Exh. GSS-7

Plymouth Failure Investigation Report

DOT	US Department of Transportation
PHMSA	Pipeline and Hazardous Materials Safety Administration
OPS	Office of Pipeline Safety, Western Region
WUTC	Washington Utilities and Transportation Commission (PHMSA Interstate Agent)

Principal Investigator	Scott Rukke, WUTC
Senior Accident Investigator	Peter Katchmar, PHMSA
Region Director	Chris Hoidal, PHMSA
Date of Report	4/28/2016
Subject	Failure Investigation Report – Liquefied Natural Gas (LNG) Peak Shaving Plant, Plymouth, Washington Operated by Williams Partners Operating, LLC

Operator, Location, & Consequences

Date of Failure	03/31/2014
Commodity Released	Natural Gas (both in liquid and gaseous states)
City/County & State	Plymouth (Unincorporated)/Benton County, WA
OpID & Operator Name	39054 - Williams Partners Operating LLC
Unit # & Unit Name	1155 – Williams Partners, Plymouth LNG
SMART Activity #	149816
Milepost / Location	Milepost 175.0
Type of Failure	Operator Error - Vessel and piping failure from detonation caused by internal auto-ignition due to a purge that failed to remove a gas-air mixture from the system.
Fatalities	0
Injuries	5
Description of area impacted	Contained within the plant grounds except for some ejected debris that caused damage to the adjacent railroad tracks.
Total Costs	$45,749,300

Executive Summary

On Monday, March 31, 2014, at approximately 8:19 a.m. PDT, the Plymouth-Liquefied Natural Gas (LNG) Peak Shaving Plant experienced a catastrophic failure and a resulting explosion on a portion of the facility's LNG-1 purification and regeneration system. The failure occurred during routine annual liquefaction startup operations. The failure initiated in the piping between adsorber vessel D20A and the salt bath heater D-40 used to heat the gas for adsorber regeneration. Five employees were injured and treated on site and one employee was flown to the hospital for additional treatment with burns. An emergency shutdown was activated and plant personnel were evacuated.

Debris from adsorber D20A and the associated piping caused extensive damages to the surrounding plant facilities, including penetration of the outer shell of the LNG-1 storage tank, a dent to the inner shell of the LNG-1 storage tank, the air scrubber to the Saturn Turbine compressor, above ground gas transmission piping at the compressor station, the LNG-1 refrigerant tower, regeneration compressor and coolers, boil-off compressor, various plant communication systems and cables, backup generator, and the surrounding buildings and structures including the control room. Furthermore, the Burlington Northern RR tracks which were located outside plant grounds were damaged by ejected debris.

The penetration of the outer shell of the LNG-1 storage tank caused the Perlite insulation between the annulus of the inner and outer tanks of the storage tank to be compromised, thereby allowing LNG "boil-off" gas to escape. Boil-off gas is the product of the constantly vaporizing LNG present in the inner tank which is open at the top. It was unknown whether boil off gas was originating directly from a debris-caused penetration of the inner tank shell of LNG-1 or was migrating through the top of the inner tank, through the annulus between the two tanks, and out the penetration of the outer tank. Regardless, a decision was made to evacuate the town of Plymouth and the surrounding communities within a two-mile radius. It was later confirmed that the inner tank of LNG-1 was not penetrated. The inner tank did sustain a minor dent, which was repaired.

Additionally, a protruding one half-inch diameter instrumentation pipe located near the bottom of the LNG-1 tank was damaged. This allowed LNG to release in a spray and vaporize. There was no pooling of the LNG and there was no resulting vapor (methane) cloud that left the plant. As soon as the plant was made safe, Williams' personnel donned cryogenic suits, entered the facility and closed the valve between the damaged pipe and LNG-1 tank wall, shutting off the LNG release at the tank. The release continued for approximately 25 hours and an estimated 9.3 barrels per hour or a total of 234 barrels was released.

The Washington Utilities and Transportation Commission (WUTC) and Pipeline and Hazardous Materials Safety Administration (PHMSA) responded to the event and conducted a combined investigation into the apparent and contributory causes of the failure.

The apparent cause of the failure was determined to be the auto-ignition of a gas-air mixture left in the piping after the pack and purge that was conducted on March 18, 2014. This pack and purge occurred 13 days prior to liquefaction start-up.

Pipeline System Overview

The Plymouth Peak Shaving Plant is a storage facility in the middle of the Williams Northwest Pipeline System, a primary artery for the transmission of natural gas to the Pacific Northwest and Intermountain Region. The pipeline is an approximately 3,900-mile, bidirectional transmission system crossing the states of Washington, Oregon, Idaho, Wyoming, Utah, and Colorado. Northwest's system provides access to British Columbia, Alberta, Rocky Mountain, and San Juan Basin gas supplies.

The LNG plant is a peak shaving storage facility that takes gas from the pipeline system in the spring and summer months, liquefies it, stores it, then vaporizes it during periods of high demand in the fall and winter months. The process of liquefying natural gas reduces the gas volume 600 to 1. That is, 600 cubic feet of natural gas becomes 1 cubic foot of LNG, and vice-versa, 1 cubic foot of LNG will expand to 600 cubic feet of natural gas when vaporized. The LNG process allows for an economic way to store natural gas for vaporization and distribution at a later date when demand increases.

The Plymouth LNG Peak Shaving Plant

The Plymouth plant consists of two separate LNG plants, LNG-1 and LNG-2. There is a compression station inside the plant fence consisting of four reciprocating compressors and one Saturn Turbine compressor. The LNG portion of the plant is a peak shaving facility that takes pipeline natural gas from the Northwest Pipeline (NWPL) interstate transmission system, removes CO2 and water vapor, then liquefies and stores the product (methane) for future vaporization and compression back into the NWPL system during periods of peak demand. It includes two 90 foot tall storage tanks with a capacity of 1.2 billion standard cubic feet (Bscf) (14.5 million gallons) of LNG each. The liquefaction process consists of two, 6 million cubic feet per day (MMCFD) refrigeration towers, each operated as an integrated cascade loop system. The facility includes four (4) vaporizers rated at 75 MMCFD. LNG boil-off within the storage tanks is captured and re-injected into the pipeline system. LNG-1 was placed in operation in 1975 and LNG-2 was placed in operation in 1979. Both LNG-1 and LNG-2 share the use of the four vaporizers.

