DOT PHMSA Internal Quarterly Report

Date of Report: *4th Quarterly Report - December 31, 2019*
Contract Number: *693JK31910001POTA*
Prepared for: *USDOT – Pipeline and Hazardous Materials Safety Administration (PHMSA)*
Project Title: *Review the Intent and Safety Impact of Hoop Stress and Percentage of Specified Minimum Yield Stress Boundaries on Natural Gas Transmission and Distribution Pipelines*
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For quarterly period ending: *December 31, 2019*

1: Items Completed During this Quarterly Period:

- Task 1 Interim Report: Kickoff Meeting Minutes
- Task 1 Interim Report: TAP Scope Review and Confirmation
- Task 1 Interim Report: Confirmation Subcontracter SOW in Place
- 1st quarterly report

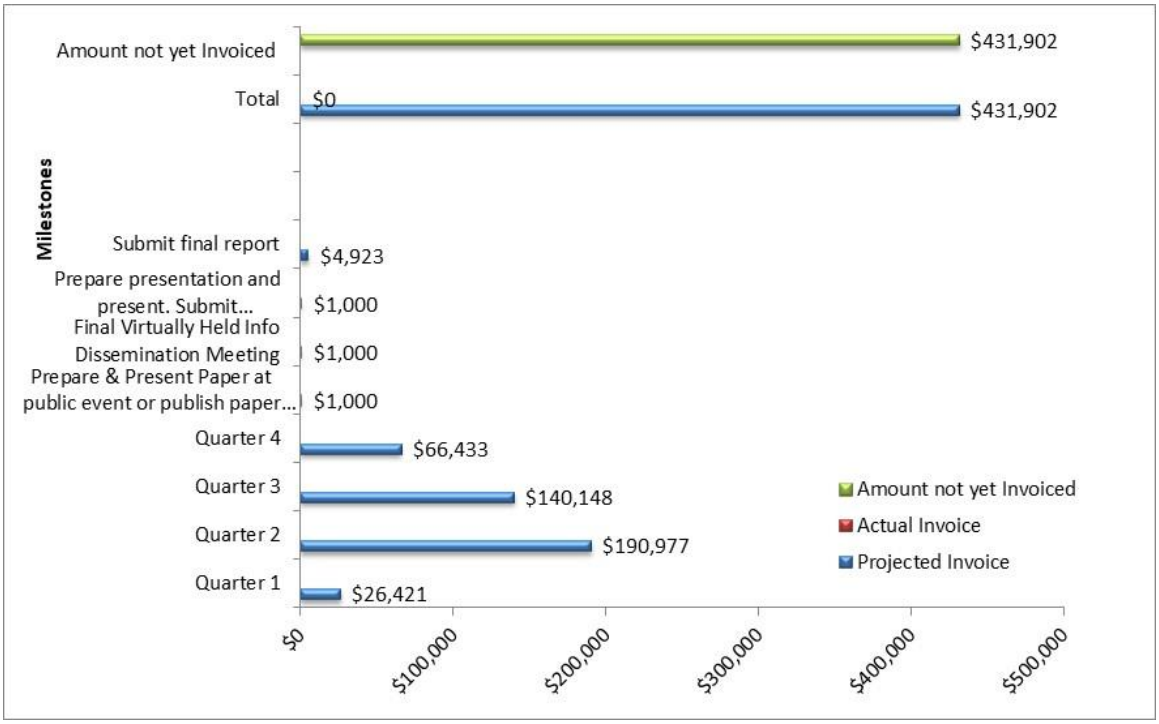
2: Items Not-Completed During this Quarterly Period:

- **None**

3: Project Financial Tracking During this Quarterly Period:

The nature of the contract for this research effort is fixed price, with clearly defined milestone/deliverable payments. **Figure 2** outlines projected invoicing, as well the invoice submitted upon delivery of the first quarter payable milestone.

Figure 1. Quarterly Payable Milestones/Invoices (Federal Costs)



4: Project Technical Status

Task #	***Activity***	***Milestone / Deliverable***	***Cost***
1	Kickoff, Contracting, and TAP	Task 1 Interim Report: Kickoff Meeting Minutes, TAP Scope Review and confirmation, Subcontract statement of Work (SOW) in place.	***$26,421***

Preliminary Kickoff Meeting
The project PM, PI, and DOT AOR held a preliminary project kickoff call on October 2, 2019 to go over the SOW and initial project details.

