Introduction to Risk Assessment (Distribution – DIMP)

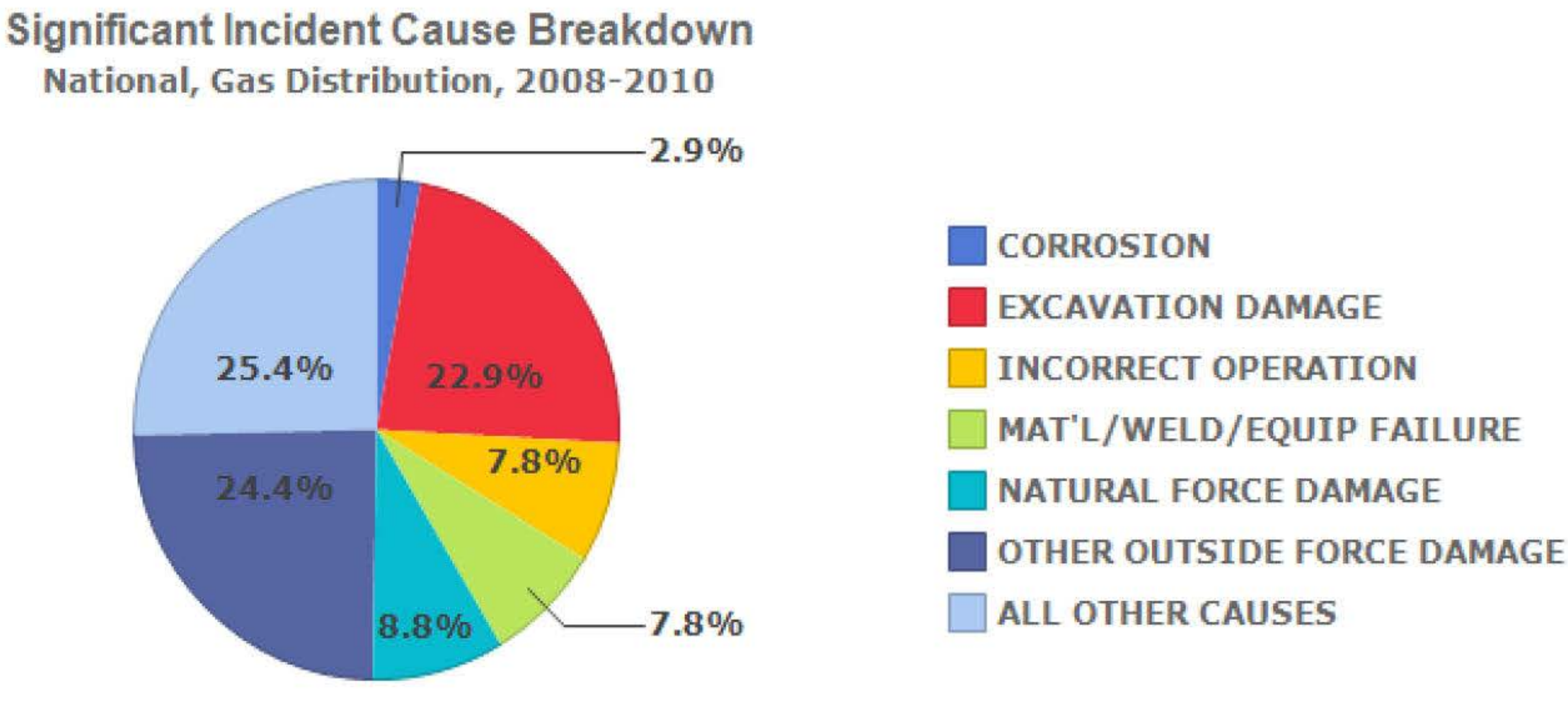
2014 KCC Kansas Pipeline Safety Seminar
October 28th & 29th

Know what's **below.**
Call before you dig.

Distribution Integrity Management Plan

Identify Threats
&
Evaluate and Rank Risk

Most significant Threat?



