Puget Sound Energy
Pipeline Replacement Program Plan
June 2019

Docket No. UG-120715

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1. Introduction

On December 31, 2012, the Washington Utilities and Transportation Commission (UTC) issued a policy statement under UG-120715 for the accelerated replacement of natural gas pipeline facilities with elevated risk. This policy statement requires each gas company, whether requesting a special pipe replacement cost recovery mechanism (CRM) or not, to file with the Commission a pipe replacement program plan containing the following elements:

1. A "master" plan for replacement or remediation of pipeline facilities that are demonstrated to have an elevated risk of failure
2. A two-year plan that specifically identifies the pipeline facility remediation goals for the upcoming two year period
3. A plan for identifying the location of pipe that presents elevated risk of failure

In accordance with this policy statement, Puget Sound Energy (PSE) had previously prepared pipeline replacement program (PRP) plans beginning in 2013 for pipe that poses an elevated risk of failure. Through PSE's Distribution Integrity Management Program (DIMP), performance of the distribution system is continually analyzed and detailed analysis is conducted. The following assets were identified through PSE's risk modeling to have an elevated risk relative to other assets in its system:

Asset	Risk	PRP Program Status
DuPont Aldyl "HD" Plastic Pipe	High consequence of fusion failure and brittle like cracking	Existing
Buried Meters	High consequence of external corrosion failure in close proximity to a building wall	New
Sewer Cross Bores	High likelihood of failure and consequence of gas migration directly into a structure	New
Older Vintage wrapped steel mains	Elevated risk reduced through implementation of PRP master plan	Completed
Older Vintage wrapped steel services	Elevated risk reduced through implementation of PRP master plan	Completed

2. PSE's Distribution Integrity Management Program (DIMP)

As required by the DIMP regulations, PSE analyzes many aspects of system performance including trends on identified system threats. The threats that are identified and evaluated in DIMP include:

- Corrosion failure
- Natural force damage
- Excavation damage
- Other outside force damage
- Pipe, weld or joint failure
- Equipment failure
- Incorrect operations

- Other cause

The analysis includes reviewing active and repaired leak data, failure analysis information, and system condition reports to identify trends affecting the distribution system. Results and conclusions of the review are reported in PSE's Continuing Surveillance Annual Report. A copy of the report is provided to the UTC after each annual update. The analysis provides insight into the risks associated with pipe and assets identified as having an elevated risk of failure that are included in the PRP plan.

PSE continues to improve pipeline safety and system reliability through the ongoing iterations of its integrity management activities. The assessment, prioritization, and mitigation of system risks continue to be refined as new and additional risk knowledge is incorporated into DIMP through normal O&M and DIMP activities. Activities related to DIMP include gathering data, conducting targeted inspections, and completing remediation and replacement work associated with integrity management driven programs. Based on additional risk knowledge and the results of the system trends analysis, the Master Plan may be modified to further accelerate or decelerate pipe replacement and mitigation schedules consistent with the identified risk. Additionally, PSE is actively monitoring system threats and performance and, from time to time, may identify additional materials or assets that have an elevated risk of failure. If any material changes are made to the PRP plan, PSE will submit the changes to the Commission as required by the Commission's Policy Statement.

3. PSE's PRP Plan Progress

The following table summarizes the miles of pipe and the number of services replaced under the replacement programs according to the Master Plan since 2013.

Table 1. Summary of Replacement Programs from 2013-2018

	DuPont Aldyl "HD" Plastic Pipe		Older Vintage Wrapped Steel Mains		Older Vintage Wrapped Steel Services	
Program (Calendar) Year	**Miles of Pipe**	**Expenditures**	**Miles of Pipe**	**Expenditures**	**Services**	**Expenditures**
2013	6.5	$6.9 million	3.2	$3.7 million	163	$1.6 million
2014	10.5	$13.5 million	4.5	$7.1 million	187	$2.1 million
2015	28.6	$41.4 million	4.0	$6.5 million	208	$2.7 million
2016	27.4	$32.7 million	5.0	$7.9 million	215	$2.8 million
2017	27.9	$41.9 million	5.2	$10.3 million	212	$3.3 million
2018	38.8	$64.5 million	0	$0	0	$0
Total	**139.7**	**$200.9 million**	**21.9**	**$35.5 million**	**985**	**$12.5 million**

PSE also originally identified bare steel pipe as a material having an elevated risk of failure. As of December 31, 2014, PSE has completed the replacement of all known bare steel pipe in accordance with the negotiated Settlement to Dockets PG-030080 & PG-030128 between PSE and the UTC.

