Nondestructive Examination (NDE) Technology and Codes
Student Manual

Volume 1

Chapter 1.0

Introduction

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1.0 INTRODUCTION

Learning Objectives:

To enable the student to:

1. Understand the importance of nondestructive examination (NDE).

2. Identify the international interest in NDE.

3. Identify sources of errors that can occur.

1.1 Overview of Course

It is of great importance that both individual components and complete engineering assemblies and structures are free from damaging defects and other possible causes of premature failure. A whole series of examination instruments and techniques have evolved over the years and new methods are still being developed to assist in the process of assessing the integrity and reliability of parts and assemblies. Nondestructive examination methods are widely used in industry for checking the quality of

This manual provides basic background information needed by students, NDE personnel, and managers who want to study the most commonly used NDE methods.

For control of NDE applications and procedural quality, international standards are being continuously evolved and developed through two major nongovernmental bodies, the International Organization for Standardization (ISO), for non-electrical standards, and the International Electro-Technical Commission (IEC) for electrical standards. In the United States, the American National Standards Institute (ANSI) is the official member of the ISO and IEC.

In the United States, there are 29 National Standards organizations and hundreds of organizations worldwide. In addition, there are thousands of ISO and IEC standards committees and subcommittees.

There are also dozens of governmental agencies that are concerned with the institution of national and international standards.

It takes time to develop adequate procedures and standards for new instruments and new technology. It takes even more time to obtain universal agreement on these standards.

Because of the continuing changes taking place, the information in this manual is for reference purposes only. The information herein should not be taken as authoritative over any formally issued specification, standard, procedure, technique, or instruction.

The field of NDE is more dynamic today than ever before. Many of the major technical societies, such as the American Society for Nondestructive Testing (ASNT), the American Society for Metals (ASM), the American Society for Quality (ASQ), the American Welding Society (AWS), and the American Society for Testing and Materials (ASTM) are deeply involved in nondestructive examination and are leading the drive for better understanding

through information dissemination and standardization.

1.2 Human Factors

1.2.1 Examiner Errors

While regulatory agencies can write the most detailed regulations and companies can devise the most sophisticated quality programs and procedures, it still remains that the actions of individual examiners will ultimately determine the success or failure of those programs. It is the human factor that contributes to examiner errors. These errors can have varying causes:

- Technique errors,
- Inadvertent errors,
- Procedural errors, and
- Conscious errors.

The various causes of examiner errors when taken collectively show an accuracy of about 80 percent. This means that the average group of examiners will find about 80 percent of flaws while missing 20 percent. Worldwide studies have shown this to be an accurate measure of examiner reliability.

1.2.1.1 Technique Errors

There can be several categories addressed under this topic but the most important is job knowledge. Have the examiners been properly trained to perform the required job? In NDE there can be no guarantee that an examination is performed properly unless the examiner has been trained and properly evaluated by written and practical examinations.

Other causes are physical, such as color blindness; lack of "skill" due to lack of natural aptitude; or lack of basic education.

A good internal audit system is necessary to evaluate examiners and to assure that these errors are identified before serious problems occur. Management must provide the examiner with feedback. Without this feedback there will be no change in performance.

Management should look at the most successful examiners and find what trait makes them superior performers. These methods should then be transferred to all examiners through additional training or technology.

Where an examiner's performance is due to lack of ability, additional training may yield little results. Management can evaluate the examination procedures to see if the procedures can be simplified, or they can reassign the examiner to a job equal to the individual's capacity.

The most effective means to assure that examiners can perform required tasks is a formal certification program. A complete certification program should include:

- Formal training program,

- Detailed written and practical (demonstration on controlled test samples) examinations,
- Documentation attesting to the training and examinations,
- Periodic renewal of the certification, and
- A strong internal audit program to assure performance.

1.2.1.2 Inadvertent Errors

The majority of examiners want to give superior performance, not make errors. However, no matter how well trained or how well intentioned the examiner is, there will be "inadvertent errors". The human factor does not allow for perfection.

It is widely assumed and believed by many that 100 percent examination means 100 percent of the discontinuities will be found. As indicated in Section 1.2.1, studies show that examiners only find about 80 percent of the discontinuities.

One example that demonstrates examination fallibility follows:

> "Federal fuses are the results of years of scientific study combined with the experience of years."

The sentence is flashed before an audience for 30 seconds to a minute. Each member is asked to count and record the number of times the letter F appears. When the results are tallied, only about 80 percent have been found. The existence of such an extensive error rate has stimulated many studies to determine "why" and to reduce this error rate. To date there have not been conclusive answers.

