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Standard Guide for Corrosion-Related Failure Analysis[1]

This standard is issued under the fixed designation G161; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

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.

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, history of equipment and its operation, 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 Guide 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

3. Significance and Use

3.1 This guide is intended to assist those encountering corrosion or possible corrosion as a causative 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.

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

3.4 Appendix X1 contains a checklist that is intended to assist in corrosion-related failure evaluations.

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 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.

4.3 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.

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 corrosion processes.

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[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 service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

5.2 Photographs or videotapes serve as documentation of the observations. Color photographs are preferable. It is helpful to include labels and indications of size, location, and orientation in the photographs. Photographs before, during, and after sampling are recommended.

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 Conditions At Time of Failure

6.1 Ascertain the operating conditions 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 conditions at the time of failure.

7. Historical Information

7.1 Historical information, when available, is extremely useful in understanding some situations. 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.

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

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

8. Sampling

8.1 Careful sampling is critical to the successful investigation of corrosion-related failures. Sampling in corrosion investigations is similar to that used in forensic investigations by criminologists. Guide E1459 and Practice E1492 address issues of labeling and documenting field evidence. These standards may provide useful guidance during sampling for corrosion investigations.

8.2 The written plan suggested in 4.2 should be supplemented with a written sampling plan. The plan should specify a sample location, identification system, and method of collection.

8.3 Avoid contamination during sampling by using clean tools. Personnel should wear gloves to avoid fingerprints and personal contact.

8.4 Sample containers should be clean and sealable to protect samples from contamination and damage. The material of sample containers should be selected carefully to avoid undesirable interaction with samples. Each container should be dated and identified according to the sampling plan.

8.5 Samples of corroded and uncorroded materials may be useful in the identification of causative factors. Samples should be as large as practical to give analysts sufficient material to work with and to protect critical corroded areas from damage during cutting and transporting. If failure initiation location is apparent, it should be sampled. When cutting samples, consideration should be given to temperature control and to the introduction of cutting and cooling fluids that could alter the surface and metallurgical conditions. Because of the solubility in water of many corrosion products, samples must be protected from extraneous moisture.

8.6 Corrosion products and deposits should be given special sampling treatment because they are often key elements in understanding the failure. Care should be used in the selection of tools for collecting these samples. Nonmetallic tools are often preferred because they present less chance for contamination of the sample or for damaging critical corroded surfaces. When there is insufficient corrosion product or deposit for easy field sampling, care should be used when handling material so