4. DuPont Aldyl "HD" Plastic Pipe

Master Plan

Risk Assessment

PSE identified an increased risk of premature, brittle-like cracking of the larger diameter (1-1/4" and larger) Aldyl "HD" plastic pipe manufactured by DuPont. PSE installed this pipe in the 1970s and early 1980s and originally estimated there to be approximately 400 miles remaining in service as of 2013. After further review, PSE estimates the total to be nearly 435 miles in service at the beginning of 2013, prior to any pipe replacement completed under the PRP plan.

The brittle-like cracking is due to slow crack growth (SCG) at locations where there is a stress concentration. Based on PSE's experience, the brittle-like cracking is primarily due to rock impingement but also occurs where the pipe has been squeezed or where other stress concentrations have been introduced due to inconsistent joining practices. The failure is referred to as brittle-like cracking because it occurs without any localized plastic deformation. While the failure occurs without plastic deformation, the pipe is not brittle. Even when a failure occurs due to SCG, the PE pipe is still resistant to crack propagation preventing it from becoming a larger crack. A study by GTI (Gas Technology Institute) performed at PSE's request provides additional insight into how installation and operating practices, environmental conditions, and operating pressures impact the life expectancy of the pipe.

PSE developed and implemented a program in 2010 to prioritize larger diameter DuPont Aldyl "HD" plastic pipe for replacement based on the likelihood and consequence of failure. The program was incorporated into DIMP and evaluates the risk of brittle-like cracking based on installation and operating practices and environmental conditions. These segments of larger diameter DuPont Aldyl "HD" plastic pipe have an elevated risk of failure as validated by DIMP system performance data.

Industry Experience

PSE's experience with the larger diameter DuPont Aldyl "HD" material is similar to industry experience with many of the older PE materials. This is highlighted by many of the Safety Recommendations issued by the National Transportation Safety Board (NTSB) on April 30, 1998. These recommendations were based on findings from NTSB's investigation of PE pipe following several natural gas distribution accidents that involved plastic piping that cracked in a "brittle-like" manner. The following summarizes many of the issues identified in the NTSB's investigation that correlate to PSE's experience with the DuPont Aldyl "HD" material:

- Nationally, brittle-like failures represent a frequent failure mode for older plastic piping.
- The procedure used to rate PE materials from the 1960s through the early 1980s may have overrated the materials long term strength and resistance to brittle-like cracking.
- The test methods used at the time did not reveal the susceptibility of many early PE materials to brittle-like cracking.
- Plastic pipe was assumed to perform in a ductile manner; therefore, plastic pipe design focused primarily on stress due to operating pressure. As a result, little consideration was given to stress due to external loading as it was assumed that these stresses would be reduced by localized yielding.
- Experts in gas distribution plastic piping indicate that some of the PE pipe manufactured from the 1960s through the early 1980s has demonstrated poor resistance to brittle-like cracking. There is evidence that some early vintage PE materials have a lower SCG resistance than other PE materials. Newer test methods more accurately predict the pipe's resistance to SCG.

Aldyl "HD" vs Aldyl "A"

In addition to the Aldyl "HD", DuPont also manufactured a medium density PE pipe marketed under the name Aldyl "A". While PSE only purchased and installed the Aldyl "HD" pipe, information on both Aldyl "A" and Aldyl "HD" pipe is included to highlight the similarities and differences in the risks of these two materials. Similar to PSE's experience with Aldyl "HD", the Aldyl "A" pipe has been found to be susceptible to brittle-like cracking.

The Aldyl "A" pipe manufactured from 1970 through early 1972 had a manufacturing issue that resulted in a brittle inside surface also referred to as low ductile inner wall (LDIW). This characteristic resulted in premature failures. In early 1972, DuPont changed the manufacturing process to address the LDIW phenomena. While only early 1970s vintage Aldyl "A" pipe had the LDIW inner surface, both Aldyl "HD" and later vintage Aldyl "A" have exhibited brittle-like cracking failure characteristics in pipes 1 ¼" and larger in diameter. The smaller diameter piping is more flexible and not as susceptible to the brittle-like cracking experienced in larger diameters.

