ASME B31.3 Process Piping

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Piping Development Process

1. Establish applicable system standard(s)
2. Establish design conditions
3. Make overall piping material decisions
   - Pressure Class
   - Reliability
   - Materials of construction
4. Fine tune piping material decisions
   - Materials
   - Determine wall thicknesses
   - Valves
5. Establish preliminary piping system layout & support configuration
6. Perform flexibility analysis
7. Finalize layout and bill of materials
8. Fabricate and install
9. Examine and test

13. Inspection, Examination & Testing

- Inspection
- Examination
  - Methods
  - Requirements
  - Acceptance Criteria
- Leak Testing
  - Methods
  - Requirements

The Material in This Section is Addressed by B31.3 in:

Chapter VI - Inspection, Examination and Testing

Inspection

"(4) *Owner's Inspector.* The owner's Inspector (see para. 340) is responsible to the owner for ensuring that the requirements of this Code for inspection, examination, and testing are met..." [300(b)]

"This Code distinguishes between examination (see para. 341) and inspection. Inspection applies to functions performed for the owner by the owner's Inspector or the Inspector's delegates." [340.1]

Inspection

The owner's inspector:

- Verifies that all required examinations and testing have been completed
- Has access to any place where work is being performed
- Must be independent of organizations performing fabrication, examination, installation or testing
- Must have 10 years experience or 5 years experience plus an engineering degree

Examination

"Examination applies to quality control functions performed by the manufacturer (for components only), fabricator, or erector. Reference in this Code to an examiner is to a person who performs quality control examinations." [341.1]

Examination

The examiner:

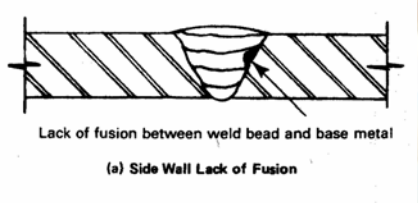
- Examines piping in accordance with Code requirements
- Examines piping is accordance with additional requirements described in the engineering design
- Prepares suitable examination records for use by the inspector
- Shall have training and experience commensurate with the needs of the specified examinations

Examination

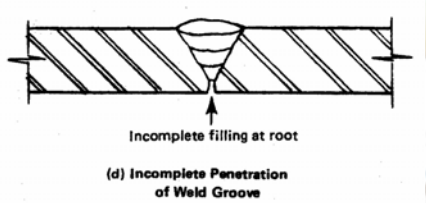
Examination is performed in order to assure that:

- Components conform to the specifications for
  - Material of construction
  - Design
  - Freedom from defects
- Piping is installed with the proper
  - Support
  - Alignment
  - Joint assembly
- Discontinuities are sufficiently small that they don't grow into leaks during operation

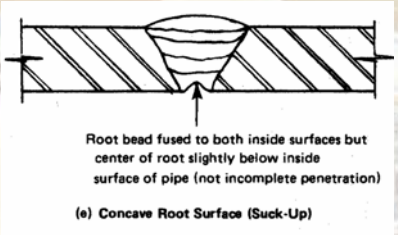
Typical Weld Imperfections



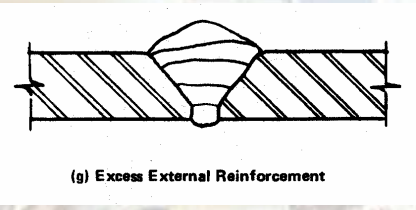
Lack of Fusion



Incomplete Penetration



Suck Up



Excess Reinforcement

Examination Methods

Examination methods include

- Visual (VT)
- Positive Material Identification (PMI)
- Liquid Dye Penetrant (PT)
- Magnetic Particle (MT)
- Radiography (RT)
- Ultrasonic (UT)
- In-Process

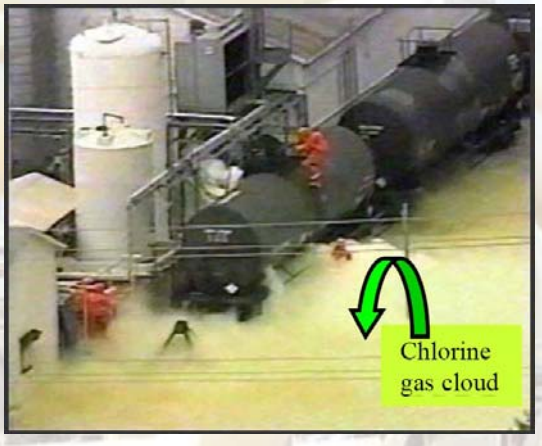
Examination Methods

Visual – Includes examination of materials, fabrication (welds), supports, and installation.

