NATIONAL ACADEMIES
Sciences Engineering Medicine
Transportation Research Board

Committee on
Criteria for Installing Automatic and Remote-Controlled Shutoff Valves on Existing Gas and Hazardous Liquid Transmission Pipelines

Pipeline and Hazardous Materials Safety Administration
Office of Pipeline Safety

PHMSA: Potential Impact Radius

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Overview

- Identifying High Consequence Area (HCA)
  - Definitions
  - Methods 1 and 2
- Potential Impact Radius (PIR) Calculation
- PIR versus Pressure and Diameter
- Gas Transmission (GT) Pipeline Mileage –
  - HCA, Moderate Consequence Area (MCA), and All Other
- Gas Transmission Ruptures –
  - Potential versus Actual Impact Radius
- Committee Questions

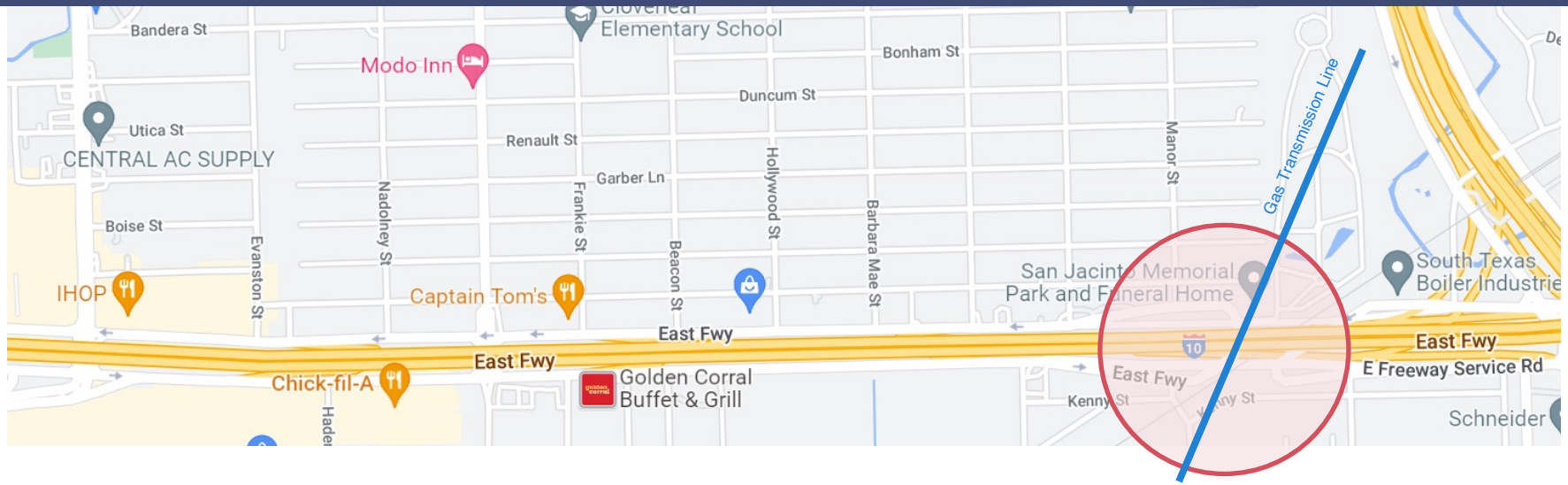
GT Pipeline Ruptures – Potential vs Actual Impact Radius - 2017 to present