Both Aldyl "HD" and Aldyl "A" were made with state-of-the-art PE resins at the time of manufacture and met applicable industry standards and complied with federal regulations. However, by today's standards they both have low resistance to SCG and are susceptible to SCG field failures. This is particularly true when these pipes are subjected to secondary loads, such as rock impingement and squeeze-off.

Predictions on the Remaining Useful Life Expectancy

PSE consulted with Gas Technology Institute (GTI) to develop data, information, and predictions on the remaining useful life expectancy based on samples of DuPont Aldyl "HD" plastic pipe extracted from PSE's distribution system. The purpose for the evaluation performed by GTI is to provide additional risk knowledge into the failure mode of DuPont Aldyl "HD" plastic pipe and information on the pipe characteristics, operating conditions, and environmental factors that may impact the material's performance. This study also provides a means to predict the remaining useful life expectancy of the pipe to validate the current remediation schedule or determine the appropriate remediation timeframe. Based on the testing and analysis performed, the study concludes that the expected useful life is impacted by temperature, operating pressure, and the severity of stress risers.

Based on the evaluation, there may be specific pipelines operating at relatively low pressures that even under extreme stress risers pose minimal risk. These facilities may be deemed to be low risk and not replaced as part of the Master Plan. The overall pipe replacement strategy will continue to prioritize based on the highest risk pipe from historical performance, however may be adjusted considering the new risk knowledge.

DuPont Aldyl "HD" Plastic Pipe Replacement Program Plan

PSE is actively replacing the larger diameter DuPont Aldyl "HD" plastic pipe that poses an elevated risk of failure. The current plan is to replace this pipe within 20 years beginning in 2013. PSE will continue monitoring the performance of larger diameter DuPont Aldyl "HD" pipe. By acquiring new risk knowledge through DIMP, PSE will update the replacement schedule and timeframe as necessary.

Based on current risk knowledge and historical performance, PSE currently plans to replace approximately 245 miles of larger diameter DuPont Aldyl "HD" plastic pipe within the first 10 years of the 20-year plan beginning in 2013. The pipe replacement in the first 10 years targets the population with a history of brittle-like cracking and fusion failures. The miles of pipe planned for replacement and the replacement schedule were updated from 190 miles and 8 years, respectively, based on new risk knowledge acquired since 2015. By 2022, the Master Plan will be reviewed to determine the appropriate replacement schedule for the remaining pipe in service. The current replacement schedule is provided in the Table 2 and Figure 1.

Table 2. DuPont Aldyl "HD" Plastic Pipe Replacement Schedule, Miles, and Estimated Expenditures

Program Years	Total Planned Replacement Miles	Estimated Expenditures[1]
1 – 10	245 Miles	$321.2 million
11 – 20	190 Miles	$320 million
Total	**435 Miles**	**$641.2 million**