- Least expensive
- Most effective

Examination Methods

Positive Material Identification – Verifies material of construction is as specified.

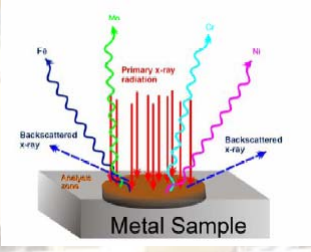


The ruptured hose should have had an Alloy C-276 exterior metal braiding. Instead, the braiding was stainless steel and was easily corroded by chlorine permeation through the Teflon liner. The hose failed after less than 2 months of service. Both the purchase and shipping papers indicated that the hose was constructed of the proper materials, but it was not. (CCPS Beacon, Aug '04)

Examination Methods

Positive Material Identification – Verifies material of construction is as specified.

- X-ray fluorescence – Sample is exposed to low radioactive or x-rays. Reflected energy is different for every element. This energy is measured, thus identifying the alloy elements.



DCI, Inc.

Examination Methods

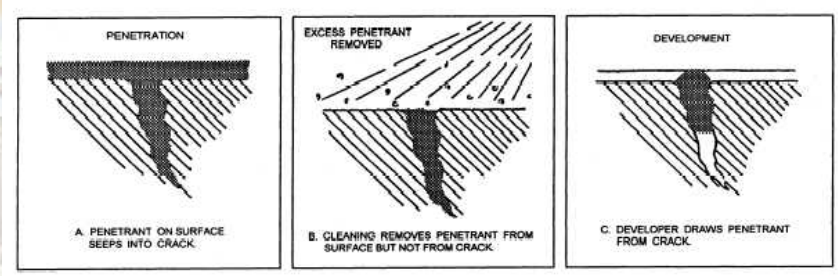
Positive Material Identification – Verifies material of construction is as specified.

- Spark emission spectrography - A spark is released that vaporizes a small portion of the sample. The instrument optically measures the atoms in the vapor to determine the components of the material.

Spectro

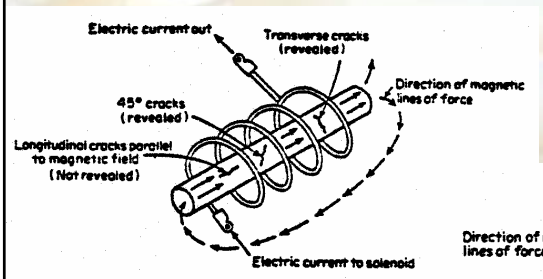
Examination Methods

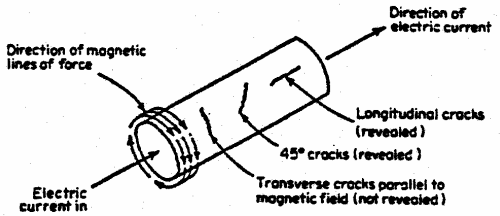
Liquid Dye Penetrant – Employs a dye penetrant applied to the surface and a developer. This method is used to detect fine cracks.



Examination Methods

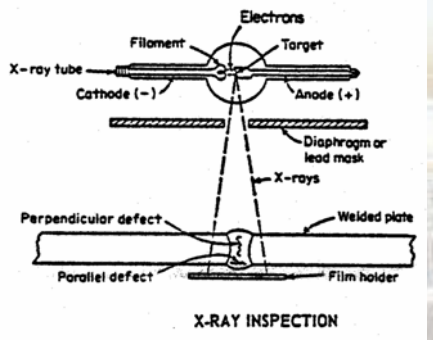
Magnetic Particle – This method is also used to detect fine cracks.

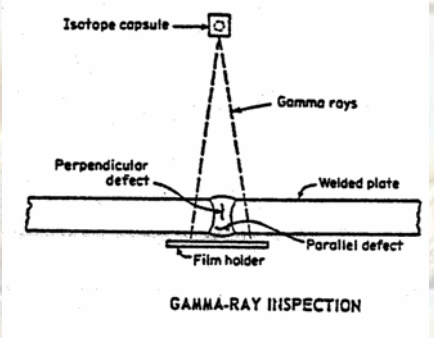




Examination Methods

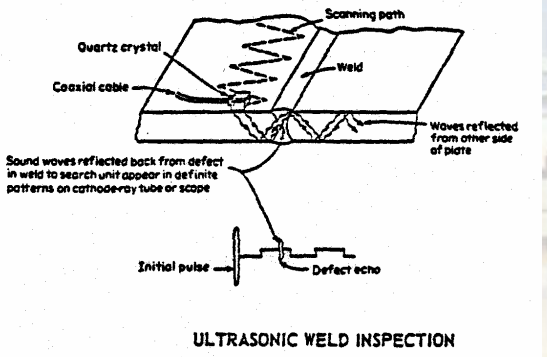
Radiography – Used to detect internal defects and defects on the inside of of the weld for welds which cannot be visually examined on the inside. Will detect some surface defects.