Source: PHMSA Significant Incidents Files March 1, 2011

- Note: Fire first incidents are excluded from 2004 onward in national statistics on the PHMSA stakeholder website. Operators are only required to report them when they cause >$50K damage to operator's facilities.

Threat assessment

Identify types of threats to which the system might be exposed.

Eight Primary Threat Categories

1. Corrosion
2. Natural Forces
3. Excavation Damage
4. Other Outside Force Damage
5. Material or Weld Failure
6. Equipment Failure
7. Incorrect Operation
8. Other

Threat Identification

- Threat categories
  - Time Dependent
  - Time Independent
- Data Gathering, Data Integration, Threat Identification, and Risk Assessment are inter-related and dependent upon each other
- A failure of one of these processes can result in threats to the integrity of the pipeline not being addressed
- Threats are Potential Pipeline Failure Mechanisms or Pipeline Failure Cause Categories
- Identifying Threats is key to Operator Integrity Decisions regarding measures to implement to reduce risk(s).

Identifying threats

- Threat Subcategories
- Potential Threats
  - Trenchless technology – unknowingly bored thru sewer or water lines
  - Future utility/road improvements
  - Customer overbuilt on pipeline
  - Hurricanes

Primary Threat	Threat Subcategories	Questions to Check Subcategory Applicability to System	Extent of Threat		
			General	Local	NA
OTHER OUTSIDE FORCE DAMAGE	Vehicular	• Are aboveground facilities being hit by vehicles? • Are aboveground facilities located near a roadway, driveway, or other location where they may be susceptible to vehicular damage? • Are susceptible aboveground facilities protected from vehicular damage?			
	Vandalism	• Has damage or leakage been caused by malicious actions of unauthorized individuals? • Has gas theft occurred?			
MATERIAL, WELD, OR JOINT FAILURE	Manufacturing defects	• Have manufacturing defects in pipe or non-pipe components been experienced?			
	Mechanical damage	• Have failures due to mechanical damage been experienced, such as underground structures in contact with facilities?			
	Materials/ Plastic	• Do any of the following materials exist in the system? > Century Utility Products? > Low-ductile inner wall Aldyl A pipe manufactured by DuPont Company before 1973? > PE 3306?			
	Weld/Joint	• Have failures in welds or other joints occurred?			
EQUIPMENT FAILURE	System Equipment	• Have failures been experienced due to leaking seals or gaskets? • Have regulator or control malfunctions been experienced?			

Threat assessment method

Is the threat applicable and a problem?

- Trend historic performance such as:
  - Leaks per mile of main/service from Annual Report
  - 3rd Party Excavator Damages per thousand
  - Corrosion Leaks per mile of bare steel main
  - Cast iron main breaks per mile of cast iron pipe
- What do the trends show?
  - Good or improving? Maintain programs.
  - If not, include the facilities in risk evaluation.
- Is the threat clustered or system wide?