Year	Location	Pipe Diameter (in)	MAOP (psi)	Pressure at time of Failure (psi)	PIR (ft) Based on MAOP	PIR (ft) Based on Pressure at time of failure	Impact Area		Pipe Ejected (ft)	Isolation Time (hr:sec)	Fire Duration (hr:sec)
							Length (ft)	Width (ft)			
2017	Dixon IL	20	800	706	391	367	365	163	-	0:31	3:06
2018	Batesville OH	24	1,440	1,296	629	596	50	50	-	0:00	1:04
2018	Moundville OH	36	1,440	1,280	943	889	250	250	100	0:25	3:05
2018	Hesston KS	26	899	837	538	519	400	200	254	0:02	2:44
2018	Buffalo OK	26	765	751	497	492	110	60	170	1:09	-
2018	Woodruff UT	20	918	780	419	386	143	90	430	1:21	-
2018	Dixon Springs TN	22	773	756	422	418	30	20	75	0:38	-
2019	Caldwell OH	30	936	803	634	586	500	500	-	1:35	14:05
2019	Mexico MO	30	900	889	621	618	437	286	125	1:12	1:31
2019	Hot Springs AR	30	1,000	980	655	648	252	114	306	2:12	-
2019	Danville KY	30	936	925	634	630	704	645	600	1:52	3:07
2019	Artesia NM	20	1,000	880	437	410	100	60	360	3:23	-
2020	Lake Worth FL	18	866	846	366	362	300	50	400	0:25	-
2021	Ellsworth KS	30	991	958	652	641	516	344	500	1:29	1:31
2021	Coolage AZ	30	944	863	636	609	600	360	125	2:46	3:01
2022	Uniontown, AL	18	1,200	1,169	431	425	468	160	72	1:26	1:45
2022	Clermont, PA	24	858	854	486	484	500	250	304	0:02	0:22

Potential Impact Radius – 49 CFR 192.903 – Integrity Management

- **Potential Impact Radius (PIR)** – developed for Gas Transmission Integrity Management to identify High Consequence Areas
  - Added to 49 CFR 192.903 in late 2003 - 03-30280.pdf (govinfo.gov)
  - Docket No. RSPA–00–7666; Amendment 192–95
  - **Pipeline Safety: Pipeline Integrity Management in High Consequence Areas (Gas Transmission Pipelines)**
- PIR calculations for natural gas were developed by:
  - Gas Research Institute (GRI) report by C-FER Technologies (C-FER), "A Model for Sizing High Consequence Areas Associated with Natural Gas Pipelines" (Stephens 2000)
- **PIR is based on a heat intensity threshold of 5000 Btu/hr-foot^2** and a significant chance of fatal injury as a 1% chance of mortality.
  - The exposure time adopted was 30 seconds based on the premise that an exposed person would stay in place for 1 to 5 seconds to evaluate the situation and then run at 5 miles per hour (7.3 feet per second) to some type of shelter within approximately 200 feet of their initial position.

Identifying Gas Transmission (GT) High Consequence Areas (HCAs) Definitions



Definitions - Potential Impact Radius (PIR)

- Used for Gas Transmission Integrity Management (49 CFR Part 192, Subpart O) to determine HCAs.
- is the radius of circle within which the failure of a pipeline could have significant impact on people or property.
- Moderate Consequence Area – uses PIR

Identifying GT HCAs - Definitions

Definitions - Identified Site defined as:

- An outside area or open structure that is occupied by twenty (20) or more persons on at least 50 days in any twelve (12)-month period; or
- A building that is occupied by twenty (20) or more persons on at least five (5) days a week for ten (10) weeks in any twelve (12)-month period; or
- A facility occupied by persons who are confined, are of impaired mobility, or would be difficult to evacuate. (e.g., hospitals, prisons, schools, day-care facilities, retirement facilities or assisted-living facilities).

Identifying GT HCAs - Definitions

Definitions

- **Potential impact circle (PIC)** is defined as a circle of radius equal to the **potential impact radius - (PIR)** - 49 CFR 192.903
- **Potential impact radius (PIR)**
  - **Radius (r)** = $0.69 * \sqrt{(p * d^2)}$
    - `r' is the radius of a circular area in feet surrounding the point of postulated failure;
    - `p' is the maximum allowable operating pressure (MAOP) in the pipeline segment in pounds per square inch; and
    - `d' is the nominal diameter of the pipeline in inches.