Examination Methods

Ultrasonic – Used to detect internal defects and defects on the inside of of the weld for welds which cannot be visually examined on the inside. Can be used to characterize surface defects.



ULTRASONIC WELD INSPECTION

Examination Methods

In-Process – Used to verify work is performed in such a way that it is likely to produce an acceptable joint. Visual observation of the following is required

- Joint preparation and cleanliness
- Preheating
- Fit-up, clearance and alignment
- For welding
  - Filler material, position and electrode
  - Condition of root pass after cleaning
  - Weld condition between passes
  - Appearance of finished weld

Examination Requirements

Progressive Sampling for Examination [341.3.4]

- For examinations that are not 100%
- When spot or random exam reveals a defect
  - Two additional samples of the same kind are examined the same way
  - If the two samples are acceptable, then lot is acceptable
  - If not, then two further samples of the same kind are examined for each defective sample the same way
  - If all the further samples examined are acceptable, then lot is acceptable
  - If not, then all items in the lot must be examined

Examination Requirements

Progressive Sampling for Examination

- For welds, the work product of each welder or welding operator must be included in the samples being examined
- Defective items must be repaired or replaced and reexamined
- “Same kind” for welds means joints made by the same welder or welding operator

Examination Requirements - VT

	Normal	Severe Cyclic	Category D
Materials & components	Random to extent needed to satisfy the examiner		Random to extent needed to satisfy the examiner
Fabrication, including welds	5% Random	100%	
Longitudinal welds	100%	100%	
Bolted, threaded & other joints	Random to extent needed…, except 100% for pneumatic test	100%	
Supports, alignment, erected piping	Random	100%	

Examination Requirements - Other

	Normal	Severe Cyclic	Category D
Circumferential groove welds	5% Random RT or UT	100% RT	No additional examination required
Socket welds and branch connection welds not radiographed	No additional examination required	100% MT or PT	
Brazed joints	5% in-process examination	(brazed joints not permitted)	
Solder joints	(solder joints not permitted)	(solder joints not permitted)	

Examination Requirements

- In-process examination can be substituted for RT or UT in normal service if specified in the engineering design
- UT can be substituted for RT under severe cyclic conditions if specified in the engineering design

Acceptance Criteria for Welds

Described in Table 341.3.2

TABLE 341.3.2
ACCEPTANCE CRITERIA FOR WELDS AND EXAMINATION METHODS FOR EVALUATING WELD IMPERFECTIONS

Criteria (A to M) for Types of Welds and for Service Conditions [Note (1)]

Normal and Category [illegible] Fluid Service — Type of Weld: Girth, Miter Groove & Branch Connection [Note (4)]	Longitudinal Groove [Note (2)]	Fillet [Note (3)]		Severe Cyclic Conditions — Type of Weld: Girth, Miter Groove & Branch Connection [Note (4)]	Longitudinal Groove [Note (2)]	Fillet [Note (3)]		Category D Fluid Service — Type of Weld: Girth and Miter Groove	Longitudinal Groove [Note (2)]	Fillet [Note (3)]	Branch Connection [Note (4)]		Weld Imperfection	Examination Methods: Visual	Radiography		Magnetic Particle	Liquid Penetrant
A	A	A	...	A	A	A	...	A	A	A	A		Crack	✓	✓	...	✓	✓
A	A	A	...	A	A	A	...	C	A	N/A	A	...	Lack of fusion	✓	✓	...	...	...
B	A	N/A	...	A	A	N/A	...	C	A	N/A	B	...	Incomplete penetration	✓	✓	...	...	...
E	E	N/A	...	D	D	N/A	...	N/A	N/A	N/A	N/A	...	Internal porosity	...	✓	...	...	...
G	G	N/A	...	F	F	N/A	...	N/A	N/A	N/A	N/A	...	Internal slag inlcusion, tungsten inclusion, or elongated indication	...	✓	...	...	...
H	A	H	...	A	A	A	...	I	A	H	H	...	Undercutting	...	✓	...	...	...
A	A	A	...	A	A	A	...	A	A	A	A	...	Surface porosity or exposed slug inclusion [Note (6)]	✓	...	...	...	...
N/A	N/A	N/A	...	J	J	J	...	N/A	N/A	N/A	N/A	...	Surface finish	✓	...	...	...	...
K	K	N/A	...	K	K	N/A	...	K	K	N/A	K	...	Concave root surface (suck up)	✓	✓	...	...	...
L	L	L	...	L	L	L	...	M	M	M	M	...	Weld reinforcement or internal protrusion	✓	...	...	...	...

