JUDY CREEK

08-35-063-11W5M to 13-36-063-11W5M
Oil Effluent Pipeline
Licence # 4218-117

Failure Analysis of 8 Inch STAR™ Aliphatic Amine Line Pipe 1250 Series

SE Ref No.: 11-1057

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1.0 SCOPE

On June 26, 2011 a failure occurred on a STAR™ Aliphatic Amine Line Pipe (STAR pipe) at the Judy Creek header system located at 08-35-063-11W5M, owned by Pengrowth Energy Corporation (Pengrowth). The failure resulted in a spill and a fire. Nobody was hurt by the incident. Figure 1 shows the fire on the site. Appendix 1 contains more field photographs showing both the fire and the cleanup of the site in progress.

The failed line pipe (licence 4218-117) was a group line, which combined flows from several wells at Judy creek and runs from the 08-35-063-11W5M header to a header system located at 13-36-063-11W5M.

Skystone Engineering (Skystone) was requested to provide the following services to Pengrowth:

- Visit the failure site, provide visual examination of the location of the failure, and select STAR pipe sections for a failure analysis.
- Perform the failure analysis of the STAR pipe and establish the reason for the failure.
- Assist Pengrowth in selecting the equipment which could be reused after the fire.

Figure 1 – Fire On Site

2.0 BACKGROUND

Table 1 shows the pipeline information retrieved from an industry database containing ERCB licensing information.

Table 1 – ERCB Pipeline Information For Pipeline Lic. # 4218-117 Current To May 31, 2011

LICENCE/LINE #:	4218 - 117		**PERMIT DATE:**	NOVEMBER 7, 2006	
ABACUS #:	115257		**LICENCE DATE:**	NOVEMBER 7, 2007	
COMPANY:	PENGROWTH ENERGY CORPORATION				
FROM LOCATION:	08-35-063-11 W5M PL		**TO LOCATION:**	13-36-063-11 W5M PL	
LENGTH:	1.49 kms	0.93 mi	**STATUS:**	Operational	
SUBSTANCE:	Oil Effluent		**H2S:**	0.55 mol/kmol	550 ppm
OD:	214.4 mm	8.44 "	**WT:**	8.9 mm	0.35 "
MATERIAL:	Fiberglass		**TYPE:**	STAR	
GRADE:	1250		**MOP:**	3450 kPa	500 psi
JOINTS:	T		**INTL COATING:**	U	
STRESS LEVEL:	0 %		**ENVIRONMENT:**		
ORIGINAL PERMIT DATE:	NOVEMBER 7, 2006		**CONST. DATE:**	JANUARY 4, 2007	
ORIGINAL LICENCE/LINE #:	4218 - 117		**NEB REG:**	No	

The failed pipeline was identical to the pipeline licence 4218-116, which ran parallel to the failed pipeline, and was installed in the same trench at the same time. Table 2 shows the information for pipeline licence # 4218-116 retrieved from an industry database containing ERCB licensing information.

Table 2 – ERCB Pipeline Information For Pipeline Lic. # 4218-116 Current To May 31, 2011

LICENCE/LINE #:	4218 - 116		**PERMIT DATE:**	NOVEMBER 7, 2006	
ABACUS #:	115256		**LICENCE DATE:**	NOVEMBER 7, 2007	
COMPANY:	PENGROWTH ENERGY CORPORATION				
FROM LOCATION:	08-35-063-11 W5M PL		**TO LOCATION:**	13-36-063-11 W5M PL	
LENGTH:	1.49 kms	0.93 mi	**STATUS:**	Operational	
SUBSTANCE:	Oil Effluent		**H2S:**	0.55 mol/kmol	550 ppm
OD:	214.4 mm	8.44 "	**WT:**	8.9 mm	214.4 mm
MATERIAL:	Fiberglass		**TYPE:**	STAR	
GRADE:	1250		**MOP:**	3450 kPa	500 psi
JOINTS:	T		**INTL COATING:**	U	
STRESS LEVEL:	0 %		**ENVIRONMENT:**		
ORIGINAL PERMIT DATE:	NOVEMBER 7, 2006		**CONST. DATE:**	JANUARY 4, 2007	
ORIGINAL LICENCE/LINE #:	4218 - 116		**NEB REG:**	No	

According to ERCB licensing, the pipelines with licence # 4218-117 and 4218-116 were made of STAR™ Aliphatic Amine Line Pipe (STAR pipe) Grade 1250. Appendix 2 contains the manufacturer's documentation for this pipe. The pipelines were licensed for sour service with H_2S concentrations up to 550 ppm. The outer diameter (OD) and the wall thickness (WT) were

214.4 mm (8.44 inches) and 8.9 mm (0.35 inches), respectively. The maximum operating pressure (MOP) was 3,450 kPa or 500 psi.

The following additional information on the operating conditions was obtained from Pengrowth:

- Age of pipelines: construction date January 4, 2007.
- Pipe OD: 8-5/8 inches or 214.4 mm.
- Pipe inner diameter (ID): 196.6 mm.
- Pipe (WT): 8.9 mm nominal, 8.01 mm minimal.
- Maximum operating pressure (MOP): 3,450 kPa or 500 psi.
- Temperature of process stream: 62-68°F or 17-20°C.
- Type of substance: water-oil-gas emulsion.
- Type of pipeline: group line, which combines production from 41 wells.
- Production rate at the time of incident: 91 m^3 oil, 28.5 E^3m^3, 3951 m^3 produced water.
- Production one week prior to the incident: 267 m^3 oil, 93 E^3m^3 gas, 11,919 m^3 produced water daily.
- Pigging frequency: no pigging.
- Batch inhibition (for connecting carbon steel pipes): 5 L of Nalco EC9205A corrosion inhibitor bi-weekly.
- Bacteria problems: no.
- Corrosive media: up to 77,975 ppm chlorides, up to 2% CO_2, and up to 400 ppm H_2S in individual wells. Appendix 3 shows the results of fluid analyses.
- Location of failure: first elbow from riser at 08-35-063-11W5M location.
- Topography of the pipeline: relatively flat area, top of a small hill.
- Appendix 4 contains selected relevant extracts from the construction binder.

The sequence of the main events was as follows (Appendix 5 shows a detailed sequence of events related to the failure on June 26, 2011):

- 11:30 – power outage: 06-35 ATCO substation voltage regulator failure – south A & B pool were affected by power outage, as well as the main facility 11-6 production complex (PC) and miscible.
- 11:35 – Field crews dispatched to deal with the outage – some equipment required manual shutdown (about 50% of wells did not shutdown with the remote shutdown in the north loop). The wells did not shut down because the power at the wells was out prior to the automated shut-down command being sent by the PC operator.