1 Estimated expenditures are in 2019 dollars and do not include AFUDC

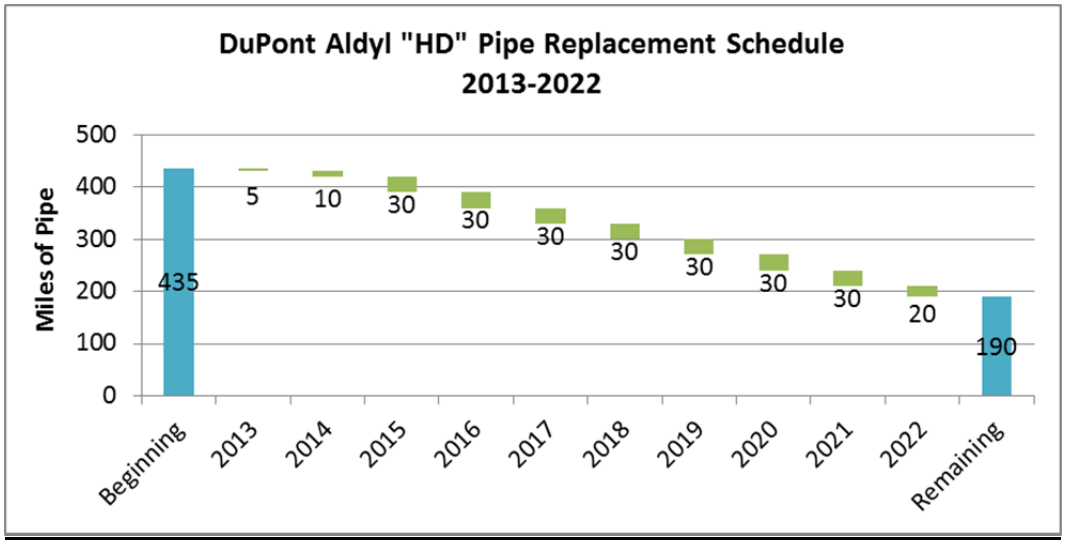

Figure 1. DuPont Aldyl "HD" Plastic Pipe Replacement Schedule for Years 1 - 10

Two-Year Plan

The two-year plan is to continue replacing DuPont Aldyl "HD" plastic pipe according to the Master Plan. The following table shows the planned replacement miles and expenditures of DuPont Aldyl "HD" plastic pipe for the current year and in calendar years 2020 and 2021.

Table 3. Planned Replacement Miles and Expenditures

Year	Planned Replacement Miles	Planned Expenditures[1]
2020	30 Miles	$50 million
2021	30 Miles	$50 million
Total	60 Miles	$100 million

1 Estimated expenditures are in 2019 dollars and do not include AFUDC

Adjustments to projects and specific locations will be made as required while managing to the Master Plan and overall system risk.

Identification Plan

PSE purchased and installed DuPont Aldyl "HD" plastic pipe in the 1970s and early 1980s. During this timeframe, PSE also purchased and installed Phillips Driscopipe M8000 and Plexco pipe. PSE's historical construction records did not capture the pipe manufacturer and only indicated the location of the pipe, material type, pipe size, and

date the pipe was installed. As a result, PSE developed and implemented a plan in 2013 to identify the manufacturer of larger diameter HDPE pipe installed in the 1970s and early 1980s. The plan focused only on identifying candidate pipe installations that may pose an elevated risk of failure.

Completion of Targeted Excavations

By the end of 2016, PSE completed the targeted excavations to identify locations of DuPont Aldyl "HD" plastic pipe in the system. Locations of the targeted excavations were strategically selected to identify all original installation jobs that potentially contain DuPont Aldyl "HD" plastic pipe. The identification effort confirmed that approximately 2,700 original installation jobs contain some amount of DuPont Aldyl "HD" plastic pipe and finalize the total population.

Ongoing Verification through Routine Operations and Planned Projects

PSE currently captures information on the pipe manufacturer through the Exposed PE Pipe Report whenever plastic pipe is exposed during routine operations and maintenance activities. Additional information is also gathered from confirmation excavations when refining the scope of DuPont Aldyl "HD" pipe replacement projects and opportunities through other planned pipe replacement projects. The information is used to further refine and verify the amount and location of DuPont Aldyl "HD" pipe remaining in service.

5. Buried Meters

Master Plan

Risk Assessment

PSE has identified an increased risk on meter set assembly (MSA) piping where pipe, fittings, or equipment intended for above ground exposure are unintentionally buried. Referred to as "Buried Meters", this condition occurs when the homeowner/building owner makes changes to the ground elevation in the area of the MSA and may result in hazardous leaks due to corrosion occurring at or near a building wall. Buried meters are identified from routine leak surveys and subsequent field inspections. The remediation strategy may include recontouring the landscaping around the MSA, or complete pipe replacement/MSA relocation, depending on the situation. There are approximately 40,000 reports of buried MSAs in the system and approximately 5,000 new reports are identified each year.

The Buried MSA Remediation Program was first initiated in 2007 in response to increased reports of buried meters through the Abnormal or Unusual Operation Condition Report (Blue Card) as they were identified during routine leak surveys. Through the implementation of DIMP in 2010 the program was identified as a moderate risk relative to other assets in the distribution system. In recent years, there has been an increase in buried meter reports through continuing surveillance activities. Also, more hazardous leaks have occurred due to corroded meter set components over the same time period. In 2018, the risk model identified the buried meter program as a high risk and a new program strategy was developed to reduce the backlog of buried meters. A taller riser design was developed with greater ground clearance to prevent the burial of additional meter sets.