LNG-1 Purification and Regeneration System (Failure Origin Site)

The purification and regeneration system is a subsystem of the LNG process consisting of two molecular sieve adsorber towers, a regeneration gas heater, also referred to as the salt bath heater (SBH), a regeneration compressor, hot and cold dust filters, and associated pipe and valving. The system removes water vapor and CO2 prior to the gas being liquefied.[1]

The adsorption process occurs as a precursor to the liquefaction phase of operation. It is a time based cycle between the two adsorber towers which allows one adsorber to remove water and CO2 and the other adsorber to regenerate or be cleaned using gas that has been heated by passing through the gas heater. This process ensures that a continuous stream of purified gas enters into the refrigeration towers where the liquefaction occurs.

[1] In order to liquefy, natural gas needs to be almost pure methane. Adsorbers are vessels which contain media that removes carbon dioxide and moisture when the pipeline quality natural gas is passed through them. Adsorbers are also known as molecular sieves.

The regeneration cycle initiates when one of the two adsorbers times out during purification. The inlet and outlet valves for the standby adsorber open to allow passage of the feed gas stream which then brings that adsorber on-line. The inlet and outlet valves of the adsorber to be regenerated close and the regeneration inlet and outlet valves open. A lateral from the main feed gas discharge, downstream of the adsorber gas filter, allows a portion of the feed gas to pass through the regeneration gas heater. The discharge of the regeneration gas heater passes through the adsorber selected for regeneration. The passage of the heated gas allows the release of the impurities from the media. The heated gas then carries the impurities out of the adsorber. Discharge from the adsorber then passes through the regeneration gas filter and cooler before entering the regeneration gas compressor. The regeneration gas compressor pressurizes the gas stream to the main pipeline pressure and discharges to the boil-off and regeneration gas header and returns it to the pipeline.

Events leading up to the Failure

The following is a timeline of the significant events that led up to the failure that occurred on the morning of March 31, 2014. This information was excerpted from pages 5-6 of the Root Cause Failure Analysis (RCFA) submitted by Williams dated October 29, 2015.

PHMSA/WUTC added emphasis by […].

> November 1, 2013 – Three manual valves were removed around hot dust filter (D-45) allowing air (containing 20.9% Oxygen) to enter the LNG-1 purification and regeneration system.
>
> March 18, 2014 – Three manual valves were installed around D-45 and pressure purging was performed from ~100 psig down to ~5 psig a total of three times [with natural gas]. Because the blowdowns for each pressure purge were only done to ~5 psig instead of the industry recognized 0-1 psig, oxygen remained in the system. The valve configuration (see appendix B) outlined in the procedure combined with the nested piping configuration around the adsorbers also made blowing down to 0-1 psig a must. The system was left at ~5 psig after the 3rd and final pressure purge. [A valve slowly leaked natural gas into the system after the purge. The pressure rose to 53 psig and remained constant until March 31, 2014.]
>
> March 30, 2014 – Regeneration Salt Bath Heater (D-40) was started and slowly brought up to its full operating temperature of 550 degrees F.
>
> March 31, 2014, 7:48-8:08 a.m. –Plymouth operators pressure system up to 685 psig. This pressurization added heat to the system due to the compression of the air and natural gas mixture still contained within.
>
> March 31, 2014, 8:14 a.m. – Regeneration compressor started and confirmed running.
>
> March 31, 2014, 8:15 a.m. – Plymouth Board Operator commands the system to align valves for normal operation using the distributed control system (DCS). As automated valves align they allow flow through the system.
>
> March 31, 2014, 8:15 a.m. – Shortly after the command is given via the DCS to align valves, [V400D on the inlet side of the Salt Bath Heater (SBH) opens and allows the gas-air mixture that was trapped on either side of this valve to flow] the flammable mixture of air and natural gas enters the D-40 salt bath heater where it auto-ignites. This ignition created a rolling detonation, against the flow of gas, through the flammable zone in the direction of the D-20A adsorber. The pressure wave generated by the detonation nearest D-20A then entered D-20A and failed the vessel by rapid over-pressurization releasing natural gas to the atmosphere where it ignited creating a large deflagration.

March 31, 2014 – Immediately following the failure, the plant was shut down, evacuated, and incident command established with the help of local emergency responders.

Events on the morning of March 31, 2014

Normal start time for all plant personnel is 6:30 a.m. At 6:45 a.m. an all-employee meeting was held in the main administrative building to plan out the work week. It lasted approximately an hour. During the meeting, the start-up of the purification system for LNG-1 and LNG-2 was discussed. The schedule goals were to start LNG-1 on Tuesday, April 1, morning and LNG-2 on Wednesday, April 2, morning.

After the meeting, the employees involved in the purification loop start-up went through the policy and procedures manual and pulled the procedures for starting the liquefaction process for LNG-1. The procedures were copied and provided to each employee. The employees went to the control room to initiate the start-up of the purification loop for LNG-1. There were newer employees as well as a couple of more experienced staff in the group. On-the-job training is an important method of ensuring that newer employees learn the correct actions for accomplishing different tasks at the plant.

Three technicians went to the control room and the other two went to the compressor building. The start-up procedures require the manual opening of different valves. Technicians in the control room directed technicians in the field by radio to perform each separate step in the start-up procedure. Once the purification system was pressured up, everyone but two technicians returned to the control room. The two technicians in the LNG-1 compressor building, adjacent to the adsorber towers, were to watch and listen for the start of the regeneration (Regen) compressor. The compressor started and appeared to be running correctly for a minute or two. At this point, one of the employees in the control room issued the command to start the regeneration process which aligned the valves in their correct orientation for purification. Valve D-400 (hot valve), downstream of the salt bath heater (SBH) opened allowing the gas-air mixture to flow into the SBH where the mixture auto-ignited. The initial explosion caused the piping immediately upstream of the SBH to fail catastrophically. A rolling detonation occurred inside the piping from the SBH propagating backward against the flow of gas until it reached the bottom of adsorber D-20A. The failed piping showed evidence that the pipe failure occurred from forces internal to the pipe. The post-accident analysis showed there were multiple explosions inside the piping before the pressure wave reached the adsorber, at which time the adsorber experienced a brittle failure. From the metallurgical analysis it was deduced that the adsorber failed due to an overloading event and there was no evidence of combustion internal to the adsorber. The pressure at the D-20A adsorber was estimated to have reached as high as 1,774 psig. Once the adsorber failed, the gas released then ignited, causing an explosion which propelled the pieces of the adsorber in all directions.