Project Official Kickoff Meeting
The project official kickoff call with DOT, OTD, GTI, the Technical Team, and the Technical Advisory Panel was held October 21, 2019. The associated kickoff presentation is in the Appendix. The SOW was reviewed in detail and approved by all parties. The TAP membership was confirmed.

Contracting and Subcontracting
Five contracts were completed in the first quarter including the contracts between GTI and DOT and GTI and OTD, as well as the three subcontracts to secure the Technical Team. It took the better part of the first three months to put all these contracts in place and based on the extremely tight project schedule the GTI PM will be requesting a 3-month extension for Task 2 to 6 and the associated milestone/deliverables. This would still allow completion of the

draft summary report by 12/31/2020.

2	Regulatory Definition Review	Task 2 Interim Report: Regulatory Definition Review	

Regulatory Review
The regulatory definition review has been started and the team is collecting and organizing regulatory and historical literature, code basis, and changes since inception.

3	In-Depth Literature Search	Task 3 Interim Report: In-Depth Literature Search (with Draft Knowledge Database Summary)	

Collection of Papers and Reports
During the quarter, 53 IPC papers were obtained, 9 reports/data sets on pipe failures, 10 reports/data sets on vintage pipe, 15 peer reviewed papers on pipeline steel and pipe properties, and other references. Additionally, a draft report on vintage steel and pipe making practices has been outlined and the initial first pass is nearly completed but needs additional input and organization.

Database Selection and Institution
The team settled on using Endnote X9 as the database to organize and store all the literature citations, abstracts, and pdf documents. All team members have installed X9 on their computer systems and have started populating the database and citations.

Consistent Keyword List for Citation Metadata Tags
The team created and reconciled a "Keywords List" to facilitate a more uniform tagging of citations in the database with metadata that is related to each of the five core technical tasks (2-6). The current keyword list is in the Appendix.

4	In-Service and Incident History Analysis	Task 4 Interim Report: In-service/Incident History Analysis (with Draft Pipeline Information Database Summary)	

Data Input and Processing
Relevant incident data was harvested from NTSB and PHMSA public records. The data conversion process is being performed to upload the data into repository database system, harmonize the data, and identify the differences between the definitions in the data fields. The incident data currently reside in various platforms and in different formats. These formats include spreadsheets and ‘pdf’ failure reports. This data is being categorized as tabulated numeric data and unstructured textual formats at this point.

Data Sorting and Harmonization
The PHMSA incident datasets from 1970 to present come with various glossaries of definitions which are being harmonized to facilitate the analytical process. This work included defining ‘mapping dictionaries’ for the datasets and translating data fields from their native format to the harmonized format. Additionally, the NTSB incident reports are being tabulated to have it ready for analysis. Keywords and values that are consistently and correctly extracted from the textual NTSB incident reports are considered as additional data fields to be included

in the data set.

Implement Data Management Platform Selection and Initial Organization (DB front end)
Data is imported and aggregated into a single unified database using Microsoft Power BI platform. Power BI supports different flexible data models that may be used to achieve this objective.

Database Selection (DB back end)
The database is planned to reside in a cloud-based platform, such as Microsoft Azure, for access and display. This workstream will develop the protocols for the administration and accessibility of the data.

Data Optimization Commenced
- Recognizing redundancies of the data,
- Identifying and sorting out outliers, and
- Identifying gaps and modification requirements for reporting and analysis.

Data Analysis
This step will start next quarter and will include analysis of the datasets to further identify the statistical trends and their parametrical relationships, including:
- Initial exploration of the data,
- Model building and pattern identification of the trends, and
- Graphical data visualization techniques using MS Power BI.

Work will identify relations, trends, and 'hidden' biases in the data sets. A dashboard tool in Power BI will be customized to display the harmonized datasets, run queries, and export the data sets to different formats. Other tools such as R and Python may also be used to perform analysis in various output forms, which show the most significant variables and their correlations.

The output of this Task will feed into Task 5 and 6 noted below which both commence next quarter.

5	Sensitivity Study of Pipeline Features/Parameters	Task 5 Interim Report: Sensitivity Study of Pipeline Features/Parameters	

This task officially starts next quarter, but the groundwork for the task was laid this quarter and included the following.

