

Nondestructive Testing Methods Training Workbook



HOBART INSTITUTE OF WELDING TECHNOLOGY

An explanation of nondestructive testing
and results obtained.

Nondestructive Testing Methods Training Workbook

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the Staff of Hobart Institute
of Welding Technology

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GLOSSARY OF WELDING TERMS

Acceptable weld - A weld that meets the applicable requirements.

Arc strike - A discontinuity resulting from an arc, consisting of any localized remelted metal, heat affected metal, or change in the surface profile of any metal object.

Backing - A material or device placed against the back side of the joint adjacent to the joint root, or at both sides of a joint in electroslag and electrogas welding, to support and shield molten weld metal. The material may be partially fused or remain unfused during welding and may be either metal or nonmetal.

Backing strip - Backing in the form of a strip.

Codes - A system of principles or rules.

Complete fusion - Fusion over the entire fusion faces and between all adjoining weld beads.

Contaminants - Implies intrusion of or contact with dirt or foulness from an outside source, making the piece unfit or unclean.

Crack - A fracture type discontinuity characterized by a sharp tip and high ratio of length and width to opening displacement.

Crater - A depression in the weld face at the termination of a weld bead.

Defect - A discontinuity or discontinuities that, by nature or accumulated effect, render a part or product unable to meet minimum applicable acceptance standards or specifications. The term designates rejectability.

Discontinuity - An interruption of the typical structure of a material, such as a lack of homogeneity in its mechanical, metallurgical, or physical characteristics. A discontinuity is not necessarily a defect.

Fillet weld - A weld of approximately triangular cross section joining two surfaces approximately at right angles to each other in a lap joint, T-joint, or corner joint.

Interpass temperature - In a multipass weld, the temperature of the weld area between weld passes.

Joint design - The shape, dimensions, and configuration of the joint.

Overlap - The protrusion of weld metal beyond the weld toe or weld root.

Porosity - Cavity-type discontinuities formed by gas entrapment during solidification.

Procedure - The detailed elements of a process or method used to produce a specific result.

Slag inclusion - A discontinuity consisting of slag entrapped in weld metal or at the weld interface.

Welding procedure qualification record - A record of welding variables used to produce an acceptable test weldment and the results of tests conducted on the weldment to qualify a welding procedure specification.

TOPIC 1

INTRODUCTION TO NONDESTRUCTIVE TESTING

OBJECTIVE

To be able to define and identify the purpose for nondestructive testing and the symbols used to indicate



Visual Testing



Penetrant Testing



Magnetic Particle Testing

INTRODUCTION

This section includes an overview of nondestructive testing, its purpose, the basic principles involved with the most common types, giving a description of the symbols used to indicate methods of inspection.

Nondestructive testing is an evaluation process in which no damage occurs to completed welds or to the surrounding structure provided the proper procedures are followed. It is used to qualify procedures, welders, and to monitor the quality of production welding.

Nondestructive testing, whether in the shop or field, can be used for detecting small discontinuities and defects quickly and effectively. The most common methods for nondestructive testing are:

Visual

Penetrant

Magnetic particle

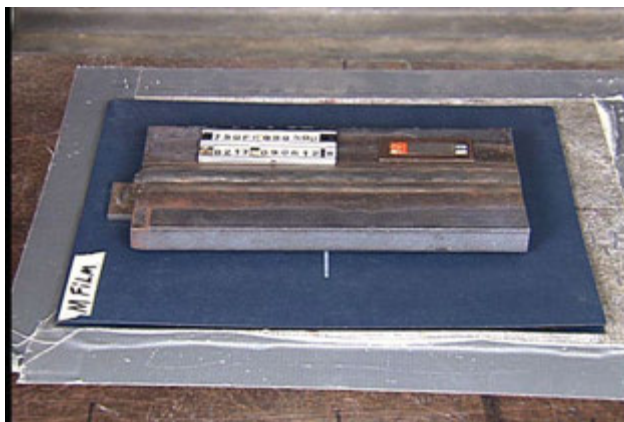
Ultrasonic

Radiographic



Ultrasonic Testing

When choosing an inspection method, take into consideration the advantages and limitations of the method.