One of the two employees who were in the compressor building sustained burns. He was able to extricate himself from the debris and walk to the administrative building, where other employees assisted with first aid. He was air-lifted to a hospital. Four other employees sustained minor injuries.

After the explosion, all of the employees evacuated the area. The station emergency shutdown (ESD) switch was pulled by one of the evacuating employees and the plant ESD switch was pulled by personnel in the administrative building.

Emergency Response

Immediately after the explosion, the plant manager called 911 to report it. The plant manager then went back to his office and called Williams Gas Control and told them, "This is not a drill. The LNG Plant has experienced an explosion. There is fire and smoke in the adsorber area and there is blowing gas from the pipeline compressor area." He then called Williams Director of Operations and told him about the explosion and fire. He then told the Field Office Administrator to start the evacuation process.

At 9:10 a.m., a representative of Umatilla County, OR, called the National Response Center, (NRC) (report number 1078318) and reported a natural gas explosion and fire. It was also reported that approximately 200 private citizens were evacuated. As soon as PHMSA received this notification, calls were placed to the Oregon Public Utilities Commission, who were not aware of the incident. After a minute of discussion, when the Columbia River area was mentioned, it was decided that the call more than likely had to do with the LNG facility near Plymouth, WA, directly across the Columbia River from Umatilla, OR.

At 9:27 a.m., a representative from Williams Northwest Pipeline called the NRC (Report Number 1078325). It was reported that at 8:31 a.m., an explosion occurred at a natural gas compressor station (storage for LNG). The caller stated that the cause of the explosion was unknown, believed to possibly have been from a heater blowing up; there was an ongoing fire at the facility, and that the plant had been evacuated; there was a reported injury, it was unknown whether the individual was transported to a hospital, and injuries were believed to be minor.

During this time, PHMSA personnel were in contact with WUTC, PHMSA's State partner for natural gas and hazardous liquid pipeline inspection in the State of Washington. WUTC had already received a call from Williams and had already deployed an inspector to respond to the event.

Due to the 911 call, local fire departments, police agencies and county emergency services personnel were dispatched to the LNG Plant. First on scene were firefighters and ambulances. After talking with the plant personnel, it was decided to move everyone to a more remote point. It was also decided to evacuate citizens within an approximate two mile radius of the plant, which included most of the citizens of Plymouth, Washington. An incident command center was set up at the weigh station at the crossing of Hwy 14 and Plymouth Road. A representative from WUTC arrived in the early afternoon of March 31, 2014, and a PHMSA representative arrived the next morning. The investigation into the cause of the event was initiated.

Summary of Return-to-Service

Williams has worked closely with WUTC and PHMSA during the investigation and the reconstruction of the LNG-1 side of the plant. All known contributory factors identified during the investigation were either "designed out" of the reconstructed LNG facility or were addressed by writing and implementing new detailed procedural requirements.

The following changes were implemented to reduce the possibility of a similar accident recurring:

1. Modification of the purge process to include piping and purge points designed to remove all possible dead-legs.
    a. Design piping to ensure a full flow-through path for purge gas through the purification loop piping during the purge process.
    b. Implement detailed purge procedures to allow safe, successful and repeatable actions by employees.
2. Combining the LNG-1 and LNG-2 purification loops into one purification loop with three adsorbers.
3. Removal of the salt bath heater involved in the incident and replacement with a new "tight wound helical coil" heater that does not use a salt bath. This allows for more consistent heat distribution to the gas.
4. Modification of the start-up procedure to start the process heater after the system has been brought up to pressure and normal flow has been established.
5. Moving the control room away from the process area.
6. Adding additional archiving capability to plant control room systems.
7. Full engineering review and analysis of process operating procedures.

Investigation Details

WUTC and PHMSA collaborated on this investigation. WUTC provided continuous oversight of the assessment and removal of the failed portions of the piping and adsorber of specific interest to the metallurgists, and of the plant reconstruction and tank repair. PHMSA personnel monitored Williams' actions and remained in contact with WUTC throughout the accident investigation and the plant reconstruction period. All employees who were at the plant on March 31, 2014, were interviewed except the one individual who was admitted to the hospital. Original design documents, maintenance records, procedures, and records of modifications made over the years were reviewed and analyzed. Williams contracted with different experts to analyze different aspects of the event. WUTC and PHMSA have reviewed and analyzed all reports submitted. The following was excerpted from the Williams' RCFA, pages 4-5.

> "In response to the March 31, 2014 incident, Williams assembled an investigation team of various disciplines including employees and consultants. This portion of the report describes the tasks of each consultant and how those results aided the investigation.
>
> **ABS Consulting (Evidence Preservation) –** Brought on-site immediately to maintain chain of custody of all evidence gathered during the investigation. With debris scattered throughout the plant site, ABS Consulting was tasked with collecting, cataloguing and maintaining custody of all evidence.
>
> **Stress Engineering Services (Metallurgical Consultant) –** SES performed metallurgical analysis of fragments from adsorber D-20A in their shop in Houston, TX and confirmed that proper materials and construction methods for the era in which the vessel was manufactured were used. Additionally the report prepared by SES concluded that while there were multiple 'points of interest' there was no combustion internal to D-20A, meaning that the vessel was likely exposed to rapid over-pressurization.

Fauske & Associated (Auto-Ignition Testing) – The Chicago based team was enlisted to perform Auto-Ignition Testing of natural gas at increasing pressures. Based on the Plymouth plant inlet composition the morning of the incident, Fauske tested a similar composition at pressures ranging from atmosphere (in order to prove their experimental setup) up to 700 psia (Plymouth Plant pressure on the morning of the incident). They concluded that the auto-ignition temperature of natural gas drops with increasing pressure and that at the pressures immediately preceding the incident auto-ignition could occur as low as at 680 °F.
The Williams' investigation team reviewed this report and agreed with Fauske's conclusions.

ABS Consulting (Blast Modeling) – While gathering evidence details, ABS generated a damage report, noting where damage had occurred in the process area. ABS then created a 3-D model of the process area and ran simulations of internal detonations at various locations throughout the process area while monitoring internal pressure throughout the system. That pressure data was then used to determine areas of expected damage based on each detonation location. The expected damage was then compared to actual damage observed in the field, in particular 4" piping connecting the adsorber to the Salt Bath Heater which had failed from the inside outwards rather than by external impact. The best matching detonation location was on the inlet of the regeneration gas heater."