Commenced Literature Review (see Task 3 above)
Commenced a literature review on material and mechanistic models and the variables that drive or contribute to likelihood of failure by hoop stress; a sensitivity study will be conducted in a later quarter on the relative influence of variables on failure; and grouping the variables by operational ranges and asset classes.

Details Added to Task Strategy to Harmonize with other Tasks
In this quarter, a strategy to complete this task was developed during the kick-off meeting and

the literature review was started. Key decisions on threat classification and failure modes were made.

Selection of Structural Equation Modeling and Path Analysis
The task will use Structural Equation Modeling (SEM), likely General SEM (not restricted to linear models or single levels). SEM is ideal for this sensitivity study since it has its foundations in Causal Modeling, is very organized, uses powerful path diagrams to set up the model, and can combine Bayesian and regression analysis when executing the estimation model, and allows many ways to conduct post-estimation analysis.

6	Safety Considerations for Segment Classifications	Task 6 Interim Report: Safety Considerations for Segment Classifications	

This task officially starts next quarter, but the groundwork for the task was laid this quarter and involves incorporating results from the Incident History Analysis (Task 3) and the Sensitivity Analysis (Task 5) to propose a new DIMP/TIMP boundary for segment classification.

Details Added to Task Strategy
The proposed classification will consider the effects of mitigating activities, such as gas odorization, patrol frequency, integrity inspections and design safety factors. As the safety requirements increase, with increasing pressure, a set of restrictions will be defined that maintain a level of safety at thresholds consistent with the intent of the code. In this quarter, the safety considerations, threat categories and failure modes were discussed.

Key Variables and Boundaries
Key variables include: the asset reliability, pipe design/materials, operational conditions, mitigative activities. The boundary classification criteria may consider degradation effects over time applied to a set of discretized design/construction/operating categories. The ongoing literature review, the incident history analysis and the sensitivity analysis will contribute to finalizing the parameters that will be used to define the TIMP/DIMP boundary condition.

7	Summary Report	Task 7 Draft Final Report (with Final Task 3 and 4 Databases)	

Task 7 Status Description Here…

8	Project Management	Ongoing: Monthly Updates, Quarterly Reports, Peer Review, Virtual Final Meeting, Public Presentation/Paper, Final Revision of Task 7 Summary Report	

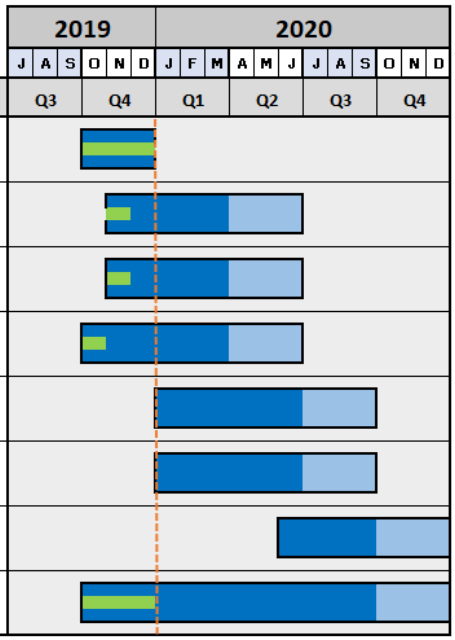
Monthly Updates were submitted.

Project Schedule: As noted in the Task 1 details above, it took nearly 3 months to complete all five contracts/subcontracts for the project. This slowed the initial project progress and a 3-month extension will be requested for Tasks 2 through 7 as shown in the project schedule in the section below. This will provide the time allocated to each task per the original

proposal/SOW.

5: Project Schedule

Project Task (Task Lead)	Start	Finish	% Complete
1 - Kickoff, Contracting, and TAP	10/1/2019	12/31/2019	100%
2 - Regulatory Definition Review	11/1/2019	3/31/2020	10%
3 - In-Depth Literature Search	11/1/2019	3/31/2020	15%
4 - In-service and Incident History Analysis	10/1/2019	3/31/2020	20%
5 - Sensitivity Study of Pipeline Features/Parameters	1/1/2020	6/30/2020	0%
6- Safety Considerations for Segment Classifications	1/1/2020	6/30/2020	0%
6 - Summary Report	4/1/2020	9/30/2020	0%
7 - Project Management	10/1/2019	9/30/2020	20%