Assemble and analyze data

Svcs by Material

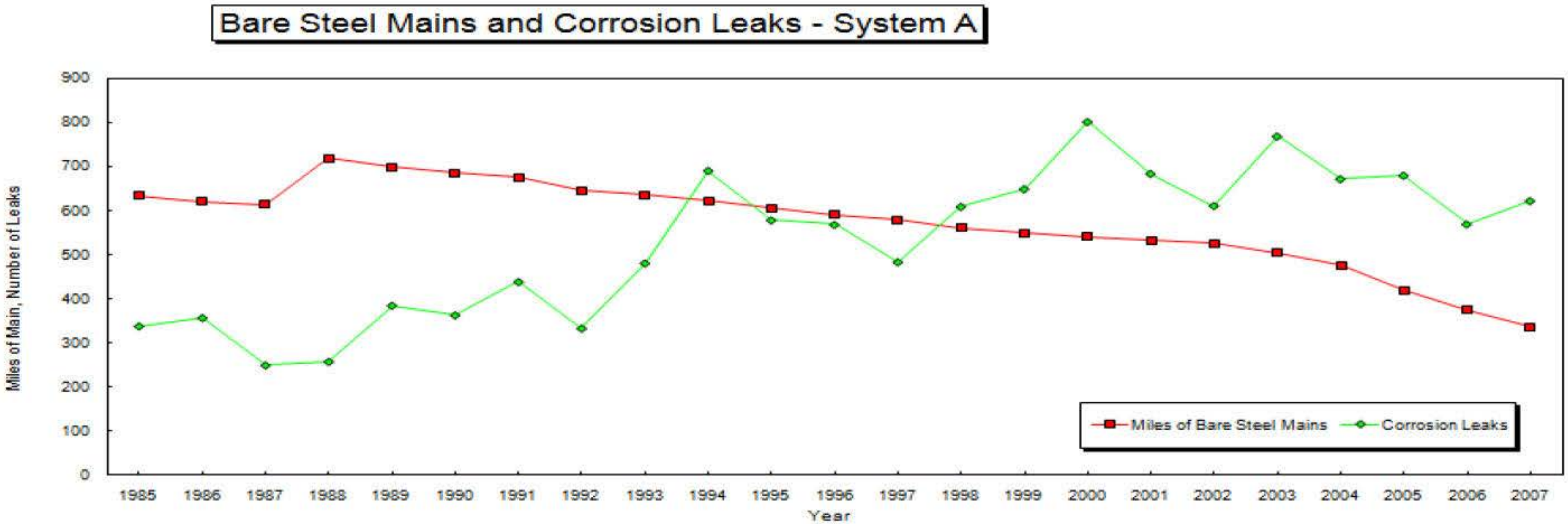
Leak Rate CI/Unpr/B.S.