GENERAL NOTES:
(a) Weld imperfections are evaluated [illegible] one or more of the types of examination methods given, as specified in paras. [illegible] or by the engineering design.
(b) N/A the Code does not establish acceptance criteria or does not require evaluation of this kind of imperfection for this type of yield.
(c) * Alternative Leak Test requires examination of these welds, see para. 345.9
(d) ✓ examination method generally used for evaluating this kind of weld imperfection
(e) ... examination method not generally used for evaluating this kind and weld imperfection.

See page 83 of the supplement.

Testing

Testing is performed to assure that there are no unacceptable leaks in the system prior to operation. Leak test methods include

- Hydrostatic
- Pneumatic
- Initial service
- Sensitive
- Alternate

Leak Test Methods

Hydrostatic – Filling the piping system with liquid, pressurizing and checking for leaks. Test liquid:

- Shall be water unless there are adverse effects
- Other liquid shall be non-toxic with a flash point at least 120ºF (49ºC)
- Chlorides in test water < 50 ppm
- Only dead bugs in water (residual chlorine)

Leak Test Methods

Hydrostatic – Test pressure:

$$P_T = 1.5\ P\ (S_T / S)$$

Where:

- P_T= Minimum test pressure
- P= Design pressure
- S_T= Stress value at test temperature
- S= Stress value at design temperature

- (S_T / S) not to exceed 6.5
- If P_T would produce a nominal stress above S_Y, P_T may be reduced

Leak Test Methods

Pneumatic – Pressurizing the piping system with gas and checking for leaks.

- Care must be taken to minimize the chance of brittle failure
- A pressure relief device is required
- Gas shall be nonflammable and nontoxic
- Test pressure shall be 110% of design pressure
- Preliminary leak check is required
- Leak check is made after pressure is lowed to design pressure

Leak Test Methods

Initial Service – Pressurizing the piping with the service fluid and checking for leaks.

- Pressure increased in steps to operating pressure
- Preliminary leak check is required if test fluid is a gas
- Leak check is made at operating pressure

Leak Test Methods

Sensitive – Pressurizing the piping with a gas and checking for leaks using a method that can detect leaks as small as 10^{-3} atm-ml/sec.

- Test pressure is at least the lesser of 15 psi (105 kPa) and 25% of the design pressure
- Preliminary leak check is required
- Leak check is made at test pressure

Leak Test Methods

Alternative – Verifying weld integrity in lieu of pressurizing above design pressure and checking for leaks.

- Groove welds shall be 100% RT or UT
- All other welds shall be MT or PT
- A formal flexibility analysis is required
- A sensitive leak test is required

Leak Tests Required

A hydrostatic test is required except:

- The owner may choose to use the initial service leak test for Category D fluid service
- The owner may choose a pneumatic leak test if s/he considers the hydrostatic test impractical
- The owner may use the alternative leak test if s/he considers both the hydrostatic and pneumatic tests impractical, and if
  - Hydrostatic test would cause damage or residual liquid would be hazardous, or there is danger of brittle fracture; and
  - Pneumatic test would present an undue hazard, or there is danger of brittle fracture

Other Leak Test Provisions

- Leak tests shall be maintained for at least 10 minutes
- All joints and connections shall be checked for leaks
- Leak tests shall be conducted after heat treatment
- Piping may be tested as subassemblies
- Flanged joints with blanks need not be tested
- Closure welds need not be tested if subjected to
  - In-process examination, and
  - 100% RT or UT examination

Other Leak Test Provisions

- Externally pressurized piping shall be tested at the higher of 1.5 times the design pressure or 15 psi (105 kPa)
- The internal pipe in jacketed piping shall leak tested before the jacket is completed
- For minor repairs and additions following testing, the owner may waive retesting when measures are taken to assure sound construction
- All joints, including structural attachments, must be left exposed for examination during the leak test
- Joints may be painted prior to hydrostatic or pneumatic leak test

Other Leak Test Provisions

- Temporary supports may be needed to support piping during a hydrotest
- Piping with expansion joints
  - Joints that depend on external main anchors to restrain pressure shall be tested in place
  - Such joints shall be tested at the lesser of 1.5 times the design pressure and the test pressure
  - When the test pressure is higher than 1.5 times the design pressure, temporary restraints may be added to limit main anchor loads

Exam & Test Workshop

What examination and leak test requirements would you specify for the following services:

Steam condensate	650 psig (45 bar) Steam
Chlorine	Heat transfer oil
Sulfuric acid	Styrene monomer
Gasoline	Lime-water slurry