Appendix A Kick Off Presentation

Review the Intent and Safety Impact of Hoop Stress and Percentage of Specified Minimum Yield Stress Boundaries on Natural Gas Transmission and Distribution Pipelines

DOT/PHMSA Agreement No. 693JK31910001POTA
ref. DOT WP#785
OTD Project

October 21, 2019

- Kristine Wiley, Khalid Farrag, GTI
- Daniel Ersoy, Element Resources
- Keith Leewis, L&A
- Jason Skow, Integral Engineering

Project Objective

The objective of this project is to complete a **knowledge-based study** to:

- Investigate **definitions** for natural gas transmission and distribution lines in 49 CFR 192; including the Oct. 1, 2019 update.
- Complete an in-depth **literature review**
- Establish **safety considerations** for new vs. existing systems related to DIMP and TIMP
- Identify **safety/integrity implications from (re)classifying** transmission-to-distribution
- Document **in-service history/incidents** and system attributes.

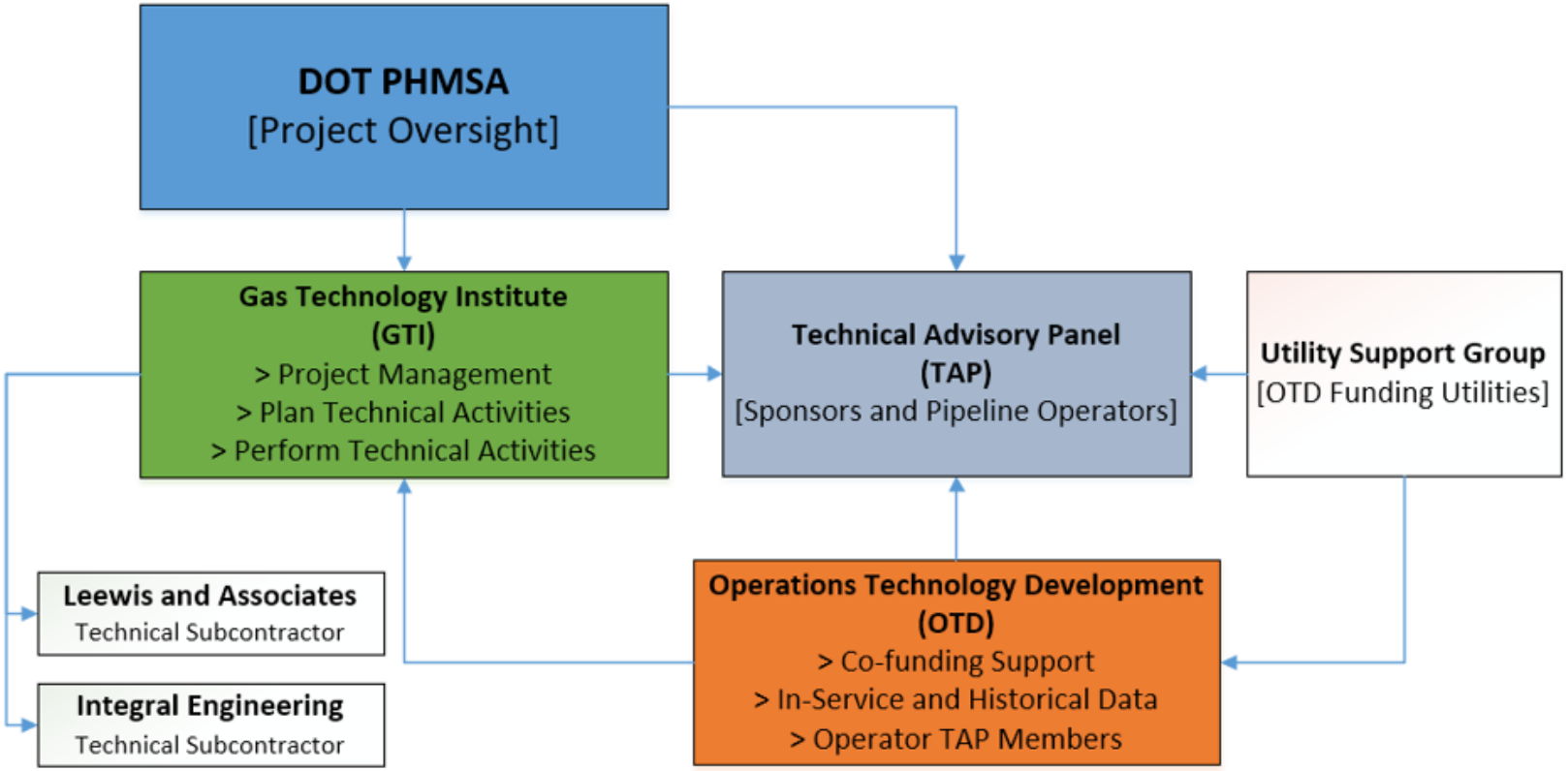
Additional emphasis will be placed on 20-30% SMYS segments and include **leak vs. rupture considerations** and effects on failure modes and related risk consequences.