Buried Meter Replacement Program Plan

PSE is actively replacing buried meters that pose an elevated risk of failure. PSE will continue monitoring the performance of buried meters through DIMP and appropriately update the replacement schedule and timeframe as necessary. For meter sets currently not identified as having an elevated risk of failure, PSE will continue to

incorporate new risk knowledge and evaluate whether this population warrants replacement under PRP in the future.

Based on current risk knowledge and historical performance, PSE will remediate approximately 40,000 buried meters within 6 years beginning in 2020. The 6 year term was chosen based on prioritizing higher risk locations first and remediating the remaining identified locations at an accelerated rate. New reports of buried meters will be added to the program as they are found, but adjustments to the program will be made as the impacts of installing the new taller riser are realized to reduce the number of new reports of riser burial or re-burial. The schedule should not create an undue burden on rate payers. Throughout the program duration, PSE is able to secure valuable contractor resources to keep a normalized work load while reducing the overall risk. The current replacement schedule is provided in Table 4.

Table 4. Buried Meter Replacement Schedule, Quantity, and Estimated Expenditures

Program Years	Total Planned Buried Meter Remediations	Estimated Expenditures[1]
1-6	40,000 Risers	$32 million

1 Estimated expenditures are in 2019 dollars and do not include AFUDC

Two-Year Plan

The two-year plan is to continue to replace/remediate buried meters according to the Master Plan. The following table shows the planned buried meter remediation and expenditures for 2020 and 2021.

Table 5. Planned Buried Meter Remediation and Estimated Expenditures

Year	Planned Buried Meter Riser Remediations	Planned Expenditures[1]
2020	5,000 Risers	$4 million
2021	7,000 Risers	$5.6 million
Total	12,000 Risers	$9.6 million

1 Estimated expenditures are in 2019 dollars and do not include AFUDC

Adjustments to projects will be made as required while managing to the Master Plan and overall system risk.

Identification Plan

Meter set assemblies that present an elevated risk of failure are continually monitored by reviewing system information that includes leak survey and patrol data. The population of 40,000 buried meters with an elevated risk of failure was identified through continuing surveillance activities. In conjunction with reviewing system performance data, PSE's geographic information system (GIS) is being utilized to proactively identify any new areas that may present an elevated risk of failure. Approximately 5,000 new reports of buried meters are identified each year and will be added to the master plan as necessary.

6. Sewer Cross Bores

Master Plan

Risk Assessment

The threat of sewer cross bores was identified through DIMP as an elevated risk to certain pipe installations. A sewer cross bore is a gas pipeline that has been inadvertently installed through an unmarked sewer pipe. Sewer cross bores occur when trenchless construction methods are utilized to install new natural gas pipe in areas where unmarked sewer lines exist. The state of Washington Damage Prevention Law requires excavators to use a One-call number locator service to alert underground facility owners of intended excavation activities and requires the marking of underground facilities in the area. However, sewer lines, and in particular, sewer laterals have proven to be difficult to locate. Sewer systems are often comprised of pipe that is not electronically locatable and sewer records are lacking in many areas. In addition, sewer lines on private property are the responsibility of the property owner, who does not possess the technology or records to be able to locate their sewer line. Sewer cross bores pose an elevated risk of failure due to the high consequence that would result if damage to the pipe occurs causing gas to leak into the sewer. If there is a sewer cross bore and it causes a blocked sewer, plumbers typically use a drain cleaning machine to clear the blocked sewer which could damage the gas line endangering people and property. Based on PSE's experience, it is more likely for plastic service lines in residential urban areas to be cross bored through sewers. Since 2013, more than 743 cross bores have been found in PSE's system.

A sewer cross bore pilot program was conducted in 2012 and in 2013 the Sewer Cross Bore Program was officially established. Hydromax USA ("HUSA") was selected as PSE's service provider to conduct sewer inspections that would help identify and remediate cross bores associated with new construction as well as sewer cross bores from legacy installations. A public awareness program was also launched to publicize PSE's cross bore safety program to make customers and plumbers aware of the sewer cross bore issue and to call PSE before clearing a sewer. The Sewer Cross Bore Program activity is tracked in the Continuing Surveillance Annual Report and has identified sewer cross bore as one of the highest risks in PSE's distribution system.