- 11:40 – PC blocked in the inlets to deal with high level of the process vessels.
- 11:45 – PC ESD due to low instrument air.
- 11:45 – 2:30 - In holding pattern until power came on about 2:30.
- 2:30 – Power was restored.
- 2:30 – Pengrowth started getting rid of high levels in inlet separators.
- 2:30 - 4:00 – Flows from different wells were automatically switching on (unknown to operations).
- 4:00 – Opening up inlets. Smoke was observed at 08-35 location.
- 4:15 – Fire at 08-35 was confirmed.
- 4:45 – Pipelines and wells were starting to be shut in.
- 5:15 – The leak was isolated and the flame started to die down.
- 5:45 – Spot fires were extinguished by the Fire Department.

3.0 ON- SITE EXAMINATION

On June 29, 2011, Dr. Alex Tatarov from Skystone visited the failure site. The weather at the time of the visit was sunny with some clouds, without any rain or fog. The site had been already cleaned up, and the location of the failure had been excavated with hydro vacuuming.

Figure 2 shows the overview of the location of the failure and flow directions. The flows from several different pipelines were gathered in a 16 inch carbon steel manifold, and through a 16 inch valve the flow came into 16 inch flanged pipe, where the flow separated into two 8 inch stainless steel flanged pipes. Each 8 inch stainless steel pipe was flange connected to a vertical 8 inch STAR pipe. From the vertical STAR pipes, fluid flowed through 90 degrees elbows and entered the STAR pipelines licences # 4218-116 and # 4218-117. The pipeline licence # 4218-116 was visually undamaged; the pipeline licence # 4218-117 was broken at the 90 degree elbow at the bottom of the riser. Arrows in Figure 2 show the flow through the visually undamaged pipeline licence # 4218-116. The flow through the failed pipeline licence # 4218-117 was similar.

Figures 3 and 4 show overviews of the failure sites from different angles. An overall visual examination showed that:

- The line separated within the body of the STAR riser pipe, near the elbow at the bottom of the riser.
- The elbow was not found. As reported by Pengrowth, neither search by ground crews, nor aerial search was able to find the missing elbow.
- The 8 inch stainless steel pipe, which originally contained a 90-degrees bend, was bent to an angle of approximately 45 degrees as a result of the incident.

- A section of the flanged STAR pipe, approximately 80 inches long was still attached to the steel flange.
- The bottom end of the broken STAR pipe was resting on a T-shaped steel support.
- The T-shaped support was displaced from its original vertical position and its upper part was resting on the manifold pipe. The bottom end of the T-shaped support was resting on the ground.
- Line 116 was visually undamaged.
- Figure 4 shows that the vertical section of the riser of line 116 was bent.
- It was concluded that the bending occurred after the accident and could not have caused the accident:
    - Currently the support is missing, and the vertical STAR pipe from line 116 successfully holds the entire load without a visible failure.
    - The current load conditions (without the support) are worse compared to the operating conditions. The load was split by half between two vertical sections of lines 116 and 117, and both vertical STAR pipes were surrounded by soil, which provided additional support against buckling.
- The lower sections of both vertical STAR pipes were not affected by fire. It is likely that they were surrounded by the soil.
- The upper sections of both vertical STAR pipes were slightly affected by fire above ground; they were slightly charred and covered with some soot. Nevertheless, there were no areas which demonstrated visible dimensional changes.
- The 16 inch steel manifold and the 8 inch stainless steel pipes were visibly affected by fire; they were discoloured and covered with black soot.

Several sections were selected for examination; they are marked in Figure 3.

Figures 5 and 6 show the overview of the horizontal sections of lines 116 and 117:

- A significant amount of rock was found at the bottom of the excavation site. It is possible that when soil was removed by hydro vacuuming, large rocks, which exceeded the diameter of the suction pipe, were not removed and collected at the bottom of the dig.
- The STAR lines ran parallel to another.
- Different sections of the STAR lines were connected by STAR collars, 10 inches in OD.
- The elbow from line 117 was missing and the elbow from line 116 was still in place.

- Both 90-degree elbows were resting on anchors, which contained horizontal steel plates (which provided vertical support) and two vertical pipes/beams which prevented elbow from movement in the transverse direction.
- The anchors allowed movement in the axial direction.
- Both lines (116 and 117) were visibly straight, except for sections adjacent to the elbows, which were visibly bent.

Figures 7 through 12 show closer views of the line pipe sections adjacent to elbows:

- Figures 7 and 8 show the angles of inclination of the first section related to the remaining pipeline.
- The angle in line 117 was measured to be 6 degrees, and the angle line 116 was measured to be 5 degrees.
- Figures 9 and 10 show the failed end of the line 117 resting on the steel plate.
- The failure occurred in the threaded connection.
- The visible interior of the failed line was filled with mud.
- Figures 11 and 12 show the elbow connection of line 116.
- The line 116 elbow was adequately secured at the anchor using rubber sheets.
- The line 116 elbow, not the pipe, was resting on the steel plate.

There was a power line in the vicinity of the location of the failure. Figure 13 shows the closest post, and figure 14 shows a closer view of the top part of the post, containing insulators. The wooden post did not contain any indications of fire damage. Thus it was unlikely that the power line participated in the ignition.

4.0 LABARATORY EXAMINATION

4.1 Visual Examination of Failed Pipe Licence # 4218-117 (Failed 6' Pup)

The failed section of the STAR pipe licence # 4218-117 (the 6' pup marked in Figure 3) was removed from the site and brought to the Skystone laboratory. The ERCB visually inspected the sample(s) after removal and prior to shipping to Skystone. The section was washed in the field. Figure 15 shows the cut-out section as received.

The section was approximately 59 inches long. Its external diameter (OD) was measured to be 8.41 inches, which is below the nominal diameter of 8.44 inches, but within the tolerance limit (from 8.37 inches to 8.51 inch)[1]. The wall thickness (WT) was measured to be 0.34 inches, which is below the nominal wall thickness of 0.35 inch, but within the manufacturer's tolerance limit (0.317-0.387 inch)[1]. The section was marked by a red paint marker, probably at the time of

[1] See email communication in Appendix 2.

construction. Visual examination did not reveal any manufacturing stencil markings on the surface of the pipe.

The failed STAR pipe contained a broken threaded connection (pin end) at the upstream end. The threaded connection was a polymer thread glued onto the external surface of the STAR pipe. The external surface contained indication of damage with rocks, which did not result in the failure. Figures 16 through 18 show closer side views of the failure.