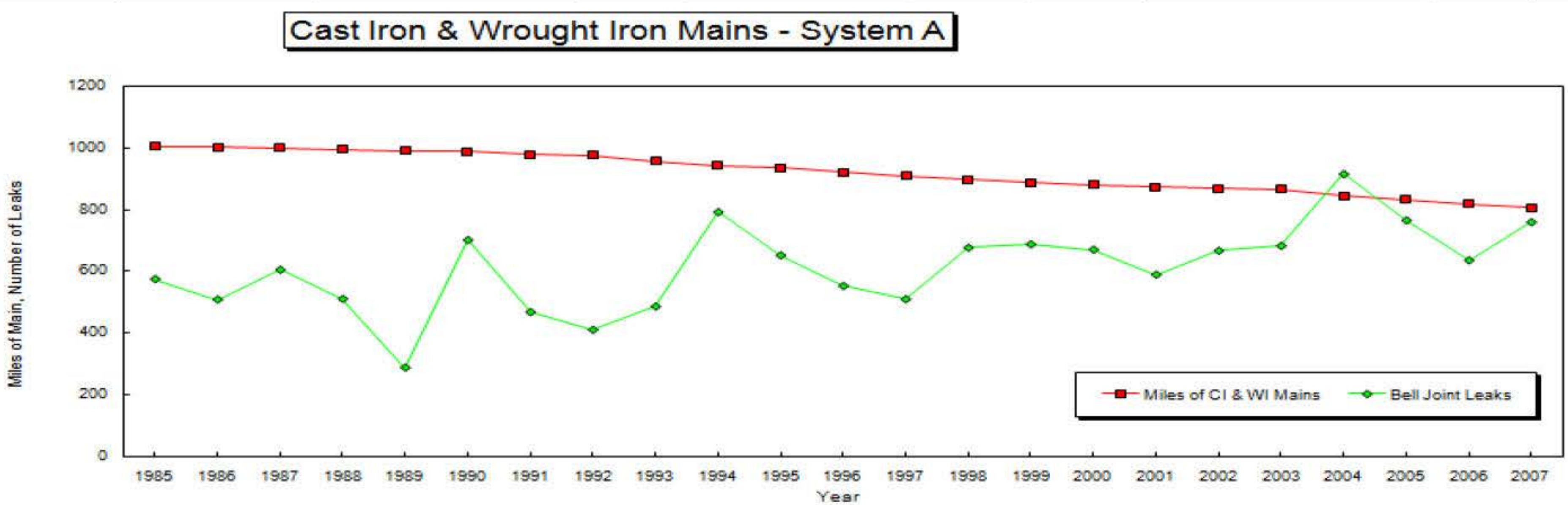
Leaks by Cause

Year	Unprotected Bare Steel Svcs	Unprotected Coated Steel Svcs	Cathodically Protected B.S. Svcs	Cathodically Protected C.S. Svcs	Plastic Svcs	CI &WI Svcs	Total Number of Svcs	Percent CI & Unpr Svcs	All Leaks per 1000 Svcs	Cor Leaks per 1000 B.S. Svcs	CI & WI Leaks/No. of CI &WI svc	Total Svc Leaks	Cor svc	Third Party svc	Outside Force svc	Constr Defect svc	Mater Defect svc	Other svc
1985	89,309	16,603	0	56,157	18,049	20	180,783	58.60%	5.85	6.80		1058	607	307	4	1	16	123
1986	88,132	16,297	0	56,282	23,343	20	184,719	56.54%	4.86	6.10		897	538	258	4	0	5	92
1987	86,893	15,996	0	56,267	29,676	19	189,494	54.31%	5.91	7.25		1120	630	311	7	5	23	144
1988	89,149	14,233	0	53,268	36,120	20	193,432	53.46%	4.39	4.95		849	441	289	4	5	17	93
1989	87,439	13,664	0	53,084	41,477	15	196,321	51.51%	5.52	6.83		1084	597	217	8	4	118	140
1990	85,334	13,188	0	53,296	46,841	20	199,318	49.44%	4.52	6.89		901	588	151	10	0	52	100
1991	83,073	12,868	0	53,267	51,982	20	201,849	47.54%	6.07	8.73		1225	725	214	7	2	100	177
1992	81,194	12,307	0	53,392	58,721	20	206,273	45.34%	4.75	5.48		980	445	237	15	7	34	242
1993	80,024	12,119	0	53,350	64,742	0	210,870	43.70%	6.07	7.59		1280	607	312	5	2	48	306
1994	75,777	11,385	0	55,326	70,672	0	213,785	40.77%	7.40	10.16		1581	770	333	5	2	62	409
1995	74,075	11,145	0	55,161	76,173	0	217,176	39.24%	7.64	9.33		1659	691	317	8	6	66	571
1996	71,978	11,235	0	54,842	82,979	0	221,655	37.54%	6.43	9.99		1425	719	247	11	5	20	423
1997	70,108	10,814	0	54,226	88,319	0	224,083	36.11%	6.12	8.50		1372	596	248	6	2	23	497
1998	68,376	10,587	0	53,619	94,254	0	227,449	34.72%	7.44	13.46		1693	920	269	68	2	37	397
1999	67,286	10,080	0	53,385	99,126	0	230,486	33.57%	7.13	12.66		1644	852	262	33	2	72	423
2000	66,521	9,665	0	52,946	104,456	0	234,197	32.53%	6.32	11.80		1479	785	211	21	2	54	406
2001	65,292	9,028	0	53,117	108,206	0	236,245	31.46%	6.84	11.73		1615	766	198	45	2	38	566
2002	63,683	8,891	0	53,026	112,266	0	238,465	30.43%	5.95	10.80		1419	688	227	18	3	79	404
2003	62,135	8,402	0	52,987	116,809	0	240,932	29.28%	7.24	14.52		1745	902	176	36	2	72	557
2004	60,529	7,585	0	52,973	121,058	0	242,740	28.06%	6.46	13.99		1567	847	223	3	0	50	444
2005	58,525	6,909	0	52,473	126,143	0	244,638	26.75%	4.86	9.07		1190	531	272	3	0	94	290
2006	56,431	6,262	0	51,935	130,919	0	246,134	25.47%	5.16	9.00		1269	508	269	1	0	97	394
2007	54,823	5,629	0	51,318	134,995	0	247,348	24.44%	5.37	10.38		1329	569	228	6	0	89	437

- Historical Service Leak Data, 1985-2007
- Analyzing percent of cast iron, bare, and unprotected steel services in the system, their leak rate, and the leak rate by cause over time.