Methodology

The project team will execute a knowledge-based study with these core elements:

- **Regulatory Definition Review** (49 CFR 192) of Transmission and Distribution classifications. This sets the status quo (benchmark).
- **In-Depth Literature Search**: Technical papers, regulations, journals, research reports - including government, industry, or academia conducted/sponsored work - related to the project scope.
- **In-service and Incident History Analysis:** For pipe segments between 20-30% SMYS.
- **Sensitivity Study of Pipeline Features/Parameters**: Related to (a) new vs. existing pipeline systems; (b) impacts of (re)classifications between Transmission/TIMP and Distribution/DIMP; and (c) Leak vs. Rupture boundaries (LRB) and failure mode.
- **Safety Considerations for Segment Classification** of existing or new pipe segments operating between 20-30% SMYS.

Project Structure and Implementation Plan



Deliverables / Milestones (details on next ten slides)

Activity	Completion Date (from Agreement)	Milestone/Deliverable
Task 1 - Kickoff, Contracting, and TAP	Month 1 Month 2 Month 3	Task 1 Interim Report: Kickoff Meeting Minutes. Task 1 Interim Report: TAP scope review and confirmation. Task 1 Interim Report: Subcontract statement of work (SOW) in place.
Task 2- Regulatory Definition Review	Month 6	Task 2 Interim Report: Regulatory Definition Review
Task 3 – In-Depth Literature Search	Month 6	Task 3 Interim Report: In-Depth Literature Search (with Draft Knowledge Database Summary)
Task 4 - In-service and Incident History Analysis	Month 6	Task 4 Interim Report: In-service/Incident History Analysis (with Draft Pipeline Information Database Summary)
Task 5 - Sensitivity Study of Pipeline Features/Parameters	Month 9	Task 5 Interim Report: Sensitivity Study of Pipeline Features/Parameters
Task 6 - Safety Considerations for Segment Classifications	Month 9	Task 6 Interim Report: Safety Considerations for Segment Classifications
Task 7 - Summary Report	Month 12	Task 7 Draft Final Report (with Final Task 3 and 4 Databases)
Task 8 - Project Management	Duration of the Project	Ongoing: Monthly Updates, Quarterly Reports, Peer Review, Virtual Final Meeting, Public Presentation/Paper, Final Revision of Task 7 Summary Report

Estimated Timeline

Task	Task Description	1	2	3	4	5	6	7	8	9	10	11	12
1	Kickoff, Contracting, and TAP												
2	Regulatory Definition Review												
3	In-Depth Literature Search												
4	In-service and Incident History Analysis												
5	Sensitivity Study of Pipeline Features/Parameters												
6	Safety Considerations for Segment Classifications												
7	Summary Report												
8	Project Management												

Technical Advisory Panel (TAP)

- **DOT/PHMSA, OTD, and GTI**
- **Gas Pipeline Participants**
  - Ameren
  - Atmos
  - Duke
  - Southwest Gas
- **Others**
  - Liquid and gas operators
  - Academia
  - Technical SMEs

Task 1 - Kickoff, Contracting, and TAP

- **Kickoff** project via teleconference with DOT PHMSA and OTD and provide kickoff meeting minutes
- **Form the TAP**, and solicit input on scope of work details, operational considerations, and deliverable design.
- Provide an interim report including the **TAP scope review feedback** and any approved changes.
- Provide an interim report that the **subcontract** statements of work are updated and in place.