- The fracture surface was of irregular shape and was mostly located within the threaded area.
- The only location where the fracture surface extended beyond the thread, was at top, close to the 12 o'clock position, as shown in Figure 16. This was the most probable location of fracture initiation.
- Figures 17 through 18 show that the polymer thread was partially removed from the external surface and the remaining thread was affected by erosion.
- Where the thread was removed, the exposed surface of the STAR pipe was affected by erosion.
- Figures 17 and 18 show that the external surface was affected by erosion beyond the threaded area.

Figures 19 through 21 show closer views of the bottom of the failed pipe.

- The bottom part was affected by wear.
- The wear pattern was uneven; the minimum wear was observed at the fracture surface, and the maximum wear was observed approximately 9 inches from the end of the thread, at the 6 o'clock position.
- In the location of the maximum wear, the entire pipe wall thickness was penetrated.
- The location of the wear corresponded to the area of the pipe where it was resting on the steel plate, as shown in Figures 9 and 10.
- It will be shown later in the report that the wear was a post-fracture phenomenon and did not contribute to the failure.

Figure 22 shows the fracture surface and the internal surface of the failed pipe. Both the fracture surface and the internal surface were affected by erosion. The erosion on the internal surface was observed only in the vicinity of the fracture surface.

The fracture surface was cut from the pipe, and the adjacent 15 inch long section was split longitudinally along the 3 and 9 o'clock positions in order to expose the interior. Figures 23 through 27 shows the results of the visual examination of the internal surface.

- The internal surface of the STAR pipe away from the failure was in good condition. It was not affected by erosion and contained no indications of either chemical or mechanical degradation.

- The winding angles of glass fibres were located at approximately ± 54 degree angles to the axial direction.
- The area affected by erosion did not extend beyond approximately 13 inches from the fracture surface.
- Mechanical damage was observed at the bottom of the pipe at the 6 o'clock position. This damage corresponded to the location of the maximum wear on the external surface, shown in Figures 19 and 21.
- At the location of the mechanical damage the glass fibres were protruding towards the pipe interior, which is consistent with an applied external force. This also indicates that the damage occurred after the pipe lost its integrity, otherwise the fibres should be protruded towards the pipe exterior under a combined actions of internal pressure and fluid flow.
- Figures 26 and 27 show closer views of the areas of internal surface affected by erosion. Erosion resulted in a significant wall loss and in delamination.
- The erosion pattern was consistent with the fluid flow from the outside towards the fracture surface. This indicates that immediately after the failure, the broken pipe ends were not separated by a large distance, so the fluid flow from the upstream fractured end was able to reach the downstream fractured end.
- This would be attributed to the riser being in a fixed position within the support of the soil until the emulsion flushed and eroded the soil away.
- It is also likely that the fluid flow engaged solid particles (sand) from the surrounding soil, which accelerated the erosion.
- No indications of either charring or burning were observed on the fracture surface.

4.2 Visual Examination of Failed Riser Licence # 4218-117 (Failed 9' Pup)

A 38 inch long section of the riser was cut from the remaining part of the failed vertical STAR riser pipe (the 9' pup in Figure 3) and delivered to the Skystone laboratory for examination. The failure fracture surface was present on one end of the riser section. Figures 28 and 29 show the failed section of the 9' pup as received.

The section in the as received condition was covered with hydrocarbons. It was approximately 38 inches long. The OD was measured to be 8.66 inches, and the WT was measured to be 0.478 inches, which exceeded the specified diameter of 8.44 inches and WT of 0.35 inches.

The section was pressure washed with water and its external surface was visually examined. Visual examination did not reveal any stencil markings on the surface of the pipe. The external surface contained a single large area of wear as shown in Figure 31 and 32. The wear area was 12 inches long, 4 inches wide and up to 0.25 inches deep. In the middle, it contained an almost round spot, where glass fibres from different plies formed a set of concentric circles. No bruising was observed around the worn area.

The wear did not result in the failure. It looked fresh, and was most likely introduced after the failure, when the STAR riser pipe was broken, and supported from the upper end by the flange connection with the 8 inch stainless steel pipe.

The remaining external surface of the riser section was in good condition, and not affected by fire, as this part was below the ground level at the time of the fire.

The fracture surface of the 9' pup was cut, and the remainder was longitudinally split into halves in order to expose the internal surface, as shown in Figure 33. Figure 34 shows a closer view of the internal surface away from the failure, in the area corresponding to the wear on the external surface shown in Figures 31 and 32. The visual examination revealed that:

- The internal surface was in good, like-new condition.
- The winding angles of glass fibres were located at approximately ± 62 degree angles to the axial direction.
- It contained no indications of wear, erosion or other mechanical damage.
- The surface was smooth and no protrusion of glass fibres towards the interior was observed. This indicates that the external surface damage shown in Figures 32 and 33 was due to wear, not impact.
- The internal surface contained no indications of chemical degradation.

Figure 35 shows the fracture surface in overview, and Figures 36 through 38 show closer views of the fracture. The visual examination of the fracture surface revealed the following:

- The fracture surface was rough and contained areas of delamination between different plies of glass fibres.
- The fracture paths mostly followed the winding directions, which is typical.
- The fracture surface contained no indication of a pre-existing crack.
- A part of the fracture surface was flattened, as shown in Figure 38.
- The flattening was due to the fact that after the failure this part was found to be resting on the steel support, as shown in Figure 3, which resulted in the observed flattening.
- The flattened area exhibited delamination between plies, similar to the remaining part of the fracture surface.
- The appearance of the fracture surface indicated that the STAR pipe likely failed in one step due to an overload.
- The flattened area of the fracture surface did not allow drawing further conclusion related to the mode of the failure.
- No indications of either charring or burning were observed on the fracture surface.

4.3 Examination of Section of Twin Pipeline and Riser Licence # 4218-116

As mentioned earlier in the report, there were two twin pipelines, licence # 4218, lines 116 and 117, which were identical and ran parallel to each other. Line 117 failed, while the line 116 did not. A section of the pipeline Licence # 4118-116, which was identical to the failed section, was cut in the field, as shown in Figure 3, and submitted to the Skystone labaratory for examination as a comparison sample.

Figure 39 and 40 show the cut-out section as received. The section contained the following parts, starting from an upstream end:

- A portion of the 6' riser pup, which was cut in the field,
- a coupling,
- a 3' pup,
- a 90° elbow,
- an 8' pup, which was a part of the pipeline, and
- another coupling.