Trending example





Threat Identification Guidance

- Good practices:
  - Creating threat matrices
  - Summarizing trending of historical leaks/leak repairs
  - Distinguishing future "other" leaks eliminated by replacement
  - Trending "mean year of installation" – older pipe replacement.

Threat Identification Guidance

- Good practices:
  - Looking at rolling averages take out yearly anomalies.
  - Identify failures without a release (e.g., overpressurization)
  - Correlating system characteristics to failure rate.
- Geographic relationship of data is critical

Facility subdivision

- Too granular of a subdivision may make number of leaks appear insignificant.
  - Facility groups were made so small that leak rate per facility grouping was very low.
- Not granular enough subdivision may hide problems.
  - Facility grouping was so broad that problems driven by individual traits were masked.

Threat assessment Resources

- See GPTC Section 4.3 Sample Threat Assessment.
- See SHRIMP Interview Questions
- But there is more to do than look at Leak & Incident Data for existing threats – look for Potential Threats

§192.1007 What are the required IM program elements?

(b) *Identify threats.* (cont)

A operator must consider reasonably available information to identify **existing and potential threats**.

Sources of data may include, but are not limited to, incident and leak history, corrosion control records, continuing surveillance records, patrolling records, maintenance history, and excavation damage experience

Incident Causes or Threats to the Integrity of a Pipeline

There are many sources of information from which an Operator may identify potential threats

- ASME B31.8 S (Transmission)
- GPTC 192-8 (Distribution)
- PHMSA Safety Advisory Bulletins
- Industry Alert Notices
- Manufacturer's Alert Notices
- Industry Research Reports
- Others

Incident Causes or Threats to the Integrity of a Pipeline from B31.8S

- Third Party Damage
  - Third party inflicted damage (instantaneous/immediate fail)
  - Previously damaged pipe (delayed failure mode)
  - Vandalism
- Corrosion Related
  - External
  - Internal
- Miscellaneous Equipment and Pipe
  - Gasket O-ring failure
  - Stripped threads/broken pipe/coupling fail
- Control/Relief equipment malfunction
  - Seal/pump packing failure
  - Wrinkle bend or buckle
  - Miscellaneous
- Incorrect Operations
  - Incorrect operation company procedure
- Weather Related
  - Cold weather
  - Lightning
  - Heavy rain or floods
  - Unknown
- Manufacturing Related Defects
  - Defect pipe seam
  - Defective pipe
- Welding/Fabrication Related
  - Defective pipe girth weld
  - Defective fabrication weld
- Outside Forces
  - Earth movement
- Environmental Cracking
  - Stress corrosion cracking

Threat Categories from GPTC G-192-8

- External Corrosion
  - Bare Steel Pipe (CP or no CP)
  - cast iron pipe (graphitization)
  - coated and wrapped steel pipe (CP or no CP)
  - Other metallic materials
- Internal corrosion
- Natural Forces
  - Outside force/weather: steel pipe
  - Outside force/weather: plastic pipe
  - Outside force/weather: cast iron pipe
- Excavation Damage
  - Operator (or its contractor)
  - Third-party
- Other Outside Force Damage
  - Vehicular
  - Vandalism
  - Fire/Explosion (primary)
  - Leakage (previous damage)
  - Blasting
  - Mechanical damage: Steel pipe, Plastic pipe, Pipe components

Threat Categories from GPTC G-192-8 (Continued)

- Material or Weld
  - Manufacturing defects
  - Materials/Plastic
  - Weld/Joint
- Equipment Failure
  - System Equipment
- Incorrect operation
  - Inadequate procedures
  - Inadequate safety practices
  - Failure to follow procedures
  - Construction/Workmanship defects
- Other Failure Causes the Operator has experienced