Radiographic Testing

The sensitivity of each method reflects its ability to respond to a discontinuity's size, shape and location. Visual inspection is limited to discontinuities exposed to the surface. Radiographic inspection could be used to detect discontinuities on or below the surface. The method to employ is based largely on the degree of quality required for the weldment.

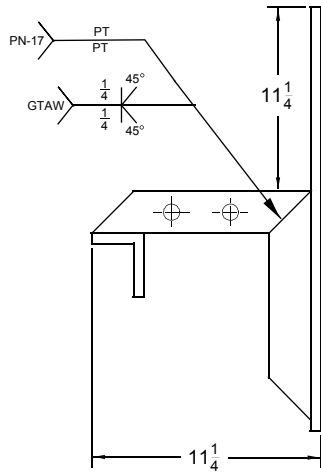
For example, to verify quality, visual or magnetic particle inspection may be all that is required for low pressure piping, whereas high pressure piping may require radiographic testing.



Magnetic Particle Testing

Cooperation between design, welding, and quality engineers is required to determine which testing methods to use in order to meet the testing requirements of the weldment.

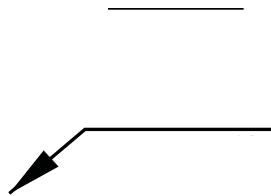
Once the decision is made, it becomes the quality assurance engineer's responsibility to provide the qualified inspector with the details of the inspection requirements, so the weld can be inspected correctly.



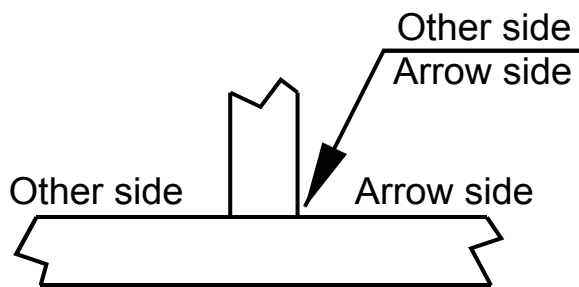
Methods of indicating inspection type will be necessary when nondestructive testing is required. This is generally done on engineering drawings by the use of nondestructive testing symbols and written procedures.

II. NONDESTRUCTIVE TEST SYMBOLS

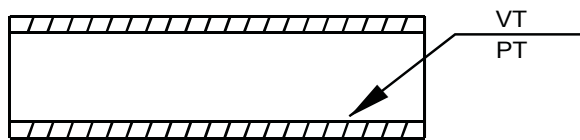
Nondestructive testing symbols are standardized much like the symbols used for welding. A reference line is used in the same manner as welding symbols, and is as long as necessary for adding information.



An arrow is used to direct the information to the desired location. It can be placed at either end of the reference line, pointing up or down, on either side where welds are to be placed.

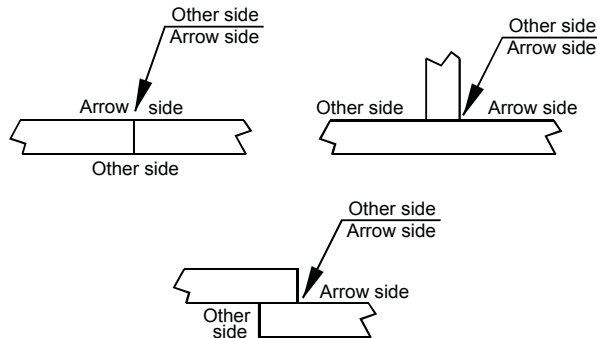


The side of the joint the arrow points to is referred to as the "arrow side". The opposite side is called the "other side". It is important because it specifies which side of the welded joint is to be inspected.