The elbow was cut from pups and visually examined. Figures 41 through 46 show the results of the visual examination of the elbow.

- The elbow contained an identification sheet, as shown in Figure 42.
- The sheet indicated that the 90 degrees 8-5/8 elbow was designed for a maximum pressure of 1250 psi at 260°F.
- The elbow was equipped with 8 round thread connections and was manufactured by FiberGlass systems in 2006 using an aliphatic amine cured epoxy.
- The bottom surface of the elbow, where it was resting on the steel plate, contained several scratches, which did not compromise the elbow integrity.
- The remainder of the external surface of the elbow was in good, like-new condition and did not contain any indications of mechanical damage.
- The internal surface of the elbow, including threaded pup ends, was uniformly covered with a black hydrocarbon deposit.
- The deposit was removed by solvent cleaning in Varsol, and the internal surface was re-examined.
- The internal surface of the elbow, including threaded pup ends, was in good, like-new condition. It contained no indications of erosion or other mechanical damage. It contained no indications of chemical degradation.

Figure 47 shows the area of elbow-to-pipeline connection at the 12 o'clock position, which was the likely location of the failure initiation in the failed licence # 4218-117:

- The exposed thread was in good, like-new condition and contained no indications of either mechanical damage or chemical degradation.
- The pup surface adjacent to the thread was in good condition. It contained several shallow surface scratches, which did not affect the integrity of the pup.

Figures 48 and 49 show the internal surfaces of the cut sections of the 3' pup and the 8' pup, which were connected to the elbow. The internal surfaces were covered with a uniform layer of black hydrocarbon deposit and showed no indications of geometry change due to erosion.

Table 3 shows the wall thicknesses and the diameters of the pups:

Table 3 – Pipe Wall Thicknesses And Diameters

ID	Location	OD, in	WT, in	OD, mm	WT, mm
3' Pup (Riser 116)	Riser 116	8.625	0.438	219.075	11.1
8' Pup	Line 116	8.625	0.461	219.075	11.7

The outside diameters of both collar couplings shown in Figure 39 were 10.0 inches. This size corresponded to the specified collar diameter for size 8, series 1250 STAR™ Aliphatic Amine Line Pipe (Appendix 2).

In conclusion, visual examination of the comparison section did not find any indications of pre-existing defects which could have contributed in the failure.

A liquid penetrant inspection (LPI) was performed on the elbow in order to find possible cracks. Figures 50 through 53 show the results of LPI examination. No surface cracks were observed in the elbow.

4.4 Examination Of Cross-Sections

Two longitudinal cross-sections were cut and prepared for examination:

1. Cross-section through the failed 6' pup from licence 4218-117.
2. Cross-section through the 3' pup from licence 4218-116.

The cross-sections were cold mounted in Buehler Varidur® compound, ground and polished starting from sandpaper grit 120 and finishing with a 1 μm aluminum oxide powder on a felt cloth. Figure 54 shows the cross-sections ready for examination.

Figures 55 through 58 show results of the examination under a high-power optical metallographic microscope:

- The STAR pipes contained numerous plies of glass filament winding.
- The winding on the internal surface was exposed to the internal environment.
- The winding on the external surface was protected from the environmental exposure by an additional layer of pure epoxy resin.
- The pipe was manufactured with a good standard of quality: the glass fibres were well bonded with the epoxy matrix, neither cracks nor delamination between different plies were observed, distribution of glass fibres was close to uniform.

- Some discontinuities were observed; most likely, these discontinuities were associated with preparation of the cross-section from a composite material, which contained a brittle glass component.
- The 9’ pup exhibited a greater wall thickness (0.48 inches), compared to the failed 6’ pup (0.34 inches), and contained four additional layers of filament winding, at a small angle to the axial direction. Figure 55 shows one of those layers.
- There were no visible manufacturer’s defects which could be associated with the failure.

5.0 MATERIAL TESTING

Material testing was performed by Alberta Innovates Technology Futures on a sample removed from the failed 6' pup, away from the failure. Appendix 6 contains the complete test report.

5.1 Differential Scanning Calorimetry

Differential scanning calorimetry (DSC) was performed as per ASTM E794 "Melting and Crystallization Temperature by Thermal Analysis". The DSC analytical technique measures the heat energy absorbed or emitted by a material as a function of temperature and can thereby be used to determine the glass transition temperature and an indication of the degree of cure. Both the top and the bottom samples were heated twice. The Alberta Innovates Technology Futures report indicates that the first heating cycle for both samples presented a small exothermic event, which was not observed during the second heating cycle. The exothermic event may indicate post-curing of the residual resin, which in turn may indicate that initially the resin was slightly under cured. Table 4 shows the glass transition temperatures during the first and the second heating cycles.

The email communication with a representative of STAR™ Aliphatic Amine Line Pipe in Appendix 2 indicates the minimum glass transition temperature is T_g=93°C.

Table 4 – DSC Test Results

	T_g Onset, °C	**T_g Midpoint, °C**	**T_g Endpoint, °C**
First Heating Run	125.88	132.23	140.01
Second Heating Run	121.62	130.06	138.49
Star Specification		93 min.	

Analysis of data in Table 2 shows that:

- The glass transition temperatures exceeded the minimum specified manufacturer's value, so the curing temperature was proper.

5.2 Ignition Loss

The samples were tested in accordance with ASTM D2584-02 Standard Test Method for Ignition Loss of Cured Reinforced Resins. The specimens were weighed, ignited and allowed to burn until only ash and carbon remain. Organic resin from the samples was completely decomposed and the residue glass fibre was weighed again. The ignition loss is considered to be the resin content of the sample. Appendix 6 shows that the ignition loss (average of triplicate samples) was 18.15%. This indicates that the STAR™ Aliphatic Amine Line Pipe consisted of approximately 81.85% glass fibre and 18.15% epoxy resin by weight. According to the manufacturer, the nominal glass percentage in the laminate is 79.4% by weight. Thus, the glass content was above, but close to the nominal manufacturer's value.

6.0 DISCUSSION

6.1 Wall Thickness Comparison

Table 5 compares the wall thickness and diameters of various analyzed parts with the specifications for STAR™ Aliphatic Amine Line Pipe.

