inspection history relative to the failed components should be reviewed.

7.7 For manufactured products, the investigator should make an effort to determine whether the mode(s) of use or storage were a factor in the suspected corrosion-related failure.

7.8 Changes in specification for, and sources of, process raw materials and supplies may be significant and should be evaluated.