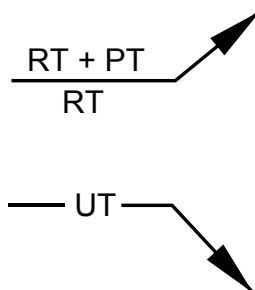


The symbols use initials to indicate the test method to be used. They are:

- VT = visual testing
- PT = penetrant testing
- MT = magnetic particle testing
- UT = ultrasonic testing
- RT = radiographic testing



When the test symbol is located below the reference line, it signifies that inspection is to be performed on the arrow side of the joint. When placed above the line, it indicates the inspection is to be performed on the other side.

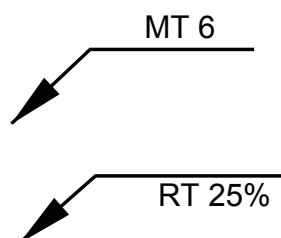


The test symbol can be placed on both sides of the reference line to indicate that each side of the weld is to be inspected.

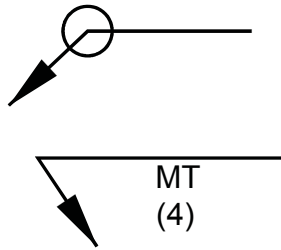
The symbol is centered between a break in the reference line when it doesn't matter on which side the inspection is to be performed. In all cases, the inspection is for 100% of the weld unless otherwise noted.



Details, such as testing procedures, specification, processes, or other pertinent information are sometimes placed at the end of the reference line inside a "tail bracket".

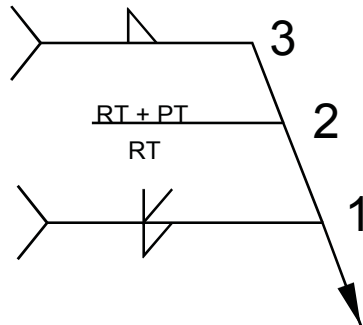


When less than 100% of the length is to be inspected, it can be specified by a section length or percentage located to the right of the symbol. The required sections or areas are usually specified in the written procedures. When no percentages are noted, 100% of the weld is to be checked.

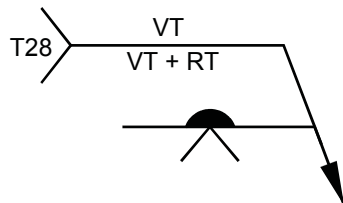


The all around test symbol is used when the inspection is to be performed completely around a welded joint.

The number of tests to be performed is indicated in parenthesis. The symbol shown here specifies four applications of magnetic particle inspection.



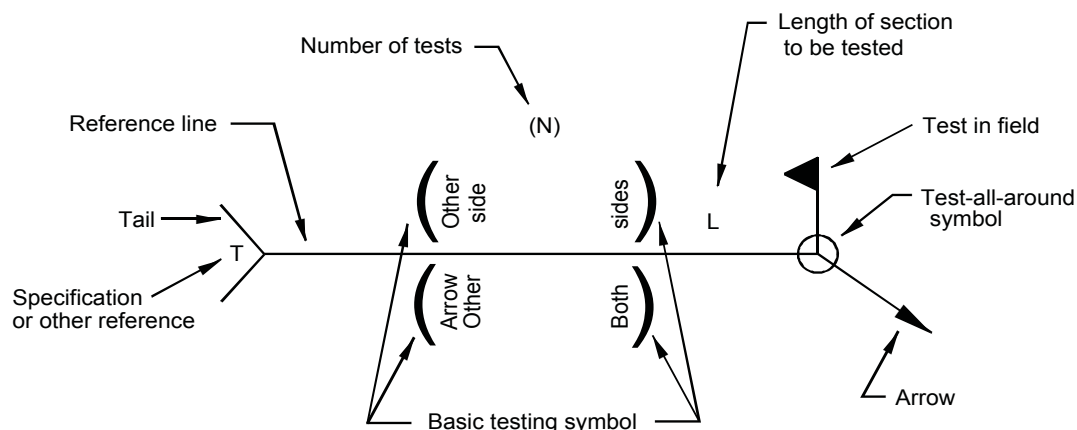
Multiple reference lines are nondestructive test symbols combined with other nondestructive or welding symbols. The order in which operations and tests are performed is indicated by the order of the lines. The first operation is the closest to the arrow.