Task 2 - Regulatory Definition Review

- There is a long/complex **code history** of related definitions and their basis. For example ASME B31.8, 800 Section 8 of USA Standard Code for Pressure Piping, etc.
- **Girth Welds** (vintage acetylene) limited distribution pressure to 20% SMYS for axial loads in 1967; MAOP was set at 30% for distribution pipe as a function of **leak vs. rupture boundary** incident reviews (not including GWs); and **consequence considerations** with Class Locations set for example CL 1: 80% x 0.90 Hydro = 72% SMYS.
- In this task, these **conflicting considerations** will be meticulously mapped out, and the baseline regulations will be crosslinked to their technical and operational basis.
- **Milestone**: Develop and submit the Task 2 Interim Report: Regulatory Definition Review.

Task 3 - In-Depth Literature Search

- This task will consist of a **literature search** to gather and summarize the existing knowledge from published papers, regulations, journals, and funded research by government, industry, and academia; and the more recent relevant papers in ASME International Pipeline Conference (IPC) and similar technical proceedings.
- This will include publications related to: **wall loss, planar defects (aka cracks), and other damage/defects** driven failure.
- The search will include any of the latest information related to the **leak-rupture boundary** and characteristics of ductile ruptures of pipelines.
- **Milestone**: Develop and submit the Task 3 Interim Report: In-Depth Literature Search. This will include a draft knowledge database summary, with the final database submitted with the project final summary report in Task 7.

Task 4 - In-service and Incident History Analysis

- The **NTSB reports and the PHMSA incident data** will be reviewed for pipeline leak and rupture events particularly to discover all the ruptures on lines operating at pressures under **40% of SMYS** to ensure there were no missed or poorly classified outliers in these prior engineering evaluations.
- For pipe segments between **20% - 30%** SMYS:
  - The team will collect and analyze the **in-service history**, including the pipe vintage, seam type, diameter, and mileage with technical commentary of these considerations to further the understanding of systems operating between 20-30% SMYS
  - Document the **incident history** of these pipe segments.
  - Determine the **effects of pipeline attributes** individually and combinations of attributes such as: vintage, seam, diameter, threat category, etc.
- The incident history for pipe operating at or **under 20%** SMYS (or **under 60** psig as available) will be reviewed.
- The team will also confirm the **leak/rupture history of legacy mill pipe** production by: diameter, steel grade, seam type, and possibly with the new data on grandfathered pipe as available. This will include the confirmation of the percentage SMYS in the incident history to their leak vs. rupture predictions when available.
- **Milestone**: Develop and submit the Task 4 Interim Report: In-service/Incident History Analysis. This will include the draft pipeline information database summary, with the final database submitted with the project final summary report in Task 7. The results in this task will be tied into the analysis on leak rupture boundary consideration in Task 5.

Task 5 - Sensitivity Study of Pipeline Features - Parameters

- This task activity will clarify and organize how older rules, based on vintage-to-modern pipe performance, provided an engineering rational to help designers, operators, and regulators understand the philosophy of the safety rules behind the earliest codes.
- **New vs. Old Pipe**
  - Seam and girth **weld** quality
  - Fracture **toughness**; impact **energy** and shape (**temperature transitions**)
  - Wall **thickness**, **diameter**, other **physical** considerations
  - Other **metallurgical** (steel type), **manufacturing** (pipe mill), and **construction** (field) features/parameters.
- **DIMP vs. TIMP Reclassifications**
  - Risk **consistency** of and between these zones
  - **Prescriptive** TIMP vs. **Performance** (non-prescriptive or risk-informed) DIMP basis
  - Suggest **improvements** that are in line with the intentions of the regulations, as well as clarify a **boundary mechanism** between the current 20% to 30% SMYS maximums.
- **Leak vs. Rupture** – Flaw geometry (new vs. vintage), YS, toughness, diameter, thickness, load/pressure.
- **Milestone**: Develop and submit Task 5 Interim Report: Sensitivity Study of Pipeline Features/Parameters

Task 6 - Safety Considerations for Segment Classifications

- **Develop a technically justifiable framework** to assist with establishing the safety considerations required to allow pipeline segments to be properly and safely defined as either transmission or distribution pipelines.
- **Note the overall safety impact of reclassifying** either “existing or new pipelines” operating between 20-30% SMYS as distribution vs transmission pipelines.
- **Incorporate Task 4 incident history and Task 5 sensitivity study, along with a review of the evolution** in: patrol frequency, inspections required, gas odorization, and design safety factors for both natural gas transmission and distribution systems; and how they influence the rules for distribution and transmission lines.
- **Milestone**: Develop and submit Task 6 Interim Report: Safety Considerations for Segment Classifications.

