

PIPELINE INTEGRITY BASICS

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Topics

- Class Locations 1, 2, 3, and 4
- High Consequence Areas (HCAs)
- Potential Impact Radius (PIR)
- Threats to Pipeline Integrity
- Means of Mitigating Threats

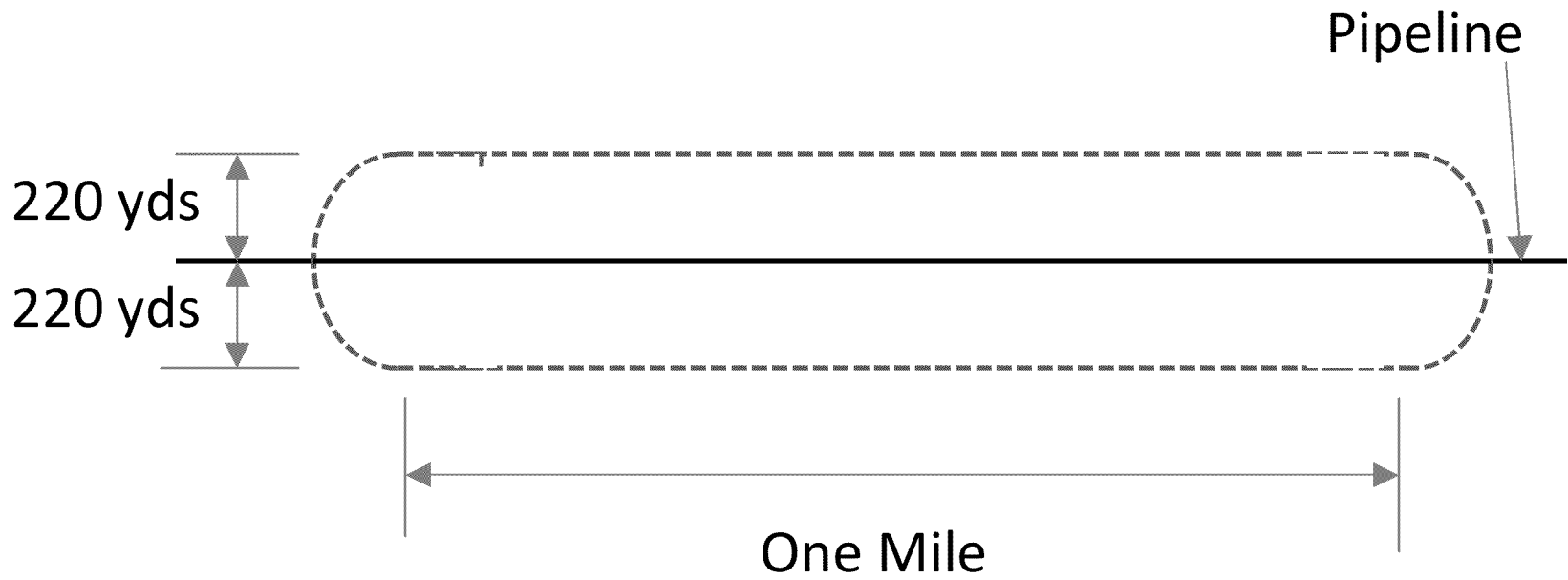
Reference Documents

- Code of Federal Regulations, Title 49, Part 192, (49 CFR 192) – Transportation of Natural and Other Gas By Pipeline: Minimum Federal Safety Regulations
- ASME B31.8 – 2007 “Gas Transmission and Distribution Piping Systems”
- ASME B31.8S – 2004 “Managing System Integrity of Gas Pipelines”

CLASS LOCATIONS

Class locations are used to establish design factors (safety margins). They are based on population density. Class locations are defined in 49 CFR 192, §192.5

CLASS LOCATION UNIT



CLASS 1

- An offshore area.
- Class location unit has 10 or fewer buildings intended for human occupancy.

Each separate dwelling unit in a multiple dwelling unit building is counted as a separate building intended for human occupancy. Thus, a four-family apartment would be considered as four buildings intended for human occupancy.

Class 2

- Class location unit has more than 10 but fewer than 46 buildings intended for human occupancy.

CLASS 3

- Class location unit has 46 or more buildings intended for human occupancy; or
- Pipeline lies within 100 yards of either a building or place of public assembly that is occupied by 20 or more persons on at least 5 days a week for 10 weeks in any 12-month period

Class 4

- A class location unit where buildings with four or more stories above ground are prevalent.

DESIGN FACTORS

The design factors determine the maximum allowable operating stress in the pipeline.

- Class 1 72% of SMYS
- Class 2 60% of SMYS
- Class 3 50% of SMYS
- Class 4 40% of SMYS

where SMYS stands for specified minimum yield strength of the pipe.