Sewer Cross Bore Replacement Plan

PSE is actively remediating pipe that poses an elevated risk from sewer cross bore. Based on detailed analysis of the characteristics associated with previously identified sewer cross bores, PSE, in concert with HUSA, has developed a computer model which assesses the likelihood that a sewer cross bore exists in an area. Utilizing the output of this model, PSE has developed a prioritized and systematic approach for alleviating the elevated risk that sewer cross bores pose. PSE will remediate the risk of sewer cross bore at the identified locations by documenting through inspection that no pipe is installed in the sewer and remediating any pipe that is found to have been cross bored through the sewer. PSE is also reducing the risk of future occurrences of new sewer cross bores being installed by contracting with HUSA to inspect sewer lines at a location after installation of any new gas line by trenchless methods.

The computer model utilizes machine learning algorithms to predict the likelihood that a cross bore exists. The model adjusts and learns as individual locations are confirmed and remediated and additional data is incorporated. Using the model, PSE has identified a population of 8,500 locations with a high likelihood in areas of high consequence should a gas line be damaged. A second population of approximately 51,500 locations has been identified with equal likelihood but less consequence. PSE has developed a plan to remediate the risk of sewer cross bore at these identified locations within 9 years beginning in 2019. Throughout the program duration, PSE

will continue to incorporate new information to refine the program and adjust the plan as needed. The current schedule is provided in Table 6.

Table 6. Sewer Cross Bore Remediation Schedule, Units, and Estimated Expenditures

Population	Program Years	Sewer Cross Bore Remediations	Estimated Expenditures
1	1	8,500 Locations	$5.5 million
2	8	51,500 Locations	$33.3 million
Total	9	60,000 Locations	$38.8 million

Two-Year Plan

The two-year plan will continue to prioritize the highest risk identified locations to remediate the risk of sewer cross bore. The following table shows the planned sewer cross bore remediations and expenditures for calendar years 2020 and 2021. PSE began using the computer model to identify locations in 2019 and will be remediating risk at 1,700 locations in 2019.

Table 7. Planned Sewer Cross Bore Remediations

Year	Sewer Cross Bore Remediations	Estimated Expenditures
2020	7,300 Locations	$4.7 million
2021	7,300 Locations	$4.7 million
Total	14,600 Locations	$9.4 million

Adjustments to projects and specific locations will be made as required while managing to the Master Plan and overall system risk.

Identification Plan

The identification of the location of sewer cross bores utilizes a computer model to identify the higher risk pipe segments. Model inputs include pipe installation year, manufacturer, nominal diameter, material, pressure, install method, actual length, and who installed the pipe. Those inputs are then used along with sewer cross bores found in the gas system to identify the higher likelihood pipe segments for cross bore risk. Those segments are the identified locations with higher sewer cross bore risk.

Remediating the risk of a sewer cross bore is performed with a camera inserted in the sewer pipe and then repair or replacement of pipe when a cross bore is found. The program includes sewers in proximity to new gas trenchless installations to confirm that new cross bores are not created and at risk sewers in proximity to legacy trenchless gas installations identified through the risk model.

7. Public Interest

The pipe replacement plans for the materials that pose an elevated risk of failure included in this PRP plan have been developed considering many factors. These factors include:

- Improving the safety of the distribution system by replacing pipe based on the relative level of risk presented for each material and location
- Minimizing the replacement costs by maximizing efficiencies and productivity
- Minimizing the impacts to municipalities and the general public

8. Rates Impact

The replacement programs included in this PRP plan that would be requested in the CRM starting with the 2020-2021 CRM rate period would include DuPont Aldyl "HD" plastic pipe, buried meter remediation, and sewer cross bores remediation.

Consistent with the requested potential rate impact analysis discussed in paragraph 55 of the policy statement, PSE's best estimate at this time is that the current impact on the overall customer rates for the three PRP plan programs would be 1.5%, while the long-term impact is expected to be approximately 0.5% for the 2020 through 2034 period.