ME 423: FLUIDS ENGINEERING

Gas Pipeline Hydraulics

Dr. A.B.M. Toufique Hasan

Professor, Department of Mechanical Engineering

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Pipe Analysis

ASME B31.8 & B31.1

toufiquehasan.buet.ac.bd
toufiquehasan@me.buet.ac.bd

Pipeline Inspection, Examination, and Testing

Prior to initial operation, a piping installation shall be inspected to ensure that the piping has been constructed in accordance with the design, material, fabrication, assembly, examination, and testing requirements of the Code ASME B31.1.

Examination denotes the functions performed by the manufacturer, fabricator, erector, or a party authorized by the owner that include **nondestructive examinations (NDE)**, such as

- Visual
- Radiography (RT)
- Ultrasonic (UT)
- Eddy current
- Liquid penetrant (PT) and
- Magnetic particle (MT) methods

The degree of examination and the acceptance standards beyond the requirements of this Code shall be a matter of prior agreement between the manufacturer, fabricator, or erector and the owner.

Visual Examination

Visual examinations may be conducted, as necessary, during the fabrication and erection of piping components to provide verification that the design and WPS (Welding Procedure Specification) requirements are being met.

In addition, visual examination shall be performed to verify that all completed welds in pipe and piping components comply with the acceptance standards or with the limitations on imperfections specified in the material specification under which the pipe or component was furnished.

(ASME B31.1) *Acceptance Standards.* The following indications are unacceptable:

(1) cracks — external surface.

(2) undercut on the surface that is greater than 1⁄32 in. (1.0 mm) deep, or encroaches on the minimum required section thickness.

(3) undercut on the surface of longitudinal butt welds.

(4) weld reinforcement greater than specified in Table 127.4.2-1.

(5) lack of fusion on surface.

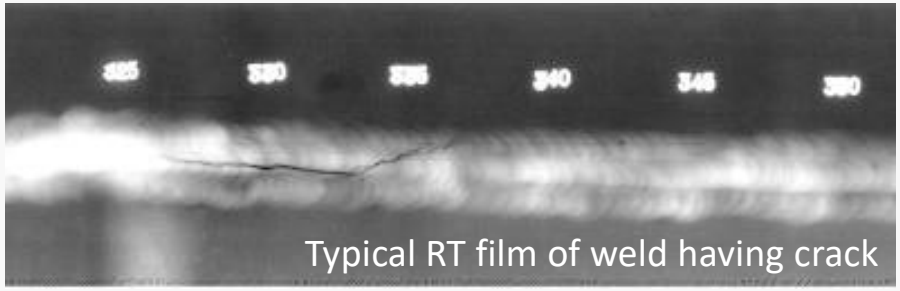
(6) incomplete penetration

(7) surface porosity

Radiography

Radiographic Testing (RT) of weld testing makes use of X-rays, produced by an X-ray tube, or gamma rays, produced by a radioactive isotope. The basic principle of radiographic inspection of welds is the same as that for medical radiography.

- Radiographic testing is a NDE approach for finding porosity, cracks, inclusions and voids in the inside of weldments.
- Surface and subsurface defects can be uncovered.


Typical RT film of weld having crack

(ASME B31.1) *Acceptance Standards.* Welds that are shown by radiography to have any of the following types of discontinuities are unacceptable:

(1) any type of crack or zone of incomplete fusion or penetration

(2) any other elongated indication that has a length greater than

(-a) 1⁄4 in. (6.0 mm) for *t* up to 3⁄4 in. (19.0 mm), inclusive

(-b) 1⁄3*t* for *t* from 3⁄4 in. (19.0 mm) to 21⁄4 in. (57.0 mm), inclusive

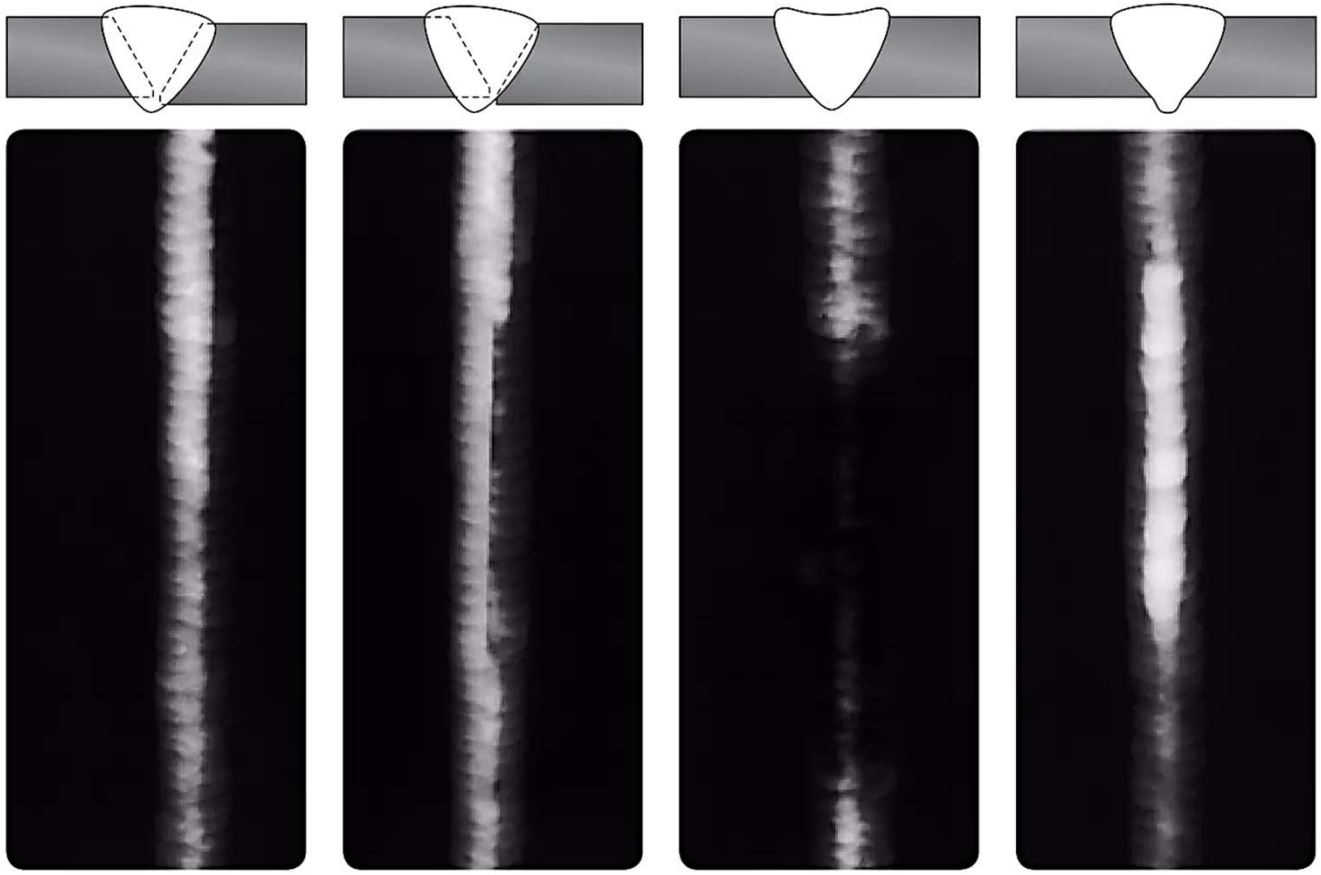
(-c) 3⁄4 in. (19.0 mm) for *t* over 21⁄4 in. (57.0 mm)

where *t* is the thickness of the thinner portion of the weld

Radiography cont.

Reference Radiographs

The following selection of radiographs illustrates the wide variety of possibilities for detection of discontinuities.



Offset or mismatch (Hi-Lo).

An abrupt change in film density across the width of the weld image.

Offset or mismatch with Lack of Penetration (LOP).
An abrupt density change across the width of the weld image with a straight longitudinal darker density line at the centre of the width of the weld image along the edge of the density change.

External concavity or insufficient fill.

The weld density is darker than the density of the pieces welded and extending across the full width of the weld.

Excessive penetration.