Safety Bulletins

- PHMSA Safety Advisory Bulletins (ex.)
  - Certain Plastic Pipe Materials
  - Cast Iron
  - Drisco 8000
  - TD Williams Repair Leak Clamps
- Manufacturer's Alerts
- PRCI Research Reports
- Others

Threat Identification

An Operator Must :

- Consider and Evaluate Existing and Potential Threats
- Justify Elimination of Threats from Consideration

Threat Identification

So, there is more to do than account for just Time Dependent and Time Independent Threats

- An Operator must look at "near misses", known threats identified in Industry literature, PHMSA Advisory Bulletins, etc. and understand how threats interact with each other
- An Operator should also consider that Interactive Threats (interaction of multiple threats) can be a potential threat.

Potential Threats

- Some Operators are struggling with potential threats:
  - Threats the Operator has not previously experienced, but identified from industry or PHMSA information
  - Threats from aging infrastructure and materials with identified performance issues may need to be considered existing threats depending on the materials in question and the operating environment
  - Threats that endangered facilities but have not resulted in a leak (e.g., exposed pipe, near misses).
  - Non-leak threats (overpressure, exposure)
  - Manufacturing and Construction Threats
  - Maintenance history

Potential Threat Identification

- This is a thoughtful consideration of what else could go on that standard risk assessment models do not account for
- Consider what other threats (and interactive threats) exist in the Operator's unique operating environment
- Consideration of near miss events and abnormal operating condition events (just to name a couple of potential threat identification areas) is needed
- It can be resource intensive depending on the materials and operating environment
- Sufficient time and resources should be committed to the task(s)

Identified Potential Threats

Examples of potential threats often not being considered:

- Over pressurization events
- Regulator malfunction or freeze-up
- Cross-bores into sewer lines
- Materials, Equipment, Practices, etc. with identified performance issues
- Vehicular or Industrial activities
- Incorrect maintenance procedures or faulty components
- Rodents, plastic eating bugs, tree roots
- Other potential threats specific to the operator's unique operating environment

Interactive (Potential) Threats

- Distribution Operators should look to their Leak and Incident history, O&M history, and other sources to identify interactive threats specific to their system.
- Examples of interacting threats to consider include:
  - Slow crack growth in older plastics where pipeline was pinched during operational event or where over-squeeze occurred due to improper tools or procedure
  - Slow crack growth in older plastics where non-modern construction practices were used
  - Water main leakage areas or areas of soil subsidence with cast iron mains
  - Installation of mechanical fittings without restraint (category 2 & 3) in soils or conditions (excavation damage) that cause pipe to pull out of fitting

Identify Threats to Integrity

- A DIMP must provide adequate details or specificity to address specific threats and risks in the Operator's unique operating environment.
- Consideration must be given to applicable operating and environmental factors affecting consequence (e.g., paved areas, business districts, hard to evacuate) relating to the Consequence of Failure (COF) when evaluating risk.
- DIMP procedures must provide for the re-evaluation of threats and the identification of new or potential threats.
- Plan must include procedures to evaluate and obtain data from external sources that are reasonably available to identify existing and potential threats.

Evaluate and Rank Risk

§192.1007 (c) *Evaluate and rank risk.* An operator must evaluate the risks associated with its distribution pipeline. In this evaluation, the operator must determine the relative importance of each threat and estimate and rank the risks posed to its pipeline. **This evaluation must consider each applicable current and potential threat, the likelihood of failure associated with each threat, and the potential consequences of such a failure.** An operator may subdivide its pipeline into regions with similar characteristics (e.g., contiguous areas within a distribution pipeline consisting of mains, services and other appurtenances; areas with common materials or environmental factors), and for which similar actions likely would be effective in reducing risk.