Williams also contracted with additional experts to evaluate LNG-1's storage tank for damage:

- **DBI, Inc. Quality Inspection and Consulting Services** – performed an out-of-service API-653 inspection on the LNG-1 tank.
- **G2MT, LLC** - was contracted to perform a residual stress analysis of a dented region on the LNG-1 tank.
- **Stress Engineering Services (Metallurgical Consultant) –** performed a Fitness- For-Service assessment on the dent in the LNG-1 tank prior to return-to-service.

All final reports submitted by the various consultants are on file with PHMSA.

Williams submitted an accounting of gas lost which is summarized in the table below on a monthly as well as overall basis.

Northwest Pipeline LLC Plymouth LNG Plant Incident Losses 16-Feb-16	Pipeline & Compressor Station Loss Mcf	LNG Tank & Plant Loss Mcf	Total Mcf
March 2014			
Pipeline Partially Closed Valve	4,263	-	
Compressor Station ESD	226	-	
LNG Plant ESD	-	33	
Tank Loss	-	9,748	
Total	4,489	9,781	14,270
April 2014			
Pipeline Partially Closed Valve	3,577	-	
LNG Tank Loss	-	71,212	
Total	3,577	71,212	74,789
May 2014			
Plant Pipeline Loss	3,647	-	
LNG Tank Loss	-	14,162	
Total	3,647	14,162	17,809
June 2014			
Plant Pipeline Loss	1,392	-	
LNG Tank Loss	-	13,405	
Total	1,392	13,405	14,797
July 2014			
Plant Pipeline Loss	-	-	
LNG Tank Loss	-	15,898	
Total	-	15,898	15,898
August 2014			
Plant Pipeline Loss	-	-	
LNG Tank Loss	-	13,140	
Total	-	13,140	13,140
September 2014			
Plant Pipeline Loss	-	-	
LNG Tank Loss	-	14,061	
Total	-	14,061	14,061
October 2014			
Plant Pipeline Loss	-	-	-
LNG Tank Loss	-	1,118	-
Total	-	1,118	1,118
November 2014			
Plant Pipeline Loss	-	-	-
LNG Tank Loss	-	2,332	-
Total	-	2,332	2,332
Estimated Total (MSCF)	13,105	155,109	168,214

Investigators requested a summary of damaged facilities that occurred as a result of the LNG Plant event. Following is an accounting of facilities impacted that was submitted by Williams:

1. "Systems affected
    a. T1 LNG Storage
        i. Incident debris penetrated the outer tank shell.
        ii. LNG contained in Tank 1 was transferred to T2.
        iii. Tank was warmed up, nitrogen purged, then air purged while being vented to atmosphere.

b. BOG (Boil-off Gas)
    i. Piping from LNG tanks to BOG compression was damaged during the incident.
    ii. LNG-1 BOG compression was damaged during the incident.
    iii. LNG tanks T1 and T2 were vented to atmosphere while repairs were made.
c. LNG Vaporization/Send-out
    i. PSV, recycle, and casing vent piping for three (five total) of the LNG send-out pumps returns to T1. Having T1 out of service renders the pumps unusable.
d. LNG-1 Liquefaction
    i. Damage was sustained to the cold box.
    ii. Communications, lighting, power, and hazardous gas systems were damaged in the incident.
    iii. The LNG-1 motor building was extensively damaged and had to be demolished.
    iv. BOG, regen, and MR (Mixed Refrigerant) compression were damaged in the incident.
    v. The control room and tech shop adjacent to LNG-1 were damaged.
    vi. Incident debris damaged the radiator for the emergency generator.
    vii. Piping and structural steel in the pipe rack adjacent to the incident area was damaged.
    viii. Plant office building was damaged by debris.
    ix. Maintenance shop was damaged by debris.
    x. LNG-1 Adsorbers were damaged during the incident.
    xi. Air coolers for compression (BOG, MR, Regen) and regeneration gas were damaged in the incident.
    xii. Refrigeration process vessels were damaged in the incident.
e. LNG2 Liquefaction
    i. Common process and utility piping systems to LNG-1 and LNG2 were damaged during the incident.
    ii. Cable tray at the LNG2 cold box was struck by incident debris.
f. MR
    i. Piping to LNG-1 and LNG2 was damaged during the incident.
    ii. BOG piping to the MR Mix tanks was damaged during the incident.
g. Vent Gas
    i. Vent gas piping was damaged during the incident.
h. NWP Pipeline Compression
    i. Damage was sustained to the Saturn air inlet filter, housing bellows, and building.
    ii. Damage was sustained to NWP compression piping."

Findings and Contributing Factors

WUTC and PHMSA find the following:

> The primary cause of this failure was a substandard purge performed after leaving the LNG-1 purification loop open to the atmosphere from November 1, 2013, to March 18, 2014. A flammable gas-air mixture remained in the system which then entered the salt bath heater and auto-ignited during start-up.