RELATIONSHIP BETWEEN PRESSURE AND STRESS

The maximum allowable operating pressure (MAOP) in a pipeline is related to the maximum allowable operating stress by the “Barlow” formula. For a Class 1 location:

$$\text{MAOP} = 0.72 * \text{SMYS} * 2t / (D)$$

where:

D is the outside diameter of the pipe and
t is the wall thickness of the pipe

MAXIMUM ALLOWABLE OPERATING PRESSURE (MAOP)

For a pipeline comprised of 30-inch-outside-diameter, 0.375-inch wall thickness, Grade X52 (52,000 pounds per square inch minimum yield strength) steel pipe, the MAOP for each class location is as follows:

- Class 1 936 pounds per square inch
- Class 2 780 pounds per square inch
- Class 3 650 pounds per square inch
- Class 4 520 pounds per square inch

MINIMUM REQUIRED WALL THICKNESS

For a 30-inch-outside-diameter pipeline comprised of X52 steel pipe that is operated at an MAOP of 936 pounds per square inch, the wall thickness of the pipe for each class location would have to be:

- Class 1 0.375 inch
- Class 2 0.450 inch
- Class 3 0.540 inch
- Class 4 0.675 inch

EFFECT OF POPULATION INCREASES

In most cases population growth that would change a class location unit by two class locations would require installing new pipe with greater wall thickness or reducing the MAOP commensurate with the current class location.

Thus, if the number of buildings in a Class 1 location unit increases from 10 or less to 46 or more (Class 3 location), the existing pipe would have to be replaced with pipe of 44% greater wall thickness or the pressure would have to be lowered by just over 30%.

HIGH CONSEQUENCE AREA

The concept of a high consequence area was developed jointly by pipeline industry experts and federal regulators to determine the parts of a pipeline system where periodic integrity assessments are needed to protect the public and the environment.

HIGH CONSEQUENCE AREA DEFINITION

- A Class 3 or Class 4 location.
- An area in a Class 1 or Class 2 location where the potential impact radius is greater than 660 feet (220 yards) and the potential impact circle contains 20 or more buildings intended for human occupancy or an *identified site*.

IDENTIFIED SITES

- Outside areas occupied by 20 or more people on at least 50 days in any 12 month period.
- Buildings occupied by 20 or more people on at least 5 days a week for 10 weeks in any 12 month period.
- A facility such as a hospital where evacuation would be difficult.

POTENTIAL IMPACT RADIUS (PIR)