Table 5 – Dimension Comparison

Item	Location	OD, in	WT, in
Failed 6' Pup	Line 117	8.41	0.34
Pipeline Section Connected to the Failed 6' Pup	Line 117	8.625	0.49
Failed 9' Pup	Riser 117	8.66	0.478
3' Pup (Riser 116)	Riser 116	8.625	0.438
8' Pup	Line 116	8.625	0.461
Pipeline Section Connected to the 8' Pup	Line 116	8.625	0.34
Star 8-5/8 Line Pipe Series 1250		8.44	0.35
Star 8-5/8 Line Pipe Series 1500		8.27	0.42
Star 8-5/8 Line Pipe Series 1750		8.42	0.49
Star 8-5/8 Line Pipe Series 2000		8.57	0.57
Tolerance for Star 8-5/8 Line Pipe Series 1250		8.37-8.51	0.317-0.387

Both the pipeline licensing information in Tables 1 and 2 specified 8 inch pipe STAR™ Fiberglass 1250 series**.** The extracts from the construction binder in Appendix 4 indicate that the components listed in Table 5 were 1250 series. Examination of Table 5 and comparison with the manufacturer's specifications in Appendix 2 showed that the failed 6' pup corresponded to the 1250 series within the limits of tolerance, while the remaining components in Table 5 corresponded to either 1500 or to 1750 series. The elbow form the failed line 117 was not found. The elbow from the twin line 116 was 1250 series. The collar couplings from the twin riser was 10 inches in diameter and corresponded to 1250 series.

As such, all the analyzed components corresponded to 1250 series or higher, which is acceptable.

6.2 Bending Stress at the Location Of Failure

Figure 6 shows that the last section of the STAR pipe, of line 117, which was the failed 6' pup, was bent to an angle of approximately 6 degrees relative to the rest of the pipeline. It is expected that the bending angle before the failure was greater:

- During the field inspection after the failure, the STAR pipe was resting on the steel plate, while before the failure the bottom of the 90-degree elbow was resting on the steel plate.
- Thus, the bottom end of the pipe should be located approximately 1.1 inches higher, where the 1.1 inches is the wall thickness of the elbow.

- In addition, the bottom part of the pipe at the time of the field inspection after the failure was worn down to a depth of 0.29 inches. Thus, the bottom part of the pipe should be located an additional 0.29 inches higher.
- Calculations showed that after taking into consideration the additional height increase discussed above, the angle of inclination of the failed 6' pup before the failure was 7.2 degrees.

It is expected that at the time of installation the last pup, as well as the rest of the pipe, were installed horizontally. The bending of the last pup must have created high stresses at the areas of its connection to the riser elbow and to the collar coupling with pipeline. The highest stress is expected to be observed in the stiffest connection, which is the connection to the riser elbow.

Distribution of stresses in the elbow connection was calculated using the Finite Element Analysis software ALGOR-23:

- The 6' pup, the elbow and the 9' riser were modeled using 2D plate elements. The actual wall thicknesses were accounted for.
- Material model: linear elastic.
- The Poisson ratio and the axial elastic modulus were taken from the manufacturer's specification in Appendix 2.
- The size of the mesh was close to 1 inch.
- The boundary conditions were as follows: The vertical 9' pup was fixed at the upper end (at the flange); a bending moment was applied to the free end of the failed 6' pup, so the deflection corresponded to the 7.2 degrees angle.

Figures 59 through 61 show the results of the calculations.

The examination of the FEA results shown in Figures 59 through 61 showed that:

- The highest stress was observed in the horizontal 6' pup (which had the thinnest wall), and the lowest stress was observed in the elbow (which had the thickest wall).
- The upper half of the failed 6' pup was in tension, and the lower part was in compression, as expected for bending.
- The area of the highest tensile stress was located at the top part of the horizontal 6' pup, where it faced the elbow. This location corresponded to the expected location of the failure initiation shown in Figure 16.
- The magnitude of the highest stress was calculated to be 13.6 ksi.
- The manufacturer's specifications in Appendix 2 indicate that the 8 inch STAR™ Aliphatic Amine Line Pipe Series 1250 has a short time tensile rating of 25,300 lbf, which is equivalent to the uniform tensile stress of 2.8 ksi.
- As such, the stress of 13.6 ksi exceeded the short time tensile rating of 2.8 ksi and was a major contributor to the failure.

The actual stress at the location of the failure was probably below the conservative value of 13.6 ksi:

- The 13.6 ksi stress was calculated in the linear elastic model, which is a conservative approximation, as it does not consider plastic deformation and/or viscoelastic properties.
- More advanced material models (such as an elastic-plastic material model, which take into consideration plastic deformation of the material after stresses exceed the yield stress, or a viscoelastic material model) would describe the behaviour of the fibreglass pipe better and would result in a lower value of the stress.
- In order to apply the more advanced material models additional manufacturer's information (such as long-term stress-strain curves) would be required.
- Nevertheless, it is clear that the actual stress in the failed pup exceeded the yield strength and thus it contributed to the failure.

6.3 Possible Reasons for Bending of the Stainless Steel Pipe

Figure 4 shows that the 90-degree elbow of the stainless steel pipe connected to the failed riser was bent to an angle of approximately 45 degrees. This deformation would require a significant force. This force could originate either from explosion or from the internal pressure of the failed pipeline after it broke.

As reported by Pengrowth, the stainless steel pipe connected to the failed riser was A312-TP316/316L, size 8 schedule 40. Table 6 below shows the results of calculation of stresses in the circular cross-section of the elbow in the case when the pipeline was split just downstream of the riser elbow and the entire force due to the internal pressure was applied to the elbow. Calculations were performed for two values of internal pressure: 500 psi, which is the MOP, and 355 psi or 2447.82 kPa, which was the maximum separator pressure at the time of the incident.

Table 6 – Elbow Bending Due To Internal Pressure

ASTM A312-TP316/316L, Sch. 40, 8"	**P=355 psi (Max. Separator Pressure)**	**P=500 psi (MOP)**
External Diameter OD, inch	8.625	8.625
Wall Thickness WT, in	0.322	0.322
Internal Diameter ID, in	7.981	7.981
Area Moment of Inertia I_{xx}, in^4	72.49	72.49
Tensile Stress UT, ksi	70	70
Yield Stress, SMYS, ksi	25	25
Internal Pressure, psi		
Max. Separator Pressure At time of Incident	355	
MOP, psi		500
8-5/8 Elbow Schedule 1250		
Internal Diameter ID, in	8.625	8.625

ASTM A312-TP316/316L, Sch. 40, 8"	P=355 psi (Max. Separator Pressure)	P=500 psi (MOP)
Area of Elbow Opening, in	58.4	58.4
Force F, lbf	20741.3	29213.1
Arm Length L, in	173	173
Max stress in Stainless Steel pipe, ksi	213.5	300.7
Yield Stress (SMYS) of Stainless Steel pipe, ksi	25	25
Conclusion	Elbow bends	Elbow bends

The examination of the data in Table 6 showed that applying the force due the internal pressure alone in the expected location of the failure (just downstream of the fibreglass elbow at the bottom of the riser) would be enough to bend the stainless steel elbow at the top of the riser.