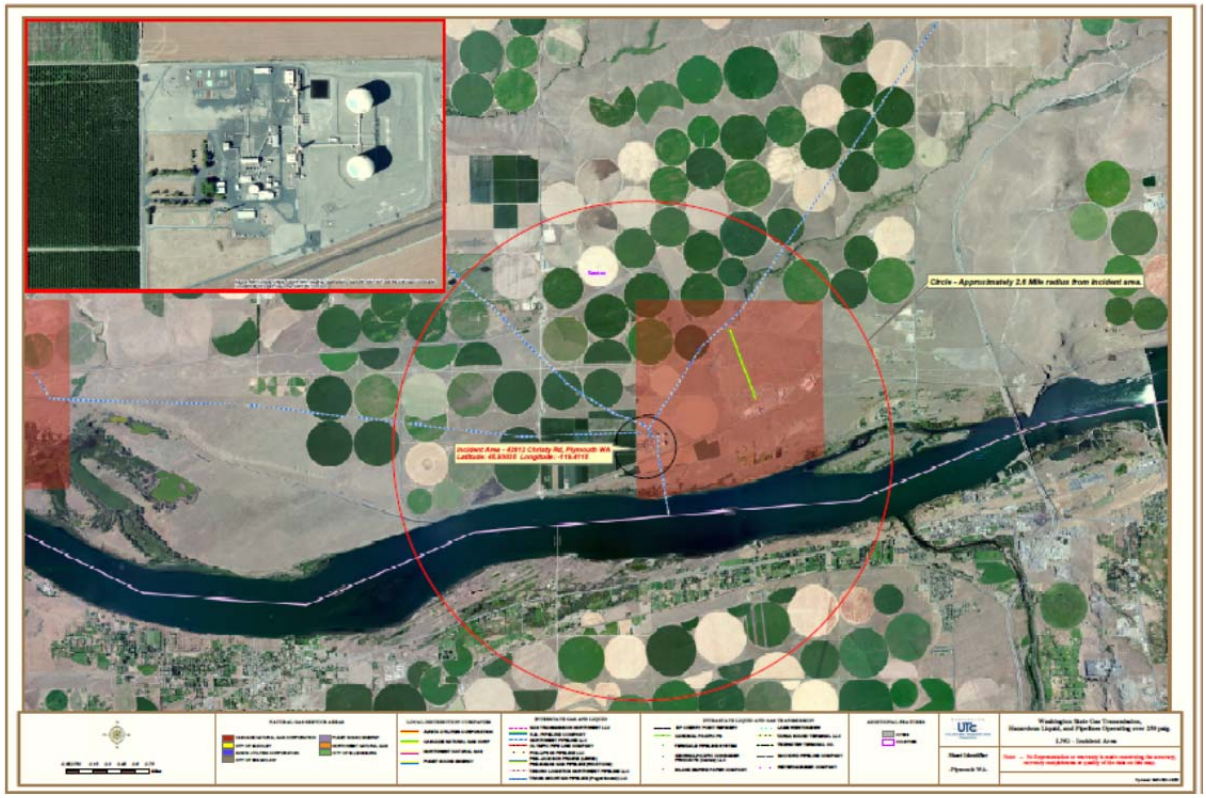
Contributory Causes:

1. The start-up sequence in the written procedure contributed to the event. The start-up of the salt bath heater combined with the rapid pressurization of the gas-air mixture in the system from 53 psig to 685 psig allowed conditions to exist that were within the temperature and pressure range for auto-ignition to occur.
2. The purge and pack procedure utilized by the employees on March 18, 2014, did not provide a sufficient amount of detail to assure successful and repeatable results.
3. Previous purge and pack operations may have at times utilized additional purge points at or near the adsorbers.
4. The low toughness of the adsorber metal allowed it to fail in a brittle manner causing fragmentation.

Appendices

A	Plymouth Final Report Photos
B	NRC Report #1
C	NRC Report #2
D	Operator Accident/Incident Report to PHMSA
E	Williams Root Cause Failure Analysis *(On file with PHMSA)*
F	ABS Consulting (Evidence Preservation) *(On file with PHMSA)*
G	Stress Engineering Services (Metallurgical Analysis) *(On file with PHMSA)*
H	Fauske and Associates (Auto-Ignition Testing) *(On file with PHMSA)*
I	ABS Consulting (Blast Modeling) *(On file with PHMSA)*
J	DBI, Inc. Quality Inspection and Consulting Services (Out-of-Service API-653 Inspection) *(On file with PHMSA)*
K	G2MT, LLC (Residual Stress Analysis) *(On file with PHMSA)*
L	Stress Engineering Services (Dented Wall Assessment) *(On file with PHMSA)*

Plymouth WA LNG plant overview. Approximate Two Mile Radius in Red Circle.



Pre-Event LNG Plant Overview.

Aerial view taken shortly after the failure. Looking South toward Columbia River.

Aerial view taken shortly after the failure. Fires still burning. Perlite insulation leakage from the penetrated outer LNG-1 storage tank. Control room lower left.

View of the outer shell penetration of the LNG-1 storage tank, looking east. Leaking 1/2-inch LNG instrument line lower left side of tank. V-shaped ice formation above outer shell penetration. Perlite insulation on ground lower left.

Close up of the pipe configuration where the spray of LNG was in the picture above.

Control room – center left. LNG-1 compressor building center right, refrigerant tower to the left of the compressor building. Natural gas fires from severed purification loop piping near the failed adsorber.

View from inside the Compressor Building where 2 employees were listening for the compressor start-up. The failed adsorber was on the outside of the back wall in this picture. The employee that was hospitalized with burns was in this area. Red arrow points to a hard hat.

Looking SE towards the failure site from in front of the Control Room. One of the twin adsorbers lying on its side. Compressor building in center-back. Refrigerant tower top-left. Use burned truck as reference.

View of the control room looking west. Use burned truck as reference.

View of the failure site looking east from inside the control room.

Inside of the control room view through the window. Looking west.

Remnants of the failed adsorber base center. Refrigerant tower top center. Large piece of debris from the failed adsorber embedded in the center of tower.

LNG-1 Salt Bath Heater where auto-ignition initiated. Red arrow indicates a failure point in the 4-inch heater gas inlet. The piping is blown outward and down. It would normally be behind the heater and up on the pipe rack. Looking Northeast. The LNG-2 storage tank in the background.

Another view of the Salt Bath Heater. The 4-inch gas inlet piping denoted with red arrows. The piping is blown to the left of the heater. Looking northwest.

The LNG-2 Salt Bath Heater which was identical to the LNG-1 Salt Bath Heater. The 4-inch inlet gas piping is painted black.

LNG-1 and LNG-2 purification systems. Looking northeast. Undamaged LNG-2 adsorbers, refrigerant tower and Salt Bath Heater center left.

LNG-2 Adsorbers – undamaged – identical to LNG-1 adsorbers pre-event.

Failed piping reassembled in secured evidence yard placed in as close to original piping configuration as possible. Stakes are placed at pipe rack cross members. Close observation reveals numerous internal failures of the piping caused by "rolling detonation". The 4" Salt Bath Heater inlet piping is placed next to the 6" outlet Salt Bath Heater piping. The pallets hold all of the small fragmented pieces of the 4" pipe.

This picture is in the opposite direction as the last picture. Notice the adsorbers in the background.

Overview of evidence yard.