Identifying GT HCAs - Definitions

Class Locations	Class 1	Class 2	Class 3	Class 4
Definition: Dwellings along a 1-mile length and 660-feet on either side of the pipeline	10 or fewer dwellings	11-45 dwellings	46 or more dwellings OR occupied sites	Buildings with 4 or more stories are prevalent
Examples	Very rural areas	Sparse suburbs, small towns and villages	Urban areas, suburban developments	Urban downtowns, apartment complexes

Relative Potential Consequences to People

Class 3

Identifying GT HCAs – Method 1

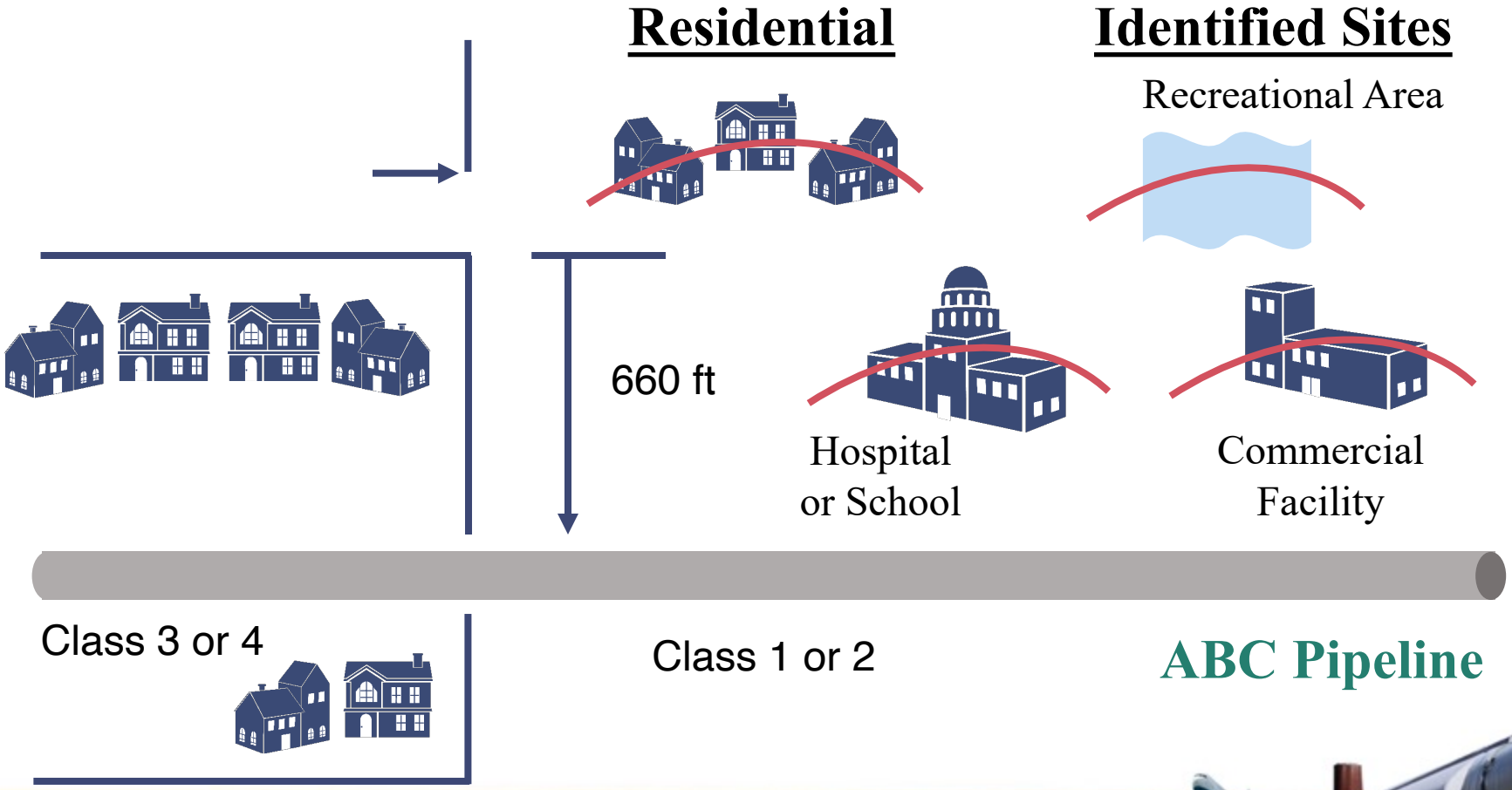
Operators can choose one of two methods to identify HCAs

- **Method 1** is based on class locations and includes:
  - All Class 3 and 4 locations;
  - Any area in a Class 1 or Class 2 location where the potential impact radius is greater than 660 feet (200 meters), and the area within a potential impact circle (PIC) contains 20 or more buildings intended for human occupancy (affects only large-diameter, high-pressure lines); or
  - Any area in a Class 1 or Class 2 location where the potential impact circle contains an "identified site" (areas where people congregate).

