



Education and Culture

# Leonardo da Vinci

**Course: Quality Assurance**  
**Module 5**

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**MODULE 5*****Objective:***

***Know the principles of basic NDT methods used in welding.***

***Scope:***

- ***Revision of weld imperfections (ISO 6520-1)***
- ***Revision of quality levels (ISO 5817)***
- ***Checking dimensions, surface and distortion***
- ***Surface inspection of cracks and other surface imperfections by visual testing (VT), penetrant testing (PT) and magnetic particle testing (MT)***
- ***Detectability of internal imperfections of welds by radiographic testing (RT) and ultrasonic testing (UT)***
- ***Destructive tests to measure mechanical properties of weld***

***Expected results:***

- ***Perform simple visual inspection of welds to EN 970 and subsequently evaluate to ISO 5817.***
- ***Identify the following destructive and non-destructive methods: bend tests, hardness tests, tensile tests and impact tests, VT, MT, PT, RT and UT.***

**Inspection and testing**

Applicable inspections and tests shall be implemented at appropriate points in the manufacturing process to assure conformity with contract requirements. Location and frequency of such inspections and/or tests will depend on the contract and/or product standard, the welding process and the type of construction.

***Inspection and testing before welding***

Before the start of welding, the following shall be checked:

- suitability and validity of welders' qualification certificates;
- suitability of welding-procedure specification;
- identity of parent material;
- identity of welding consumables;
- joint preparation (e.g. shape and dimensions);
- fit-up, jiggling and tacking;
- any special requirements in the welding-procedure specification (e.g. prevention of distortion);
- arrangement for any production test;
- suitability of working conditions for welding, including environment.

***Inspection and testing during welding***

During welding, the following shall be checked at suitable intervals or by continuous monitoring:

- essential welding parameters (e.g. welding current, arc voltage and travel speed);
- preheating/interpass temperature;
- cleaning and shape of runs and layers of weld metal;
- back gouging;
- welding sequence;
- correct use and handling of welding consumables;
- control of distortion;
- any intermediate examination (e.g. checking of dimensions).

#### *Inspection and testing after welding*

After welding, the compliance with relevant acceptance criteria shall be checked:

- by visual inspection;
- by non-destructive testing;
- by destructive testing;
- form, shape and dimensions of the construction;
- results and records of post-weld operations (e.g. post-weld heat treatment, ageing).

#### *Inspection and test status*

Measures shall be taken, as appropriate, to indicate, e.g. by marking of the item or a routing card, the status of inspection and test of the welded construction.

### **Calibration and validation of measuring, inspection and testing equipment**

The manufacturer shall be responsible for the appropriate calibration or validation of measuring, inspection and testing equipment. All equipment used to assess the quality of the construction shall be suitably controlled and shall be calibrated or validated at specified intervals.

### **Surface inspection on cracks and other surface imperfections by visual testing**

Visual examination is a simple, accessible low - cost inspection method, and it is an excellent process-control tool to help avoid subsequent fabrication problems and evaluate workmanship.

Visual inspection only identifies surface discontinuities. Consequently, any conscientious quality control program should include a sequence of examinations performed during all phases of fabrication.

Visual Inspection is performed in three phases.

- I. Prior to Welding.
- II. During Welding.
- III. After Welding.

I. Prior to Welding.

Some typical action items requiring attention should include the followings:

- Groove angle.
- Root openings.
- Joint alignment.
- Backing.
- Consumable insert.
- Joint cleanliness.
- Tack welds
- Preheat (if required)
- Identification of filler material
- Identification of base material
- Verification of competence
- Verification of the suitability of the equipment
- Verification of Health, Safety and Environment factors

II. During Welding.

Some typical action items requiring attention by those responsible for weld quality should include the followings:

- Check preheat and interpass temperatures.
- Check conformance to Welding Procedure Specification or Weld Schedule.
- Examine weld root pass.
- Examine weld layers.
- Examine second side prior to welding

Any of these factors, if ignored could result in discontinuities that could cause serious degradation.