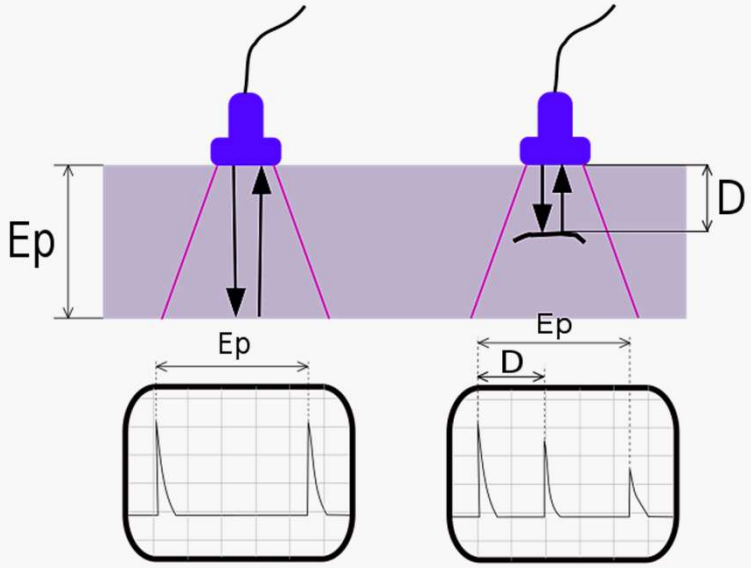
A lighter density in the centre of the width of the weld image, either extended along the weld or in isolated circular drops.

Ultrasonic Examination

Ultrasonic testing (UT) is a family of non-destructive testing techniques based on **the propagation of ultrasonic waves in the object or material tested**.

In most common UT applications, very short ultrasonic pulse waves with center frequencies ranging from 0.1-15 MHz and occasionally up to 50 MHz, are transmitted into materials to detect internal flaws or to characterize materials.

A common example is ultrasonic thickness measurement, which tests the thickness of the test object, for example, to monitor pipework corrosion and erosion. Ultrasonic testing is extensively used to detect flaws in welds.



Ultrasonic Examination cont.

(ASME B31.1) ***Acceptance Standards.*** Welds that are shown by ultrasonic examination to have discontinuities that produce an indication greater than 20% of the reference level shall be investigated to the extent that ultrasonic examination personnel can determine their shape, identity, and location so that they may evaluate each discontinuity for acceptance in accordance with (1) and (2).

(1) Discontinuities evaluated as being cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length.

(2) Other discontinuities are unacceptable if the indication exceeds the reference level and their length exceeds the following:

(-a) 1⁄4 in. (6.0 mm) for *t* up to 3⁄4 in. (19.0 mm).

(-b) ⅓*t* for *t* from 3⁄4 in. (19.0 mm) to 21⁄4 in. (57.0 mm).

(-c) 3⁄4 in. (19.0 mm) for *t* over 21⁄4 in. (57.0 mm)

where *t* is the thickness of the weld being examined.

PRESSURE TESTS (Hydro Test)

The **pressure testing / Hydrostatic testing / Hydro test** of piping systems to ensure leak tightness shall be acceptable for the determination of any leaks in piping subassemblies.

Test Medium.

Water shall normally be used as the test medium unless otherwise specified by the owner.

Test water shall be clean and shall be of such quality as to minimize corrosion of the materials in the piping system.

PRESSURE TESTS (Hydro Test) cont.

(ASME B31.1) 137.4.5 Required Hydrostatic Test Pressure. The hydrostatic test pressure at any point in the piping system **shall not be less than 1.5 times the design pressure**, but shall not exceed the maximum allowable test pressure of any nonisolated components, such as vessels, pumps, or valves, etc.

The pressure shall be continuously maintained for **a minimum time of 10 min** and may then be **reduced to the design pressure and held for such time** as may be necessary to conduct the examinations for leakage.

Examinations for leakage shall be made of all joints and connections. The piping system, exclusive of possible localized instances at pump or valve packing, shall show no visual evidence of weeping or leaking.