Pipeline & Hazardous Materials Safety Administration

(Version 4.0.0 PROD)

HMIS->INCIDENTS->TELEPHONICS

[Return to Search]

NRC Number: 1078318

Call Date: 03/31/2014 **Call Time:** 12:10:00

Caller Information

First Name:	KATHY	Last Name:	LIEUALLEN
Company Name:	UMATILLA COUNTY		
Address:	4700 NORTHWEST PIONEER PLACE		
City:	PENDLETON	State:	OR
Country:	USA	Zip:	97801
Phone 1:	5419663651	Phone 2:	
Organization Type:	LOCAL G	Is caller the spiller?	○ Yes ◉ No ○ No Response
Confidential:	○ Yes ◉ No ○ No Response		

Discharger Information

First Name:		Last Name:	UNKNOWN
Company Name:			
Address:			
City:		State:	XX
Country:	USA	Zip:	
Phone 1:		Phone 2:	
Organization Type:	UNKNOW		

Spill Information

State:	OR	County:	UMATILLA
Nearest City:	UMATILLA	Zip Code:	

Location

Spill Date: 03/31/2014 (mm/dd/yyyy) Spill Time: 08:20:00 (24hh:mm:ss)

DTG Type: <- Select DTG Type ->

Incident Type: Fixed Facility Reported Incident Type: FIXED FACILITY

Description

CALLER STATED THEY RECEIVED A REPORT OF A NATURAL GAS EXPLOSION. CALLER ALSO STATED THAT THERE IS APPROXIMATELY 1 BILLION CUBIC FEET OF GAS RELEASED TO THE ATMOSPHERE. CALLER ALSO STATED THAT IT IS UNKNOWN WHAT EXPLODED BUT THERE IS A VISIBLE FIRE.

Materials Involved

Material / Chris Name	Chris Code	Total Qty.	Water Qty.
NATURAL GAS	ONG	1 CUBIC FEET	0 UNKNOWN AMOUNT

Medium Type: <- Select Medium Type ->

Additional Medium Information:

ATMOSPHERE

Injuries:		Fatalites:	
Evacuations:	◉ Yes ○ No ○ Unknown	No. of Evacuations:	200
Damages:	○ Yes ◉ No ○ Unknown	Damage Amount:	
Federal Agency Notified:	○ Yes ○ No ◉ Unknown	State Agency Notified:	○ Yes ○ No ◉ Unknown
Other Agency Notified:	○ Yes ○ No ◉ Unknown		

Remedial Actions

PRIVATE CITIZENS BEING EVACUATED.

Additional Info

CALLER STATED THAT THE EVACUATIONS ARE ON THE OREGON SIDE AND IS UNAWARE OF ANY EVACUATIONS ON THE WASHINGTON SIDE.

Latitude

Degrees: Minutes: Seconds: Quadrant:

Longitude

Degrees: Minutes: Seconds: Quadrant:

Distance from City: Direction:

Section: Township:

Range: Milepost:

Rescinded **Comments** (max 250 characters)

<< Previous 1..1 of 1 << Save >>

Pipeline & Hazardous Materials Safety Administration

(Version 4.0.0 PROD)

HMIS->INCIDENTS->TELEPHONICS

[Return to Search]

NRC Number: 1078325

Call Date: 03/31/2014 **Call Time:** 12:27:00

Caller Information

First Name:	TERRY	Last Name:	HARDMAN
Company Name:	WILLIAMS NW PIPELINE		
Address:	295 CHIPETA WAY		
City:	SALT LAKE CITY	State:	UT
Country:	USA	Zip:	84108
Phone 1:	8015846522	Phone 2:	8015807923
Organization Type:	PRIVATE	Is caller the spiller?	(•) Yes ( ) No ( ) No Response
Confidential:	( ) Yes (•) No ( ) No Response		

Discharger Information

First Name:	TERRY	Last Name:	HARDMAN
Company Name:	WILLIAMS NW PIPELINE		
Address:	295 CHIPETA WAY		
City:	SALT LAKE CITY	State:	UT
Country:	USA	Zip:	84108
Phone 1:	8015846522	Phone 2:	8015807923
Organization Type:	PRIVATE		

Spill Information

State:	WA	County:	BENTON
Nearest City:	PLYMOUTH	Zip Code:	

Location

42612 EAST CHRISTY RD.

Spill Date:	03/31/2014 (mm/dd/yyyy)	Spill Time:	08:31:00 (24hh:mm:ss)
DTG Type:	<- Select DTG Type ->		
Incident Type	Fixed Facility	Reported Incident Type	FIXED FACILITY

Description

THE CALLER IS REPORTING A EXPLOSION AT A NATURAL GAS COMPRESSOR STATION (STORAGE FOR LIQUID LNG). THE CALLER STATED THAT THE CAUSE OF THE EXPLOSION IS UNKNOWN, BELIEVED TO POSSIBLY BEEN FROM A HEATER BLOWING UP. THE CALLER STATED THAT THERE IS AN ONGOING FIRE AT THE FACILITY, THE PLANT WAS EVACUATED. CALLER STATED THAT THERE IS A REPORTED INJURY, UNKNOWN IF INDIVIDUAL WAS TRANSPORTED TO A HOSPITAL, INJURIES ARE BELIEVED TO BE MINOR.

Materials Involved

Material / Chris Name	Chris Code	Total Qty.	Water Qty.
LIQUEFIED NATURAL GAS	LNG	0 UNKNOWN AMOUNT	0 UNKNOWN AMOUNT

Medium Type: <- Select Medium Type ->

Additional Medium Information:

/POTENTIAL RELEASE

Injuries:	1	Fatalites:	
Evacuations:	(•) Yes ( ) No ( ) Unknown	No. of Evacuations:	
Damages:	( ) Yes (•) No ( ) Unknown	Damage Amount:	
Federal Agency Notified:	( ) Yes ( ) No (•) Unknown	State Agency Notified:	( ) Yes ( ) No (•) Unknown
Other Agency Notified:	( ) Yes ( ) No (•) Unknown		

Remedial Actions

INVESTIGATION UNDERWAY, FACILITY EMERGENCY SHUT DOWN ACTIVATED (REMOVING ALL NATURAL GAS IN THE FACILITY).

Additional Info

EVACUATED: HEAD COUNT IS UNKNOWN.