There was no need to involve an explosion in the failure scenario in order to explain the bending of the stainless steel elbow.

6.4 Failure Scenario

A failure scenario which would be consistent with the existing material evidence could be as follows:

- When two identical fibreglass pipelines (licence #4218, lines 116 and 117) were installed by trenching in January 2007, they were laid flat.
- As reported in the construction binder, the installation started from the location 13-36-063-11W5M and finished at the location 08-35-063-11W5M, so tie-in stresses could be expected at the 08-35 location.
- The fibreglass pipes were equipped with 8 round threaded connections.
- To tie in the pipeline at the location 08-35-063-11W5M, smaller sections of fibreglass pipe (pups) were ordered.
- The wall thicknesses of the submitted pups were different, but all met the minimum wall thickness requirements for the 8 inch 1250 schedule STAR™ Aliphatic Amine line pipe.
- The failed 6’ horizontal pup connecting line 117 to the riser elbow exhibited the smallest wall thickness of 0.34 inches and was connected to the horizontal pipe section with a wall thickness of 0.49 inches.
- The 8’ pup installed in a similar location in line 116 exhibited a wall thickness of 0.46 inch, and was connected to the pipe with wall thickness of 0.34 inch.
- The riser elbows were supported by anchors and the elbows were resting on steel plates.
- The trench was backfilled and the lines were put in service.

- Some ground subsidence occurred over time and the pipelines close to the riser sunk in the ground relative to the elbows, which were resting on the anchors.
- This resulted in pipeline bending, which was more pronounced in the pipeline sections closest to the anchors.
- The last pup of line 117 was 0.34 inches thick, and the last pup of line 116 was 0.46 inches thick, which is 35% thicker.
- This is why the last pup (6' pup) of line 117 was bent more and eventually failed.
- Bending of the pup resulted in tensile stress at its upper half, and in the compression stress in its lower half. The highest tensile stress was at the 12 o'clock position at the last engaged thread in the pup-to-elbow connection.
- The elbow wall thickness was approximately 1.1 inches, and a sharp transition in wall thickness, combined with the threaded connection, resulted in stress concentration.
- Calculations showed that the static stress at the location of the failure exceeded the short-time tensile rating of the STAR pipe, which was the major contributing factor for the failure.
- Another major contributing factor to the failure was the power outage, which took place from 11:30 AM to 2:30 PM on the date of the failure, followed by automatic restarts of numerous wells.
- Automatic restart of wells could result in fluid surge. During well shutdown, gas pockets are created in the pipelines, and after restarting the well and opening the flow, gas pockets are moved down the pipelines followed by significant volumes of liquid phase, which resulted in dynamic peak stresses due to fluid surge.
- The failed line combined volumes from 17 wells, and numerous fluid surge events were expected after the power restoration.
- The combination of the static stress due to pipe bending, static stress due to internal pressure, and dynamic stresses due to fluid surges resulted in the failure.
- The failure initiated at the location of the highest static stress, which was at the 12 o'clock position, in the connection of the pup with the thinnest wall next to the thick walled elbow.
- As a result of the failure, the elbow and the pup separated from each other.
- Material evidence showed that for some time after the failure the distance between the separated parts (the pup and the elbow) was relatively small.
- Immediately after the failure the flow escaped in a horizontal direction through the lower (horizontal) downstream opening of the elbow.
- One part of the flow from the upstream failure went to the surrounding soil, saturating it with gas, oil and water, and another part of the flow mixed with hard

soil particles (such as sand) and hit the downstream fracture surface. This resulted in the observed erosion of the fracture surface shown in Figures 22, 26 and 27.

- The flow in the vicinity of the fracture surfaces was highly turbulent, which resulted in vibration of both fractured ends, which became unsupported after the separation.
- The vibration of the downstream pipe resulted in the wear of its bottom surface over the steel plate. Figures 19 and 21 demonstrate this wear.
- The vibration of the upstream portion (the vertical part of the riser) resulted in the wear of its side surface as shown in Figures 31 and 32.
- The jet force of the fluid escaping in the horizontal opening of the elbow pushed the elbow away from its original location.
- In the beginning, when the surrounding soil was not saturated with gas, oil and water, the soil provided significant support and prevented the elbow displacement.
- With time, the soil became saturated with gas and water and turned into slurry that was unable to support the elbow in its original position. Figure 62 shows that in the vicinity of the failure the ground turned into slurry.
- The elbow (and the riser attached to it), started to be gradually displaced in the direction opposite to the fluid flow. This resulted in the observed bending of the stainless steel elbow.
- It is likely that when a subsequent water slug arrived, the shock load pushed the elbow against the T-shaped support.
- This impact broke the vertical STAR riser pipe from the fibreglass elbow with an attached section of the STAR riser pup.
- The upper part of the broken vertical section of the STAR riser pup remained attached to the support, as shown in Figures 2 through 4.
- This likely happened close to the end of the failure, as subsequent water slugs did not separate the fracture surface of the riser vertical pup, and the support post.

Please note that the above scenario requires neither fire nor explosion to explain the observed material evidence. This indicates that the fire likely initiated at the last stage of the failure.

This is in agreement with the timing schedule, when the power was restored at 2:30 PM (so automatic restarts of the wells should be expected at this time), and the fire was first reported at 4 PM, or 1.5 hours later.

6.5 Discussion on Ignition Source, Fire and Unlikely Explosion

Fire initiation requires that three conditions are satisfied simultaneously:

1. Flammables are present.
2. An oxidation agent is present.
3. An ignition source is present.

The flammables were oil and gas, which escaped from the ruptured pipeline.

Oxygen was present only above ground (which was saturated with water and oil). As such, no oxygen was present at the location of the openings in the pipeline, which at all times were below the ground level.

The absence of the fire below the ground level is supported by the fact that neither side surfaces, nor fracture surfaces of the examined fibreglass pipes were charred or burnt.

As no fire was below the ground level, and all the fire was above ground, the ignition source should be located also above the ground. Several ignition sources could be considered:

- An ignition from the nearby power line.
- A lightning strike.
- Rock-to-rock strike above ground.
- Rock-to-steel strike above ground.
- Steel to steel strike, when the T-shaped steel support contacted the steel manifold.