This multiple reference line shows a single V-groove weld with melt through to be inspected on the arrow side with a combination of visual and radiographic testing methods. Visual inspection is performed on the other side. Inspection details are located in procedure T-28.

The engineering staff can provide information for welding and inspection using symbols and notes on the engineering drawings.

Knowledge of the testing methods, procedures, and the symbol elements, can enable you to better understand this common language and help to maintain higher quality at lower cost.



TOPIC 1

REVIEW QUESTIONS

1. Define the purpose of nondestructive testing:

2. Where are nondestructive symbols placed?

3. List the common methods of nondestructive testing:

4. How long should the reference line of a nondestructive test symbol be?

5. An arrow is used to direct the information to:

6. The side of the joint the arrow points to is called the:

TOPIC 2

PRINCIPLES OF VISUAL TESTING

OBJECTIVE

To be able to identify the basic principles and applications of visual testing.

VISUAL INSPECTION CHECKLIST

NAME OF COMPANY _____

INSPECTION SITE LOCATION _____

CITY, STATE, ZIP CODE _____

CODE/COMPANY SPECIFICATION _____

WELDER I.D. # _____

PROCEDURE NO. _____

INSPECTOR I.D. # _____

REVISION _____

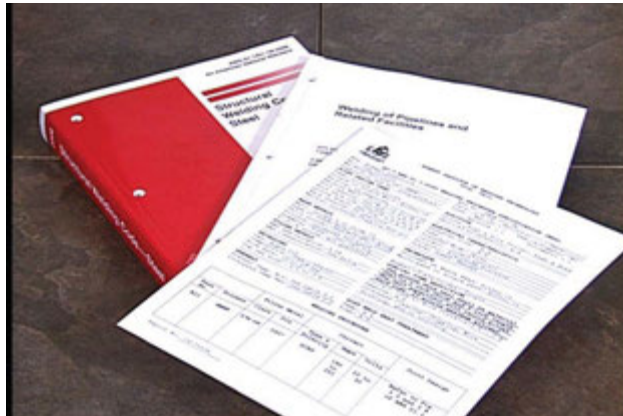
PRE-WELD INSPECTION

	CONFORMS	NON-CONFORMS
1) Usage of Proper Procedures		
2) Welder Qualified to Procedure		
3) Base Metal Free from D.C. & Foreign Material		
4) Base Metal Specifications		
5) Base Preparation		

INTRODUCTION

Visual testing is the most popular and widely used nondestructive testing method. It consists of examining weld and overall weldments and comparing the evaluation to a set of standards.

When correctly applied, it is an effective method of quality control insuring conformance to a procedure and allowing errors to be corrected. This leads to production of a higher quality weldment at reduced costs.



Visual inspection practice requires the inspector to be familiar with all duties which apply to inspection, such as:

- Learning to read blueprints
- Having a knowledge of welding
- Processes specifications
- Procedures and workmanship standards



The inspector must be capable of making:

- Responsible judgments
- Accurately recording data
- Writing concise reports

Even though visual testing is the simplest method of performing inspections, detailed written procedures are needed to ensure proper application of the inspection.



