Weld Quality

Inspection & Testing

Lecture Scope

- Quality: definition
- Selection of weld quality level and acceptance standards
- Role of inspection and the inspector
- Inspection plan
- Non-destructive examination and other test methods

Quality: Definition

- In engineering terms, an item has the right quality if it performs satisfactorily through its intended life
- Quality is "fitness for purpose"

Specifying Weld Quality Standards

- Selection of a quality level involves balancing design, manufacturing and inspection practices to achieve fitness-for-service at the lowest total cost.
- Specifying needlessly high quality levels adds cost to a structure with no benefit
- Conversely, inadequate quality leads to structural failure, increased maintenance costs, foregone revenues, and loss of life or property.

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Selection of Quality Standards

An appropriate weld quality standard takes account of the following factors:

1. Service conditions
2. Material and weld properties
3. Risk of defects
4. Inspection adequacy
5. Consequences of failure

Selection of Quality Standards

1. Service conditions
   - Loads:
     - magnitude, constant or cyclic, static or dynamic. Resultant stress levels, margins against yielding, fatigue and fracture
   - Working temperatures
     - Low temperatures may pose a risk of brittle fracture. High temperature can lead to creep and other metallurgical effects
   - Ambient environment:
     - corrosion and oxidation, stress corrosion cracking, wear, erosion

Selection of Quality Standards

1. Service conditions
2. Material and weld properties
   - Effects of welding on strength, toughness, fatigue and corrosion resistance

Selection of Quality Standards

1. Service conditions
2. Material and weld properties
3. **Risk of defects**
   - **Welds may contain various defects that reduce their strength and resistance to failure**

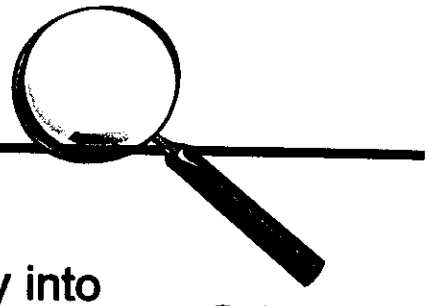
Selection of Quality Standards

1. Service conditions
2. Material and weld properties
3. Risk of defects
4. Inspection adequacy
   - Inspection may be less than 100% efficient, due to:
     - process inefficiency
     - sampling error
     - human failure
   - Consequently, welds after inspection are not necessarily free from all defects

Selection of Quality Standards

1. Service conditions
2. Material and weld properties
3. Risk of defects
4. Inspection adequacy
5. Consequences of failure
   - The consequences of structural failure tend to increase with:
     - size
     - stored energy (pressure vessels, towers)
     - toxic contents (vessels, tanks, piping)
     - proximity to people
     - redundancy (duplication of critical components may reduce the consequences of failure)

Inspection



- The only thing that puts quality into manufactured products is making them right.
- Inspection is a tool for confirming that the desired quality has been met.
- Inspection during manufacture according to a logical inspection plan enables quality to be monitored before defects are produced.

Inspection Plans

- While inspection of simple items can be left to the discretion of individual inspectors, complex structures are usually inspected according to a defined inspection plan
- Inspection plans should be designed to give assurance that the specified quality levels are met
- Plans should specify:
  - Items to be inspected
  - At what stage in manufacture (inspection hold points)
  - Inspection methods and procedures
  - Acceptance criteria

Inspection Plans

- In some cases 100% inspection of all production is required
- In others, sampling procedures are applied
  - Sampling may be partial
    - a specified proportion is inspected
    - progressive examination may be employed in which the frequency of sampling is increased if rejections exceed a certain percentage
  - Sampling may be statistically-based
    - statistical sampling plans use probability theory to make inferences about production quality

Responsibility for Quality

- The contracting company is responsible for the quality of its work
- The contractor normally employs its own quality control staff
- The purchaser or his agent "the Engineer" may hire an inspector to verify the contractor's work
- Known as "third-party" inspection
  - e.g. ASME Code requirements for third party inspection

Duties of the Welding Inspector

The welding inspector's duties include:

- Verification of welding procedure and operator qualifications
- Surveillance of manufacturing examination and test activities
- Inspection prior to, during, and after welding
- Handling and disposition of deviations from requirements

Inspector Qualifications

- Welding inspectors must be familiar with the product, engineering drawing and specification, codes and standards, and manufacturing and inspection procedures.
- Inspectors may be qualified to standards such as:
  - Canadian Standard W178 "Qualification Code for Welding Inspection Organisations"
  - American Welding Society Welding Inspector Qualification and Certification Program

Non Destructive Examination

- Non destructive examination techniques allow examination of the quality of material without altering its usefulness
- NDE methods generally consist of the following elements
  1. Probing energy or medium
  2. A component to be examined
  3. A detection device for measuring effects on the energy
  4. A means for display or recording the results

Common NDE Methods

- Codes and standards for welded structures commonly specify one or more of the following NDE methods:
  - Visual examination (VT)
  - Liquid Penetrant (PT)
  - Magnetic Particle (MT)
  - Radiography (RT)
  - Ultrasonic examination (UT)

NDE Methods

- Visual
  - Visual examination is the most commonly applied method of inspection
  - It is simple and inexpensive, does not normally require special equipment and gives important information about conformity with specifications, eg.
    - joint preparation and alignment
    - weld size and appearance
    - dimensional accuracy
    - absence of visible defects
  - Visual inspection is limited to conditions on the surface conditions

NDE Methods

- Visual
- Penetrant inspection
  - Penetrant inspection uses a dye or fluorescent penetrant to make surface flaws readily visible
  - equipment and materials can be simple and portable
  - limited to surface-breaking flaws

NDE Methods

- Visual
- Penetrant inspection
- Magnetic Particle Inspection
  - Uses disturbances in the magnetic field in a magnetized steel component to indicate the presence or surface or near-surface flaws
  - Equipment and materials are simple and portable
  - Limited to surface or near-surface flaws on ferromagnetic materials (steel)

NDE Methods

- Visual
- Penetrant inspection
- Magnetic Particle Inspection
- Radiography
  - absorption of radiation from gamma or x-ray sources indicates weld defects with significant height parallel to the beam direction
  - X-ray equipment is costly and non-portable; gamma ray sources can be used in-situ
  - Principal limitations are safety hazards from radiation and lack of sensitivity to planar defects oriented normal to radiation beam

NDE Methods

- Visual
- Penetrant inspection
- Magnetic Particle Inspection
- Radiography
- Ultrasonic examination
  - Echo and diffraction of high frequency sound pulses indicates the flaws or non-uniformities within the material
  - Equipment and probes are complex but portable
  - Limitations: requires skilled operator, no record of results, may be prone to false echoes and indications

Other Test methods

- Proof Testing
  - Of pressure vessels, often takes the form of a hydrostatic or pneumatic pressure test above the design pressure
  - Of other structures may include test loading--e.g. by placing sandbags or scrap iron--to verify the capacity of the structure
- Leak Testing
  - Of closed vessels or pipes
    - sensitivity may be improved by addition of tracer gas e.g. helium
- Destructive tests
  - removal of specimens of material for testing or examination
  - testing of sample products