Evaluate and Rank Risk

- Risk = Frequency (Threat) X Consequence
- Predictive
- How frequently does it happen?
- If it happens, how significant could it be?
- Does it warrant additional risk reduction measures?
- GPTC Section 5 – example
- There are multiple methods for Risk Modeling

Evaluate and Rank Risk

- Cumulative threats model
  - Operator subdivides the system geographically
  - Determines likelihood & consequence weighting
  - Aggregates the risk due to each threat to the system

Risk Score for Groups of Facilities by Primary Threat Category	CORROSION (likelihood x consequence)	NATURAL FORCES (likelihood x consequence)	EXCAVATION DAMAGE (likelihood x consequence)	OTHER OUTSIDE FORCE DAMAGE (likelihood x consequence)	MATERIAL OR WELDS (likelihood x consequence)	EQUIPMENT (x likelihood x consequence)	INCORRECT OPERATIONS (likelihood x consequence)	OTHER (likelihood x consequence)	Total Risk Score
Operating District D	23	12	89	89	45	3	1	77	339
Operating District I	45	10	83	82	35	5	2	69	331
Operating District A	10	9	87	88	19	2	1	81	297
Operating District E	18	21	50	45	48	8	1	87	278
Operating District G	21	8	90	88	20	1	1	45	274
Operating District H	15	3	68	67	20	3	1	34	211
Operating District B	0	5	76	66	7	8	1	45	208
Operating District J	0	11	70	50	2	9	1	43	186
Operating District F	8	9	55	60	2	3	1	29	167
Operating District C	0	4	30	20	6	4	1	15	80

Evaluate and rank Risk

Corrosion	Total Risk Score (likelihood x consequence)
Bare steel pipe VA	9
Bare steel pipe MD	4
Cast Iron DC	3

Natural Forces	Total Risk Score (likelihood x consequence)
DC Cast Iron - water main breaks	78
Washouts Montgomery	54
Downtown Alexandria Flood district	12

Excavation Damage	Total Risk Score (likelihood x consequence)
Mapping omissions & inaccuracies	85
Fiber optic planning district	77
Blasting Leesburg	58

Outside Forces	Total Risk Score (likelihood x consequence)
Meter sets in Parking Garages Without protection	78
Aboveground regulator stations near road widenings - VDOT	65

Material or Weld	Total Risk Score (likelihood x consequence)
Mechanical coupled services from 1950 - 1970	75
Kerotest valves - thoughout system	12
Pre 1970 plastic pipe - uprated in '90s	8

Equipment Failure	Total Risk Score (likelihood x consequence)
Obsolete recitfiers	1

Incorrect Operation	Total Risk Score (likelihood x consequence)
Overpressure System	65

Other	Total Risk Score (likelihood x consequence)
Pipe on building rooftops	34

Threat specific model

Relative Risk Ranking of groups	Total Risk Score
Mapping omissions & inaccuracies	85
DC Cast Iron - water main breaks	78
Meter sets in Parking Garages without protection	78
Fiber optic planning district	77
Mechanical coupled services from 1950 - 1970	75
Aboveground regulator stations near road widenings - VDOT	65
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Bare steel pipe MD	4
Cast Iron DC	3
Obsolete recitfiers	1

Evaluate and Rank Risks

- System subdivision for the evaluation and ranking of risks must be sufficient to appropriately analyze risk(s) present in the Operator's unique operating environment.
- System subdivisions may be predicated on threats (materials, construction, etc.) and consequences (wall-to-wall pavement, high density population areas, etc.)
- Geographical segmentation may be appropriate when systems are separated by space or a specific, predominate threat exists (e.g., where flooding can be expected, earthquake prone area). However, different materials may be a predominate threat in a region, and segmentation may need to be refined to accommodate different failure rates.

Evaluate and Rank Risks (cont.)

- Plan must provide explanation of the process used to validate the data used in the risk ranking and to review the output of the risk ranking model for "reasonableness".
- The Plan (or Model used such as Opti-main) must address risks specific to services as well as mains.
- When changes are made to a risk model, the risk ranking should be re-run and results incorporated into DIMP promptly.

QUESTIONS?