Latitude

Degrees: Minutes: Seconds: Quadrant:

Longitude

Degrees: Minutes: Seconds: Quadrant:

Distance from City: Direction:

Section: Township:

Range: Milepost:

Rescinded **Comments** (max 250 characters)

<< Previous 1..1 of 1 << Save >>

NOTICE: This report is required by 49 CFR Part 191. Failure to report can result in a civil penalty not to exceed 100,000 for each violation for each day that such violation persists except that the maximum civil penalty shall not exceed $1,000,000 as provided in 49 USC 60122.	OMB NO: 2137-0522 EXPIRATION DATE: 10/31/2017

U.S Department of Transportation Pipeline and Hazardous Materials Safety Administration	**Report Date:**	05/06/2014
	No.	20140002 - 15014 **updated - old value was 15013 --- (DOT Use Only)

INCIDENT REPORT – LIQUEFIED NATURAL GAS (LNG) FACILITIES

A federal agency may not conduct or sponsor, and a person is not required to respond to, nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirements of the Paperwork Reduction Act unless that collection of information displays a current valid OMB Control Number. Send comments regarding this collection of information, including suggestions for reducing the burden to: Information Collection Clearance Officer, PHMSA, Office of Pipeline Safety (PHP-30) 1200 New Jersey Avenue, SE, Washington, D.C. 20590.

INSTRUCTIONS

Important: *Please read the separate instructions for completing this form before you begin. They clarify the information requested and provide specific examples. If you do not have a copy of the instructions, you can obtain one from the PHMSA Pipeline Safety Community Web Page at http://www.phmsa.dot.gov/pipeline/library/forms.*

PART A - KEY REPORT INFORMATION

Report Type: *(select all that apply)*	**Original:**	**Supplemental:**	**Final:**
		Yes	**Yes** **updated - old value was NULL**

Last Revision Date:	03/25/2016
1. Operator's OPS-issued Operator Identification Number (OPID):	39054
2. Name of Operator	WILLIAMS PARTNERS OPERATING LLC
3. Address of Operator:	
3a. Street Address	ONE WILLIAMS CENTER
3b. City	TULSA
3c. State	Oklahoma
3d. Zip Code:	74172
4. Local time *(24-hr clock)* and date of the Incident:	03/31/2014 08:19
5. National Response Center Report Number:	1078325
6. Local time *(24-hr clock)* and date of initial telephonic report to the National Response Center (if reported):	03/31/2014 09:23
7. Incident resulted from:	
Unintentional release of commodity	Yes
Intentional release of commodity	No
Emergency shutdown	No
Reasons other than the above	No
- Describe:	
8. Commodity released: (select only one, based on predominant volume released)	Natural Gas while being handled in gaseous phase
- Other Commodity Name:	
9. Estimated volume of commodity released unintentionally - Thousand Cubic Feet (MCF):	14,000.00
10. Estimated volume of intentional and controlled release/blowdown - Thousand Cubic Feet (MCF)	154,200.00
11. Estimated volume of liquid spilled to the ground (Barrels):	
12. Were there fatalities?	No
- If Yes, specify the number in each category:	
12a. Operator employees	
12b. Contractor employees working for the Operator	
12c. Non-Operator emergency responders	
12d. General public	
12e. Total fatalities (sum of above)	
13. Were there injuries requiring inpatient hospitalization?	Yes
- If Yes, specify the number in each category:	
13a. Operator employees	1
13b. Contractor employees working for the Operator	0
13c. Non-Operator emergency responders	0

13d. General public	0
13e. Total injuries (sum of above)	1
14. Was the LNG Facility shut down due to the incident?	Yes
- If No, Explain:	
- If Yes, complete Questions 14a and 14b: *(use local time, 24-hr clock)*	
14a. Local time and date of shutdown	03/31/2014 08:19
14b. Local time LNG Facility restarted	03/15/2016 08:15
- Still shut down? (* Supplemental Report Required)	
15. Was there an ignition?	Yes
16. Was there an explosion?	Yes
17. Number of general public evacuated:	150
18. Number of operator/contractor personnel evacuated:	18

PART B - ADDITIONAL FACILITY INFORMATION

1. Facility Information:

	LNG FACILITY / PLANT
Name of LNG Plant / Facility	Plymouth LNG Peak Shaving Plant
NPMSLNG ID	
Plant / Facility Status	In Service
Plant / Facility Location	
State	Washington
Latitude	
Longitude	
Process	
Liquefaction/Vaporization Rate (MMCF/D) at the time of the Incident	0
Number of Vaporizers in service at the time of the Incident	0
Total Capacity (MMCF/D)	300
LNG Source *(list all that apply)*	
Truck	
Railroad	
Ship/Barge	
Liquefaction	Yes
Interstate or Intrastate	Interstate
LNG Storage	
Number of LNG Tanks	2
Volume of LNG in Storage at the time of the Incident (Bbls)	344309
2. Type of LNG Plant / Facility*: (select all that apply)*	
Base Load	
Peak Shaving	Yes
Satellite	
Mobile / Temporary *(select the following based on use at time of Incident)*	
Intrastate	
Interstate	
Other	
Describe	
3. Function of LNG Plant / Facility at the time and date of the Incident*: (select all that apply)*	
Marine Terminal *(select one or both)*	
Import Terminal	
Export Terminal	
Storage *(select one or both)*	Yes
With Liquefaction	Yes
Without Liquefaction	
Stranded Utility	
Vehicular Fuel	
Nitrogen Rejection Unit or Other Special Use	
Describe:	
4. Item involved in Incident: *(select only one)*	
Item involved	In-plant Piping
- If Other Describe:	

PART C - ADDITIONAL CONSEQUENCE INFORMATION

1. Estimated Property Damage:	
1.a Estimated cost of public and non-Operator private property damage	$ 71,300
1.b Estimated cost of Operator's property damage & repairs	$ 40,790,000
1.c Estimated cost of Operator's emergency response	$ 190,000

1.d Estimated other costs	$ 4,698,000
Describe	Purification system upgrade, certain MI inspections and enviro monitoring.
1.e Total estimated property damage (sum of above)	$ 45,749,300
Cost of Commodity Released	
1.f Estimated cost of commodity released unintentionally	$ 80,960
1.g Estimated cost of commodity released during intentional and controlled blowdown	$ 672,800
1.h Total estimated cost of commodity released (sum of 1.f & 1.g above)	$ 753,760