As it was discussed earlier in this report, the ignition from the nearby power line was considered to be unlikely, as the wooden part of the closest power line post shown in Figures 13 and 14 showed no indications of either charring of burning.

The most likely source of ignition was the steel to steel strike, when the T-shaped steel support contacted the steel manifold. Figures 2 through 4 show that the steel support was resting on the steel manifold after the fire. As well, Figure 1 in the report and several photographs in Appendix 1 show the support was resting on the manifold during the fire.

According to the failure scenario, the impact of the steel support over the steel manifold happened some time after the break. At this time the escaped gas must have been mixed with air, and the impact of two massive steel parts inevitably produced a spark, which ignited the air-gas mixture.

There is no evidence that the ignition was accompanied by an explosion:

- Explosions usually occur when expansion of the ignited mixture is somehow restricted. The ignition occurred above ground and nothing restricted expansion of the combustion products.
- The explosion usually creates a shock wave, which damages the weak parts. The weakest part was of the riser made of STAR fibreglass pipe. No damage which could be associated with the shock wave was observed.

- The bending of the stainless steel elbow could be potentially associated with and explosion. Calculations in this report showed that no explosion is required in order to explain the elbow bending.
- An explosion wave must spread the soil around its epicenter uniformly to a certain radius. For this situation, the burnt area would be expected to be close to a circular shape. The aerial photograph of the failure in Appendix 1 and Figure 63 showed that the distribution of the burnt area is not circular, and that all the flammables flowed to one side due to ground inclination.

7.0 CONCLUSION

The 8 inch STAR™ Aliphatic Amine line pipe schedule 1250 failed in the connection of the riser elbow to the pipeline.

Both static and dynamic stresses contributed to the failure.

- Ground settling resulted in high static bending stress of the last section of the pipeline connected to the riser elbow supported by the anchor.
- The failure was in the last connection of the pipeline. Static tie-in stresses could have contributed to the failure.
- Dynamic stresses contributed to the failure. The failure happened soon after the power outage, when numerous wells were restarted, and several fluid surges may have occurred.
- The combination of the static and the dynamic stresses resulted in the failure.

The fire initiated at some time after the pipeline rupture:

- The soil was saturated with liquid and turned into slurry.
- The gas was mixed with air above ground.
- Sudden loading from a subsequent water slug caused the vertical part of the broken riser to impact the T-shaped steel support.
- The support fell and hit the manifold, resulting in a spark, which lit the fire.
- There is no evidence that the observed failure resulted in or was associated with an explosion.

This engineering report was completed July 11, 2011
APEGGA Permit to Practice P09634.

Prepared By:

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Original Report was stamped and signed on July 11, 2011.

Reviewed By:

F.S. Gareau, P. Eng.

Figure 2 – Excavated Failure Site: Flow Direction

Figure 3 – Location Of Failure: Sample Identification

Figure 4 – Location Of Failure: Bending of 8" Stainless Steel Elbow

Figure 5 – Closer View Of The Failure

Figure 6 – Location Of Failure: Two Parallel Identical Pipelines

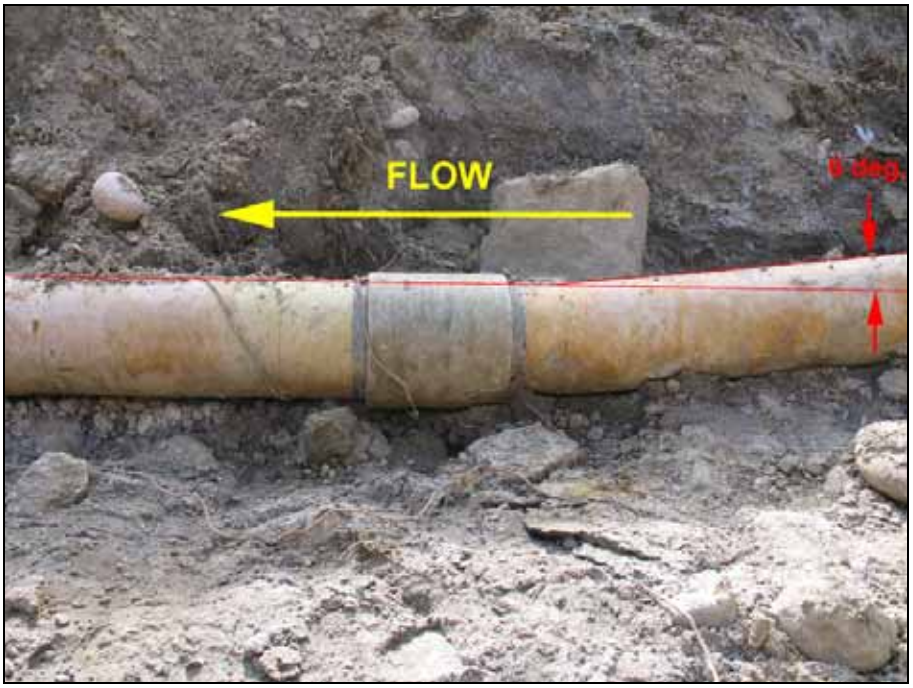


Figure 7 – Pipeline Licence # 4218-117. Inclination Of Failed 6' Pup Adjacent To Riser