Identifying GT HCAs – Examples of Method 1

46 or more BIHOs Or with 4 or more stories

20 or more BIHOs



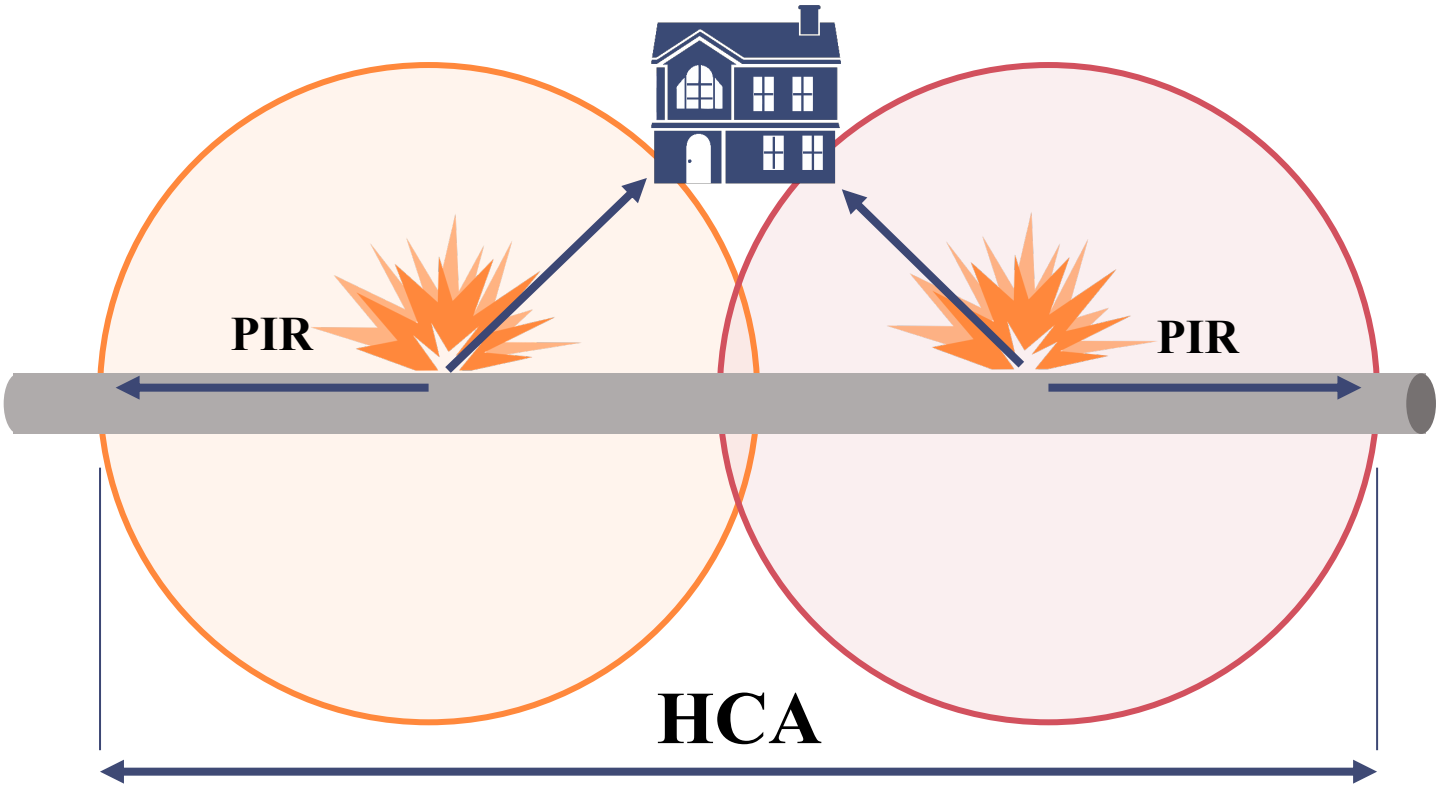
Identifying GT HCAs – Method 2

Method 2

- **Method 2** is based on calculating the distance at which significant effects can be expected from a postulated pipeline rupture and resulting fire, using PIR, and includes:
  - Any location on the pipeline with a potential impact circle containing—
    - (i) 20 or more buildings intended for human occupancy; or
    - (ii) An identified site
- Rule provisions extend the HCA outside the first and last potential impact circle along a segment by one PIR

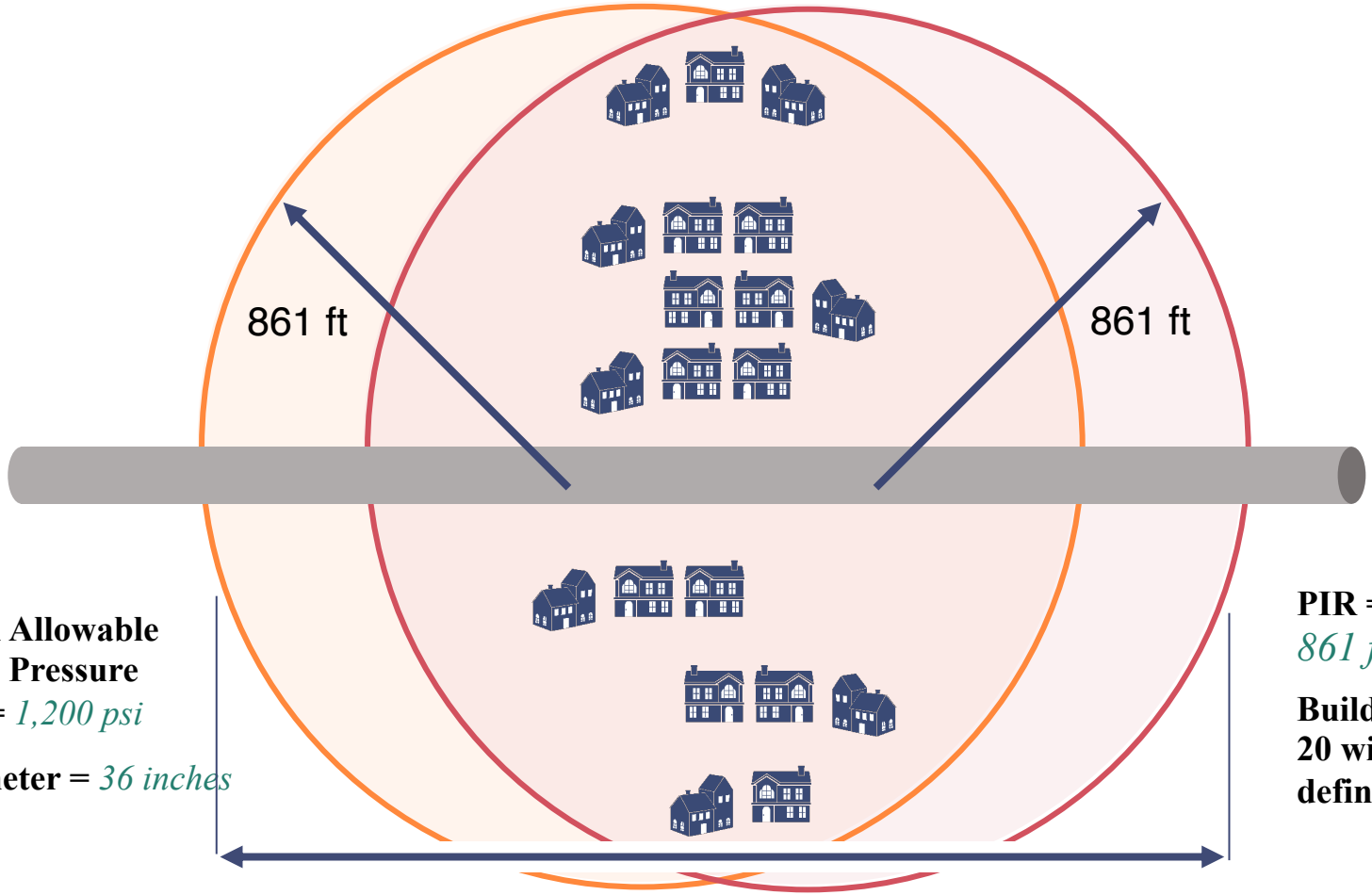
Identifying GT HCAs – Method 2 Identified Site