Since we do not know conclusively how to prevent these errors, quality programs have attempted to build in remedies. These remedies include:

Automation - Much of the repetitive errors can be eliminated by automation. Once an instrument is set up and calibrated properly, it will not produce inadvertent errors. Many of the nondestructive examinations now performed, particularly ultrasonics and eddy current, use some type of computer for data acquisition and/or evaluation.

Checklists - Detailed checklists can be used to assure all examination steps are accomplished. An example is the checklist used by a receipt examiner to check an incoming shipment. The checklist would identify all the steps to follow to assure the order meets the requirements of the purchase order.

Comparison Standards - Comparison standards are actual acceptable production pieces used for comparison with other production parts.

Templates - Templates placed on a part being examined will immediately call the examiner's attention to a missing part, hole, etc.

Overlays - These are visual aids in the form of transparent sheets that can be marked and placed over the item being examined.

Templates are commonly used in radiography to lay out discontinuities or possible surface conditions. The examiner can then take the overlay and place it on a weld or casting and determine if an indication is surface or internal.

Product Design - Designers and engineers must be aware of what kind of final examination a product will require. If radiography is required, the examiner must have access to both sides of an object. If ultrasonic is required, materials and geometry are factors.

Examination Aids - The use of optical magnifiers and other devices that magnify and enhance a part help eliminate errors.

Work Schedule - If an examiner is fatigued, the individual will not be able to maintain concentration for long periods. This can present both an examination problem and a safety problem. It may be useful to reorganize the work, allow for rest periods, rotate examination activities, or enlarge the job scope to give a wider assortment of tasks.

1.2.1.3 Procedural Errors

Some errors affecting quality may be inadvertent errors caused by persons other than the examination group. Parts may be inadvertently put in the shipping area or a release area before an examination is performed. This error can be eliminated by assuring that all levels of the organization are aware of the quality program and that an adequate marking system for parts is implemented and understood by all personnel.

1.2.1.4 Conscious Errors

Errors of this type are consciously and knowingly committed by an individual. Such errors may be "shortcuts" or deciding certain procedural steps are not required or "add nothing" to the process. These errors may be by a manager, examiner, or both. While errors of this type are committed by examiners, they are more commonly traceable to managers and engineers.

Conflicting Management Policies - Management may write an extensive quality program and state they are committed to quality, but their actions indicate that cost and delivery schedule are the real priority. Most examiners quickly learn the real priorities within a company and act accordingly.

Failure to Enforce Quality Requirements - If management consistently fails to enforce quality requirements and accepts nonconforming materials as "accept-as-is," examiners will stop reporting the conditions which could potentially lead to more serious oversights.

Failure to Act - If management does not respond to examiners' suggestions or complaints, they will stop raising issues and try to do their best with potentially defective equipment or deficient information.

Management Fraud - In some incidents a manager may attempt to deceive customers or

regulators with fictitious quality records. This usually requires the manager and examiner to work together.

Examiner Fraud - For numerous reasons, including undue supervisory coercion, financial gain, relationships with production personnel requesting a "break," or just being lazy, many examiners have been influenced to look the other way. The solution is to use personnel of high integrity and have decisive follow-up on internal audit findings should this type of activity be uncovered.

Examiner Shortcuts - As discussed earlier, the examiner may decide that a certain procedural step can be skipped without causing a problem. The examiner may not understand the importance of the step to the overall process and must not make such independent decisions.

Flinching - Examiners occasionally face borderline examinations. For example, an indication or measurement may be just over or under tolerance. An examiner may think a measurement is close enough. However, an examiner must only accept conditions within drawing or specification tolerance. Acceptance of out-of-tolerance condi-tions must be approved by an engineer and the customer.

Measures of Examiner Accuracy - Because of the collective effect of examiner errors, it is critical to monitor examination activities. Accepting rejected items or rejecting acceptable items can be a costly and potentially hazardous problem. It should be noted that many studies have shown examiners tend to reject more good products than accept bad products. Conscious errors can be controlled with the following:

- Strong management support for quality program,
- Training,
- Certification, and
- An internal audit program.

1.2.2 Environmental

The environment in which an examiner must work can have an impact on the accuracy of examinations, particularly inadvertent examiner errors. If the examiner becomes distracted with concerns for personal safety, examination accuracy will decrease. Examples of unsatisfactory environments are:

- Confined spaces,
- High temperatures,
- Heights, and
- Radiation areas.

The types and amounts of protective clothing required affect the examiner's attention. Working in full protective clothing, including supplied air, is a high stress and high fatigue environment.

The effects of the environment on the examiner and human attention cannot be completely eliminated; therefore, the preferred solution is to reduce dependence on the examiner in these environments. The unsatisfactory

environmental condition should be engineered, or remote examination techniques should be employed. This is the joint responsibility of management, engineering, and examination personnel.