Task 7 - Summary Report

- **A draft final report** containing the project results from Tasks 1 to 6 will be written and provided to DOT/PHMSA and the TAP for review and comment. After comments are received and incorporated, a final report will be provided to DOT/PHMSA.
- As noted in Task 8, the project will be summarized in a **webinar** describing the project scope, methods, and deliverables to the pipeline community. **Papers** will be submitted to the appropriate industry publications and **presentations** will be given at industry forums to ensure widespread dissemination of the project results.
- **Milestone**: A **draft** final summary report, **final** summary report, **public** version of final summary report. This report will also include an associated final project **knowledge database** and pipeline **information database**.

Task 8 - Project Management and Communications

- Regular communication and monthly updates to PHMSA
- Quarterly reporting activities
- Coordination with the TAP, subcontractors, and outside organizations and users
- Annual PHMSA Peer Reviews
- Final virtual presentation of the project results to a web-based meeting that PHMSA will organize and announce
- A project presentation to at least one public pipeline conference/workshop/forum or published periodical/magazine

Questions

Appendix B Key Word List

Assessment	Code	Standards	Welding	Anomalies	Threats	Corrosion	Toughness	SteelsTypes	Coating	Failure	OPS - P&M	Risk-Reliability	Pipe
hydrotest	49CFR191	API 579-1	acetylene girth welding	Anomaly	Manufacturing Defect	Cathodically Protected	Charpy	acid steelmaking	asphalt	brittle fracture	cost benefit ratio	decision analysis	chemistry
ILI Inspection	49CFR192	ASME B31.8	bond line	axial crack	Equipment Damage	corrosion	compact specimen	basic oxygen furnace (BOF)	Bare Steel	burst	dig optimization	probabilistic assessment	diameter
IMP	Class Area	ASME B31.8S	butt weld long seams	crack	Excavation Damage	ECDA	CTOD	basic steel making	coal tar wrapping	cleavage	Distribution Line	QPA	grade
inline inspection	CSA Z662	ASME B31G	ERW	crack-like	mechanical damage	External Corrosion	CVN	bessimer	Coated Pipe	constraint	excavation	QRA	grain size
integrity management	Gathering Line	FFS	flash welded	defects	Natural Force Damage	hydrogen	fracture toughness	electric furnace	coatings	d/t	mitigation	quantitative probabilistic assessment	hardness
	Hazardous Liquid	fitness for service	girth weld	dents	Outside Force Damage	hydrogen induced crack	SENT	integrated steel making	FBE	dimensional analysis	mitigative	quantitative risk	hoop stress
	HCA	NACE	HAZ	hook crack	ROW assessment	ICDA	toughness	ladle metallurgy	pipeline protective coatings	ductile fracture	odorization	RBDA	Installation Year
	Incident		HF-ERW	lap	ROW survey	Internal Corrosion		open hearth	polywraps	Explosion	Offshore Pipe	reliability	modulus
	Incorrect Operation		high frequency ERW	metal loss	scenario analysis	SCC				failure mode	Onshore Pipe	reliability based design and assessment	Operating Pressure
	MAOP		lap welded long seams	Seam Defect	Third-Party Damage	SCCDA				failure model	pipeline reroute	reliability target	pipe making
	Natural Gas		LF-ERW	wall loss	Threats	selective seam corrosion				fatigue	preventive	reliability threshold	pipe manufacturer
	NTSB		long seam		Vandalism					fatigue crack	repair optimization	structural reliability	Pipe Material
	PHMSA		Low fequency ERW							fatigue loading	repair plan		Pipe Size
	pressure reduction		seamless pipe							fracture	utility		pipeline bending technolgies
	Pressure Testing		SMAW or stick welding							Gas Release			pipeline construction
	safety factor		spiral seam							Ignition			pipeline cutouts
	SMYS		submerged arc welded long seams							impact radius			Pipeline Operator
	Transmission Line		weld impurities							leak			poissons ratio
			weld inclusions							POF			strain hardening
			welding							probability of failure			tensile strength
										RSTRENG			tolerance
										rupture			UTS
										stored energy			vintage
													wall thickness
													yield strength
													YS