Determining High Consequence Area

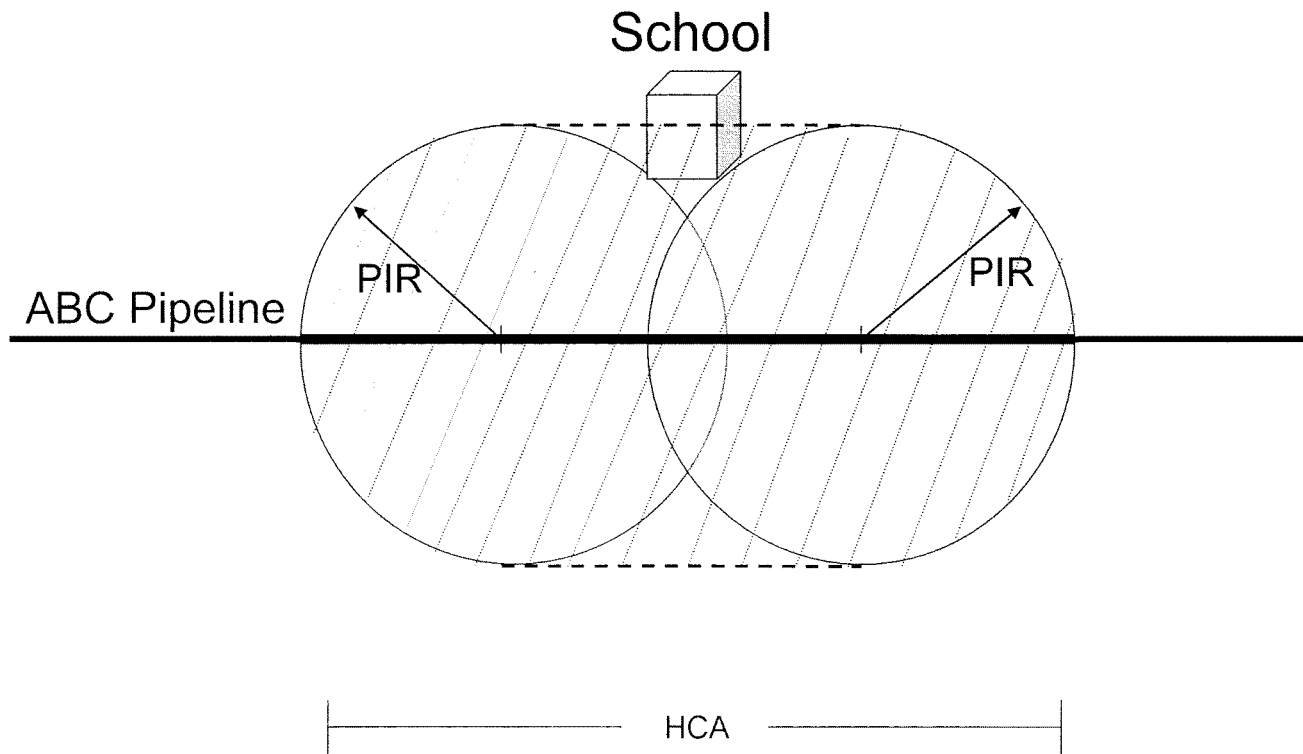


Figure E.I.A

POTENTIAL IMPACT RADIUS (PIR)

PIR is the distance beyond which a person standing outside in the vicinity of a pipeline rupture and fire would have a 99% chance of surviving.

The PIR increases as the diameter of the pipeline increases and as the pressure in the pipeline increases.

EXAMPLES OF PIRs

Diameter, inches	Pressure, psig	PIR, Feet	PIR, Yards
16	1440	419	140
30	1000	654	218
36	1000	786	262

$$\text{PIR} = 0.69 * (\text{diameter}) * (\text{pressure})^{0.5}$$

What is a pipeline “integrity threat”?

A condition or set of circumstances that, if not mitigated, could cause a pipeline to fail.

THE FIRST LINE OF DEFENCE AGAINST INTEGRITY THREATS

- Design by ASME Standards
- Select good line pipe materials
- Provide competent supervision and inspection
- Coat and cathodically protect the pipeline
- Conduct an appropriate pre-service hydrostatic test
- Maintain and inspect the pipeline in service
- Protect the pipeline from outside forces
- Operate the pipeline safely

TIME-DEPENDENT THREATS

Threat	Percentage of Significant Pipeline Incidents between 1991 and 2010
External Corrosion	9.9%
Internal Corrosion	12.9%
Stress Corrosion Cracking	1.0%

TIME-STABLE THREATS

Threat	Percentage of Significant Pipeline Incidents between 1991 and 2010
Manufacturing Defects	3.4%
Construction and Fabrication Defects	3.3%

RANDOM THREATS

Threat	Percentage of Significant Pipeline Incidents between 1991 and 2010
Mechanical Damage	23.4%
Equipment Failure	13.3%
Incorrect Operations	1.8%

RANDOM THREATS (continued)

Threat	Percentage of Significant Pipeline Incidents between 1991 and 2010
Forces of Nature	11.8%
Miscellaneous & Unknown	18.9%

MITIGATION OF TIME-DEPENDENT THREATS

- Identify applicable threats
- Prioritize segments by perceived severity
- Conduct the appropriate assessments to determine the conditions of the segments
- Repair injurious defects
- Calculate times to failure for anomalies that were not severe enough to require repair
- Re-assess well before the times to failure are reached, repair injurious defects, and re-calculate the times to failure

ASSESSMENT METHODS

- ILI in-line inspection with “smart” pig
- HT hydrostatic test
- ECDA external corrosion direct assessment
- ICDA internal corrosion direct assessment
- SCCDA stress corrosion cracking direct assessment
- NDE non-destructive examination of an exposed or above-ground component

LIMITATIONS ON ASSESSMENT METHODS

- Pipeline must be “piggable” to use ILI
- ILI technology not yet reliable for all types of anomalies
- Some segments cannot be taken out of service for HT
- ECDA, ICDA, and SCCDA each only apply to one single threat although ECDA can be effective for finding prior excavation damage

ASSESSMENT METHODS FOR TIME-DEPENDENT THREATS

Threat	Assessment Methods
External Corrosion	ILI, ECDA, HT
Internal Corrosion	ILI, ICDA, HT
Environmental Cracking	ILI, SCCDA, HT

ASSESSMENT METHODS FOR TIME-STABLE THREATS

Threat	Assessment Methods
Manufacturing Defects	HT, ILI
Construction and Fabrication Defects	HT, NDE

MITIGATION OF TIME-STABLE THREATS

- Good pre-service hydrostatic test
- Non-destructive inspection of welds during construction and fabrication

MITIGATION OF RANDOM THREATS

Threat	Mitigation Methods
Mechanical Damage	One-call system, markers, public awareness, patrolling
Equipment Failure	Periodic inspection and maintenance
Incorrect Operations	Operator training and qualification

MITIGATION OF RANDOM THREATS (continued)

Threat	Mitigation Methods
Forces of Nature	Patrolling and monitoring
Miscellaneous & Unknown	Mitigation cannot be defined unless the threat is known

QUESTIONS?