Example of an HCA Segment Using Method 2 – Identified Site



Includes the Area Extending Axially Along the Length of the Pipeline – One PIR in each direction – shown in 49 CFR Part 192, Appendix E

Identifying GT HCAs – Method 2



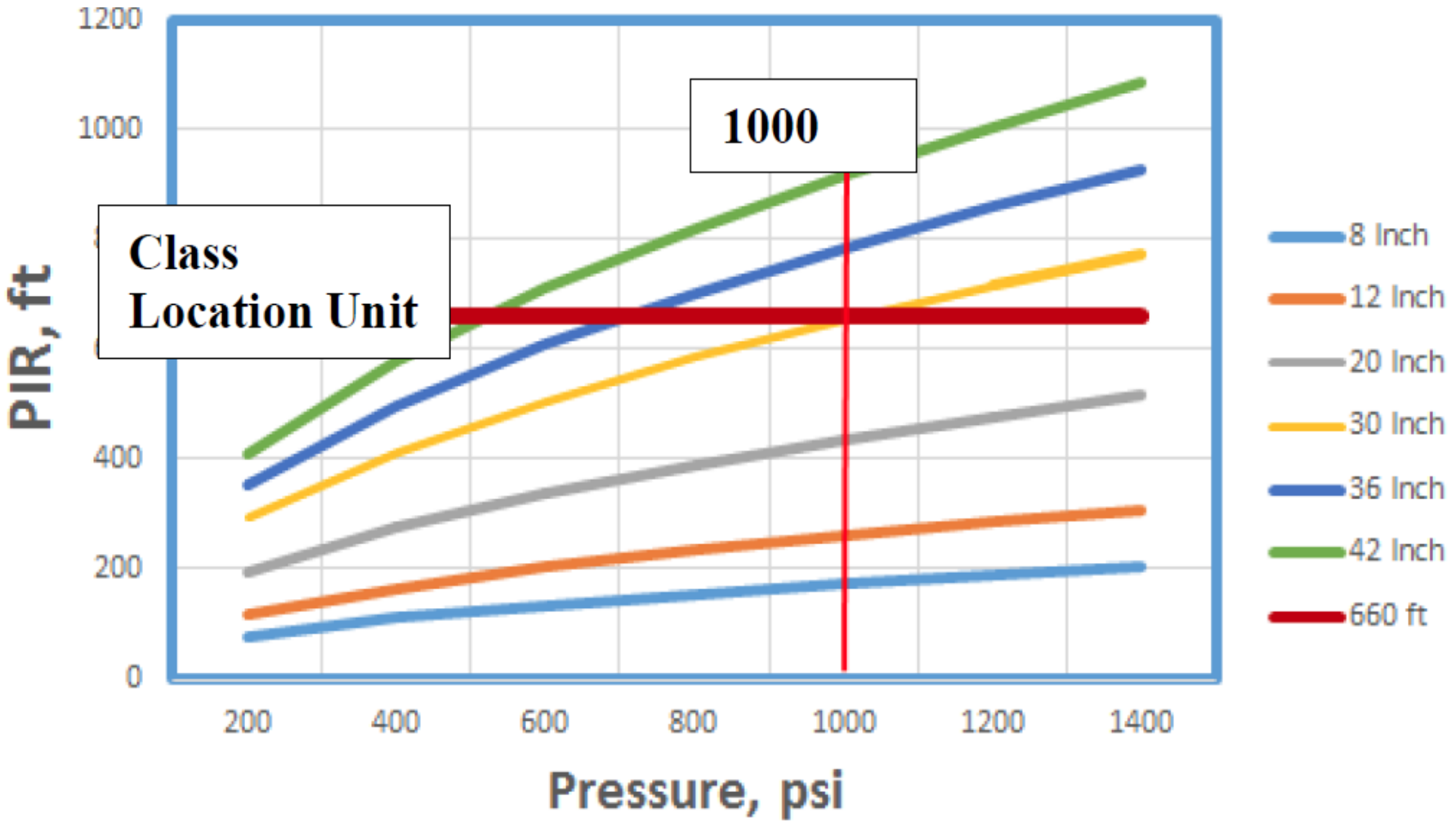
Maximum Allowable Operating Pressure (MAOP) = *1,200 psi*