PART D - ADDITIONAL OPERATING INFORMATION

1. Was a computerized Control System in place?	Yes
- If Yes:	
1.a Was it operating at the time of the Incident?	Yes
1.b Was it fully functional at the time of the Incident?	Yes
2. How was the Incident initially detected: *(select only one)*	Local operating personnel, including contractors working for the Operator
- If Other - (*Explain in PART G Narrative)*	

PART E - DRUG & ALCOHOL TESTING INFORMATION

1. As a result of this Incident, were any Operator employees tested under the post-accident drug and alcohol testing requirements of DOT's Drug & Alcohol Testing regulations?	Yes
- If Yes:	
1a. Specify how many were tested:	16
1b. Specify how many failed:	0
2. As a result of this Incident, were any Operator contractor employees tested under the post-accident drug and alcohol testing requirements of DOT's Drug & Alcohol Testing regulations?	No
- If Yes:	
2a. Specify how many were tested:	
2b. Specify how many failed:	

PART F - APPARENT CAUSE

Select only one APPARENT Cause of the Incident, and answer any questions on the right or below as indicated. Describe secondary, contributing, or root causes of the Incident in the narrative (PART G).

Apparent Cause:	F7 - Incorrect Operation

F1 - Corrosion Failure

External / Internal Corrosion	

F2 - Natural Force Damage

Natural Force Damage	
If **Other Natural Force Damage**,	
1. Describe:	
Complete the following if any Natural Force Damage sub-cause is selected.	
2. Were the natural forces causing the Incident generated in conjunction with an extreme weather event?	
2a. If yes, specify: *(select all that apply)*:	
- Hurricane	
- Tropical Storm	
- Tornado	
- Other	
- If Other, Describe:	

F3 - Excavation Damage

Excavation Damage	

F4 - Other Outside Force Damage

Other Outside Force Damage	

- If Damage by Car, Truck, or Other Motorized Vehicle/Equipment NOT Engaged in Excavation:	
1. Vehicle/Equipment operated by:	
- If Damage by Boats, Barges, Drilling Rigs, or Other Maritime Equipment or Vessels Set Adrift or Which Have Otherwise Lost Their Mooring:	
2. Select one or more of the following IF an extreme weather event was a factor:	
- Hurricane	
- Tropical Storm	
- Tornado	
- Heavy Rains/Flood	
- Other	
- If Other, Describe:	
- If Intentional Damage:	
3. Specify:	
- If Other, Describe:	
4. Did the Intentional Damage involve a breach of security?	
- If Yes, *(Explain fully in the PART G Narrative)*	
- If Other Outside Force Damage:	
5. Describe:	

F5 – Material Failure of Pipe or Weld	**Use this section to report material failures ONLY IF the "Item Involved in Incident" (from PART B, Question 4) is "In-plant Piping" or "Weld".**

1. The sub-case selected below is based on the following *(select all that apply)*:	
- Field Examination	
- Determined by Metallurgical Analysis	
- Other Analysis	
- Sub-cause is Tentative or Suspected; Still Under Investigation *(Supplemental Report required)*	
Material Failure of Pipe or Weld	
If Low Temperature Embrittlement (due to a process fluid) 2. Was **insulation degradation** a factor in this failure?	
F6 - Equipment Failure	
Equipment Failure:	
- If Other Equipment Failure:	
1. Describe:	
Complete the following if any Equipment Failure sub-cause is selected.	
2. Did this failure involve **Low Temperature Embrittlement** due to process fluids?	
3. Was **insulation degradation** a factor in this failure?	
F7 – Incorrect Operation	
Incorrect Operation:	Other Incorrect Operation
- If Other Incorrect Operation:	
1. Describe:	Inadequate purge following maintenance activities.
Complete the following if any Incorrect Operation sub-cause is selected.	
2. Was this Incident related to: *(select all that apply)*	
- Inadequate procedure	Yes
- No procedure established	
- Failure to follow procedure	
- Other:	
- If Other, Describe:	
F8 - Other Incident Cause	
Other Incident Cause:	
- If Miscellaneous:	
1. Describe:	
- If Unknown:	
2. Specify:	

PART - G NARRATIVE DESCRIPTION OF THE INCIDENT

At approximately 08:19 PDT the Plymouth LNG facility experienced an internal detonation resulting in rapid overpressure and subsequent failure of portions of the LNG1 purification and regeneration system, including in plant piping and an adsorber vessel, causing damage to adjacent buildings and equipment. Debris from the rupture penetrated the outer wall of one of two LNG storage tanks. Natural Gas vented from the vapor space between the inner and outer walls of the storage tank but did not ignite.

Station personnel immediately executed an ESD of the facility. Of 5 employees taken to the hospital for evaluation, 4 employees were treated and released and 1 employee was admitted for burn injuries and released several days later.

A third party investigation firm was contracted to document the incident location and manage all evidence. Various consultants were engaged in the completion of an incident investigation. The investigation determined the leading cause was the presence of a fuel/air mixture remaining in the system following maintenance activities. The fuel/air mix then auto-ignited within the system piping upon startup when the flammable mixture entered the inlet of a salt bath heater.

PART H - PREPARER AND AUTHORIZED SIGNATURE

Preparer's Name	Jared Ellsworth
Preparer's Title	Manager Pipeline Safety
Preparer's Telephone Number	8015846539
Preparer's E-mail Address	jared.ellsworth@williams.com
Preparer's Facsimile Number	
Authorized Signature's Name	Jared Ellsworth
Authorized Signature Title	Manager Pipeline Safety
Authorized Signature Telephone Number	8015846539
Authorized Signature Email	jared.ellsworth@williams.com
Date	03/25/2016

Appendix E

Williams Root Cause Failure Analysis

This document is on file at PHMSA

Appendix F

ABS Consulting (Evidence Preservation)

This document is on file at PHMSA

Appendix G

Stress Engineering Services (Metallurgical Analysis)

This document is on file at PHMSA

Appendix H

Fauske and Associates (Auto-Ignition Testing)

This document is on file at PHMSA

Appendix I

ABS Consulting (Blast Modeling)

This document is on file at PHMSA

Appendix J

DBI, Inc. Quality Inspection and Consulting Services (Out-of-Service API-653 Inspection)

This document is on file at PHMSA

Appendix K

G2MT, LLC (Residual Stress Analysis)

This document is on file at PHMSA

Appendix L

Stress Engineering Services (Dented Wall Assessment)

This document is on file at PHMSA