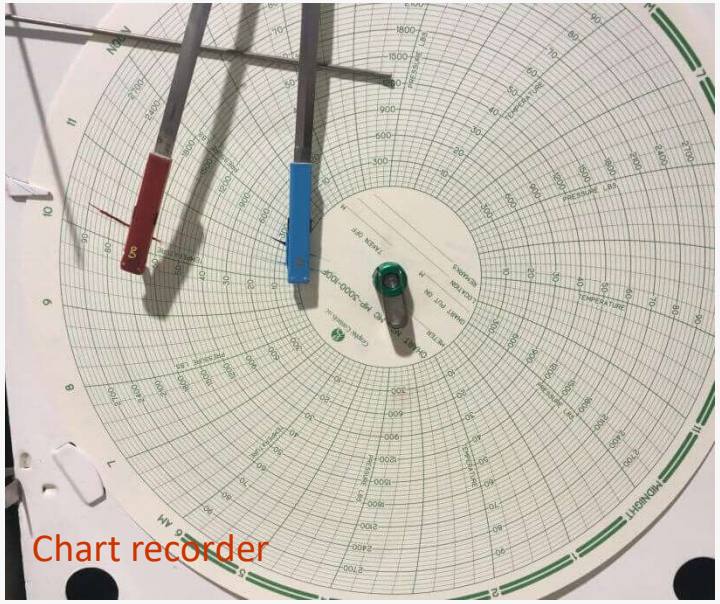


Chart recorder

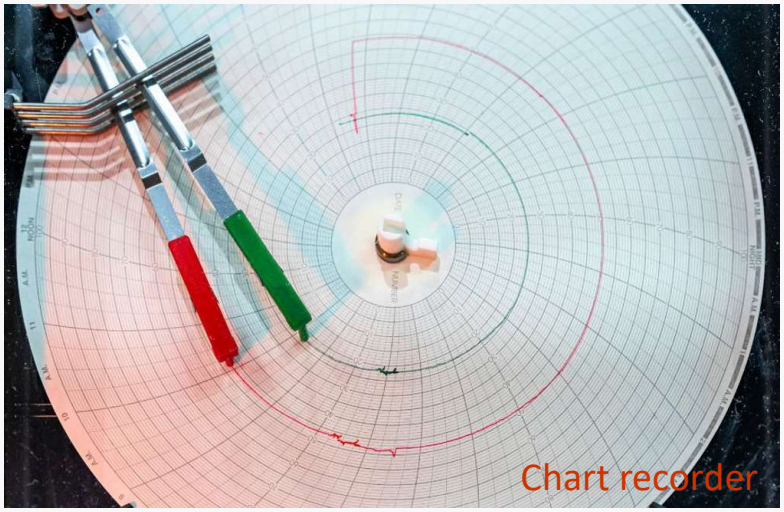


Chart recorder

Gas pipeline Pigging

Pipeline pigging is a concept in pipeline maintenance that involves the use of electro-mechanical devices known as pigs, which clean pipelines and are capable of checking pipeline conditions.

Pigs sweep the line by scraping piping surfaces and pushing debris ahead. They can perform many functions as they travel along a pipeline:

- Clearing The Line
- Breaking Up Clogs
- Inspecting The Interior
- Pipeline Cleaning

Blowdown valves and piping systems are installed around the mainline valve in a gas transmission piping system in order to evacuate gas from sections of pipeline in the event of an emergency or for maintenance purposes.

The objective of the blowdown assembly is to remove gas from the pipeline once the pipe section is isolated by closing the mainline block valves in a reasonable period of time. The pipe size required to blow down a section of pipe will depend on the gas gravity, pipe diameter, length of pipe section, pressure in the pipeline, and blowdown time. AGA recommends the following equation to estimate the blowdown time:

$$T = \frac{0.0588 P_1^{\frac{1}{3}} G^{\frac{1}{2}} D^2 L F_c}{d^2} \quad \text{(USCS units)} \qquad (6.9)$$

where

T = blowdown time, min
P_1 = initial pressure, psia
G = gas gravity (air = 1.00)
D = pipe inside diameter, in.
L = length of pipe section, mi
d = inside diameter of blowdown pipe, in.
F_c = choke factor (as follows)

Choke factor list

Ideal nozzle = 1.0
Through gate = 1.6
Regular gate = 1.8
Regular lube plug = 2.0
Venturi lube plug = 3.2

BLOWDOWN CALCULATIONS cont.

In SI units,

$$T = \frac{0.0192 P_1^{\frac{1}{3}} G^{\frac{1}{2}} D^2 L F_c}{d^2} \quad \text{(SI units)} \qquad (6.10)$$

where

P_1 = initial pressure, kPa
D = pipe inside diameter, mm
L = length of pipe section, km
d = pipe inside diameter of blowdown, mm

Other symbols are as defined before.

Problem

Example 4:

Calculate the blowdown time required for an NPS 6, 0.250 in. wall thickness, blowdown assembly on an NPS 24 pipe, 0.500 in. wall thickness, considering a 5 mi pipe section starting at a pressure of 1000 psia. The gas gravity is 0.6 and choke factor = 1.8.

Ans: 58 min. approx