III. After Welding.

Following welding, some typical action items requiring attention by the visual inspector should include followings:

- Examination of weld surface quality.
  - The typical discontinuities found at the surface are as:
  - Porosity
  - Lack of fusion
  - Incomplete joint penetration
  - Undercut
  - Underfill
  - Overlap
  - Cracks
  - Metallic and non-metallic inclusions
  - Excessive and negative reinforcement
  - Off set
  - Arc Strikes

- Suck back
- Overlay
- Burn through
- Discoloration
- Verifying weld dimensions
- Verifying dimensional accuracy
- Reviewing subsequent requirements

#### *Non destructive evaluation of welded joints*

The application of non-destructive testing is highly dependent on the geometrical conditions of the component, the configuration and accessibility of the joint. This is particularly true for volumetric methods, radiographic and ultrasonic testing.

The methods for surface testing visual, magnetic particle, penetrant and eddy current are primarily dependent on the surface conditions and accessibility.

In order to guarantee the application of all the fabrication procedures and the required properties for the product, appropriate inspections and tests shall be implemented during the manufacturing process

Location and frequency of such inspections and/or tests will depend on the contract and/or product standard, on the welding process and on the type of construction. As a general rule the state of inspection and testing of the welded product have to be indicated in some way. Such a means shall be adequate to the type of product; as an example, a Fabrication and Control Plan may be required for big products (on which the testing activities are marked); while routing cards or confined space inside the manufacturing plant shall be sufficient for small series product to indicate the inspection and testing status. The following table reports a typical chart for tests to be carried out before, during and after welding operations.

In some situations, the signature of the inspector<sup>1</sup> shall be required in order to enhance the traceability of the welding and related process activities. Moreover, the reference number of the relevant test report shall be included, if required.

All the procedures or instructions relevant to inspection and testing shall be made available to the inspection personnel, and properly controlled.

As to NDT, testing activities (method, technique and extension) shall be carried out in consideration of and in accordance with the quality level of the product. Some of those parameters are reported in the manufacturing codes, where the designer chooses the class of the weld taking into consideration all of the above mentioned factors. All these aspects should be considered during the design review phase by the welding coordinator.

Table of verification topics.

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<sup>1</sup>

| <b>TEST</b>   |                            | <b>Checked<br/>(date)</b> | <b>Signature of<br/>the inspector</b> | <b>Reference<br/>report</b> |
|---|----------------------------|---------------------------|---------------------------------------|-----------------------------|
| <b>Tests before welding operations</b>  | <b>Reference procedure</b> |                           |                                       |                             |
| Suitability and validity of welders qualification certificates                              |                            |                           |                                       |                             |
| Suitability of welding procedure specification  |                            |                           |                                       |                             |
| Identity of parent material   |                            |                           |                                       |                             |
| Identity of welding consumables   |                            |                           |                                       |                             |
| Joint preparation (e.g. Shape and dimensions)   |                            |                           |                                       |                             |
| Fit-up, jiggling and tacking  |                            |                           |                                       |                             |
| Special requirements in the welding procedure specification (e.g. Prevention of distortion) |                            |                           |                                       |                             |
| Arrangement for any production test   |                            |                           |                                       |                             |
| Suitability of working conditions for welding, including environment                        |                            |                           |                                       |                             |
| <b>Tests during welding operations</b>  |                            |                           |                                       |                             |
| Preheating / interpass temperature  |                            |                           |                                       |                             |
| Welding parameters  |                            |                           |                                       |                             |
| Cleaning and shape of runs and layers of weld metal;  |                            |                           |                                       |                             |
| Back gouging;   |                            |                           |                                       |                             |
| Welding sequence;   |                            |                           |                                       |                             |
| Correct use and handling of welding consumables;  |                            |                           |                                       |                             |
| Control of distortion;  |                            |                           |                                       |                             |
| Dimensional check   |                            |                           |                                       |                             |
| <b>Tests after welding operations</b>   |                            |                           |                                       |                             |
| Compliance with acceptance criteria for Visual Testing                                      |                            |                           |                                       |                             |

|  |  |  |  |  |
|--|--|--|--|--|
| Compliance with acceptance criteria for other NDT examinations (e.g. Radiographic or Ultrasonic Testing) |  |  |  |  |
| Compliance for destructive testing (when applicable)   |  |  |  |  |
| Results and records of post-welding operations (e.g. PWHT)   |  |  |  |  |
| Dimensional checking.  |  |  |  |  |