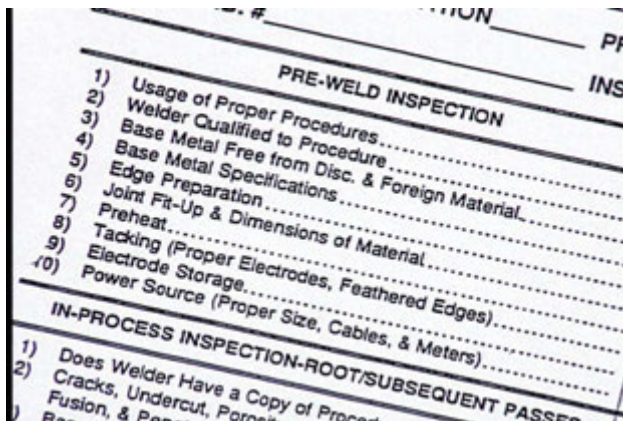
PREWELD INSPECTION

To perform preweld inspection, an inspector becomes familiar with all aspects of the job, such as:

- Material specification
- Bill of materials
- Welding procedures

When completely familiar with all the written details, the inspector compares the dimensions of all the parts, checking dimensions to engineering drawings, and verifying tolerances of parts to ensure proper final fit-up of the weldment.

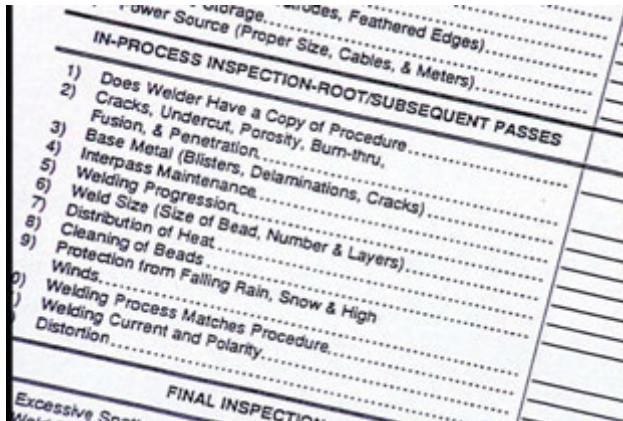
The inspector examines the joint preparation and surface conditions of the materials for proper cleaning and lack of flaws. Poor fit-up, contaminated base metal surfaces, improper equipment, and incorrect settings can lead to weld discontinuities or defects.



If backing is specified, it should be in accordance with the job specifications and be correctly and securely fastened. The tack welds become part of the finished weld and should meet the same soundness requirements.



Preweld inspection should include examining the equipment to insure it is in proper operating condition.



IN-PROCESS VISUAL INSPECTION

In-process welding begins with:

- Verifying specified procedures
- Observing welds during production
- Deleting problems before completion of welds
- Observing welder skill
- Verifying proper interpass temperatures
- Assuring interpass cleaning requirements are met
- Comparing each pass or layer to a sample workmanship standard



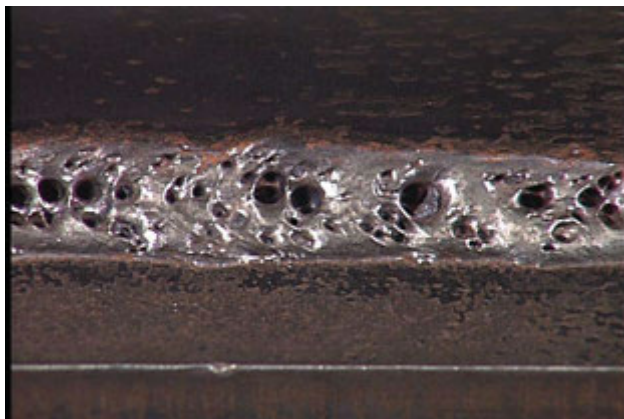
VISUAL TESTING OF FINISHED WELDS

The inspector should compare the finished welds or weldments to the engineering drawings or specifications. This assures:

- Proper part dimensions
- Weld size
- Weld location
- The correct amount of welds on the weldment

Accuracy of the measurement is more important than the method of measuring. A good-looking weld could be rejected if it is not the correct size.

Tools, such as high-low gage, fillet weld gage, or a scale can be used to measure correct dimensions.



Another part of post-weld inspection is the examination of the weld surface. Common discontinuities visible to the surface area are:

- Cracks
- Porosity
- Overlap
- Arc strikes
- Undercut
- Spatter