Pipe Diameter = *36 inches*

PIR = $0.69\sqrt{pd^2}$ = *861 feet*

Building Count ≥ 20 within the PIC defines as HCA

PIR versus Pressure and Diameter



Identifying GT Moderate Consequence Area - Definition

Definitions:

- **Moderate Consequence Area (MCA)**
  - Uses the Potential Impact Radius of 49 CFR 192.903
  - Five or more buildings intended for human occupancy
  - Any portion of the paved surface, including shoulders, of a designated interstate, other freeway, or expressway, as well as any other principal arterial roadway with 4 or more lanes
- **49 CFR 192.710(a)(2)**
  - Requires a piggable GT MCA with a MAOP over 30 percent of specified minimum yield strength to be periodically reassessed every 10 years.

GT Pipeline Mileage – HCA, MCA, and All Other

Gas Transmission Pipeline – (10/03/22)

	Total (miles)	HCA	MCA ILI-able	MCA ILI-not-able	All Other
Class 1	236,538	1,646	7,913	1,192	225,787
Class 2	30,419	1,631	7,059	866	20,863
Class 3	33,689	17,101	4,423	1,768	10,397
Class 4	871	732	50	6	83
Total	301,517	21,110	19,445	3,832	257,130

1) GT Miles from Part L of the GGGT Annual Report; 2) HCA Miles from Part Q of the GGGT Annual Report; 3) MCA Miles from Part R of the GGGT Annual Report; 4) CY 2021 GT Annual Report data as-of 10/3/2022

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Committee Questions

Committee questions on potential impact radius (PIR):

1) PIR calculations and how those calculations differ from real world data/scenarios
   - Reply: See slide above with facts from actual ruptures and impacted area.
2) How PIR informs the determination of High Consequence Areas (HCAs)
   - Reply: Used to determine HCA pipeline mileage for gas transmission (GT) pipelines. Also, PIR is used to determine the mileage in a Moderate Consequence Area (MCAs).
3) If PIR is used as a factor in economic analysis at PHMSA, and if so, how is it used
   - Reply: PIR is used to determine the GT pipeline mileage in HCAs and MCAs. The HCA and MCA mileage may be a factor in economic analysis.

Committee Questions - continued

Committee questions on potential impact radius (PIR):

4) Any alternatives to PIR that PHMSA uses and, if so, in what context and why
   - Reply: 49 CFR 192.903 allows "2 Methods" for determining GT HCAs
     - **(1)** Class location or **(2)** PIR.

5) Insight into whether PHMSA is considering changes [to PIR calculations / definitions] that would significantly increase or decrease the affected areas.
   - Reply: PHMSA is not considering changes to PIR at this time.
     - PHMSA has strengthened the assessment and repair requirements for non-HCAs in the Gas Rule – RIN 1 and 2:
       - 192.712 and 192.714 strengthens repair criteria for non-HCAs
       - 192.710 – requires initial and periodic assessments of piggable MCAs
     - Gas Rule changes impact 21,110 HCA miles and 19,445 MCA miles

Any Questions?

Thank You

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