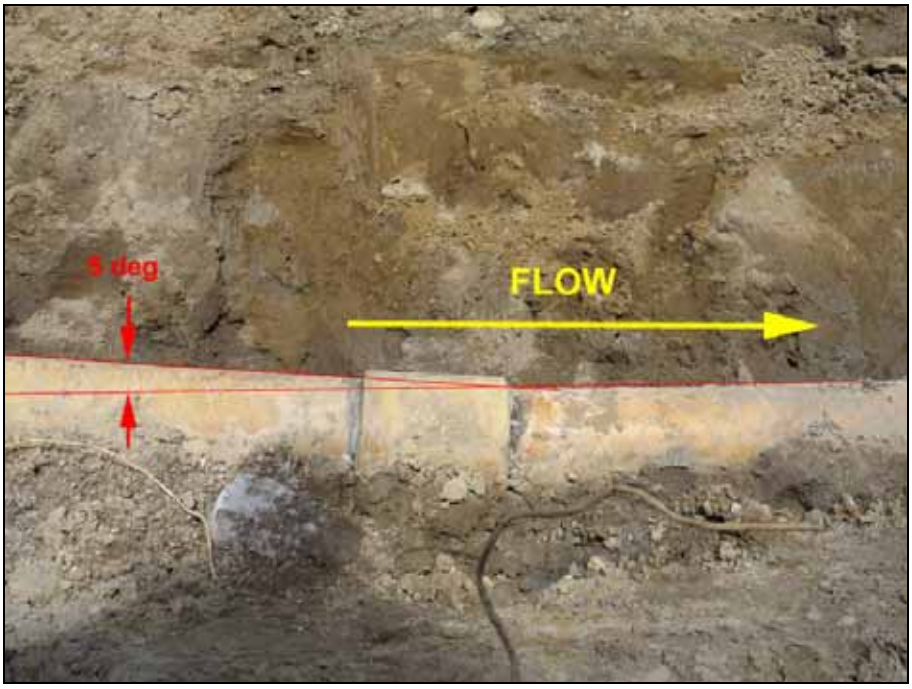


Figure 8 – Pipeline Licence # 4218 -116. Inclination Of 8' Pup Adjacent To Riser

Figure 9 – Line 117: Failed 6' Pup Resting On Anchor Steel Plate: Side View

Figure 10 – Line 117: Failed 6’ Pup Resting On Anchor Steel Plate: Front View

Figure 11 – Line 116: Riser Elbow Resting On Anchor Steel Plate: Side View

Figure 12 – Line 116: Riser Elbow Resting On Anchor Steel Plate: Rear View

Figure 13 – Power Line Post Close To The Failure Site: Overview

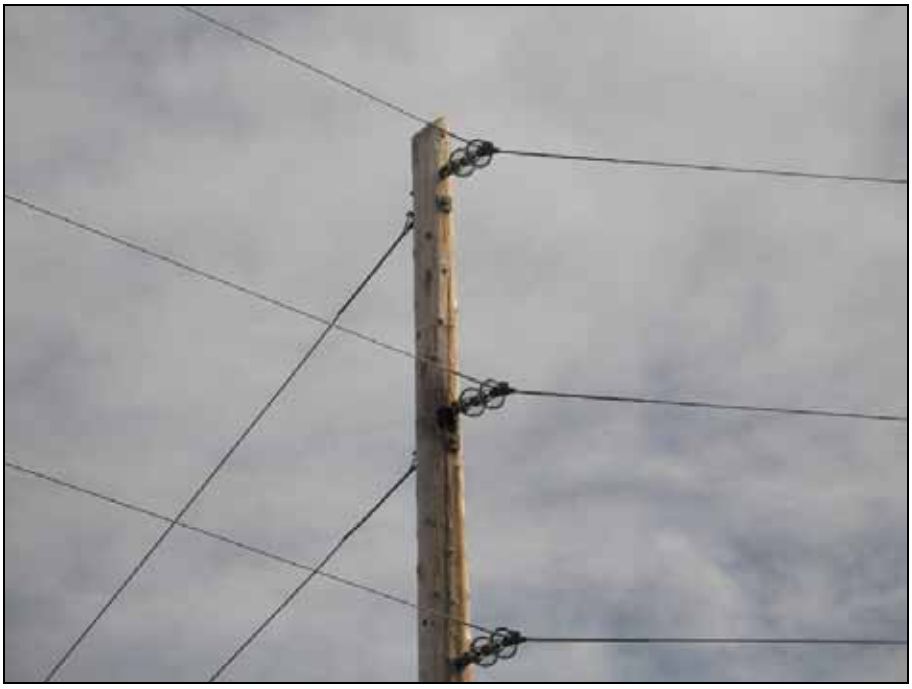


Figure 14 – Top of Power Line Post Close To Failure Site: Closer View

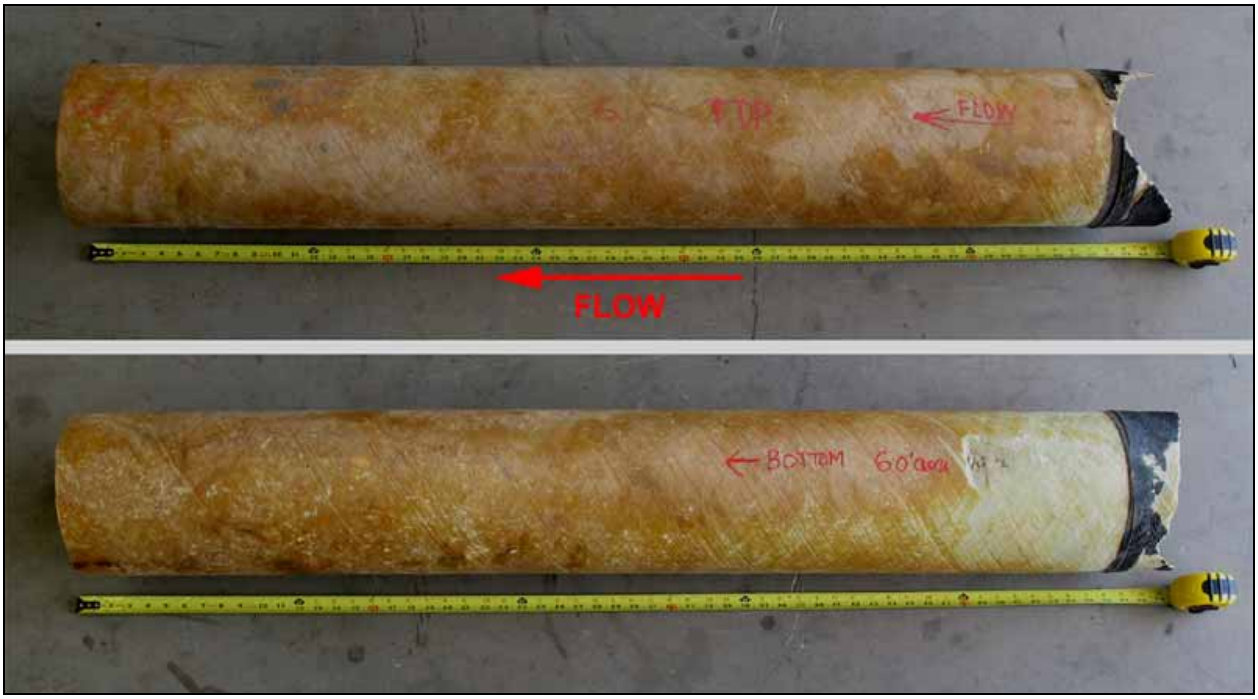


Figure 15 – Section Of Failed 6' Pup As Received: Top & Bottom View

Figure 16 – Failed 6' Pup: Top View. Arrow Indicates Expected Location Of Failure Initiation

Figure 17 – Failed 6' Pup: Side View

Figure 18 – Failed 6' Pup: Side View

Figure 19 – Failed 6' Pup: Bottom View

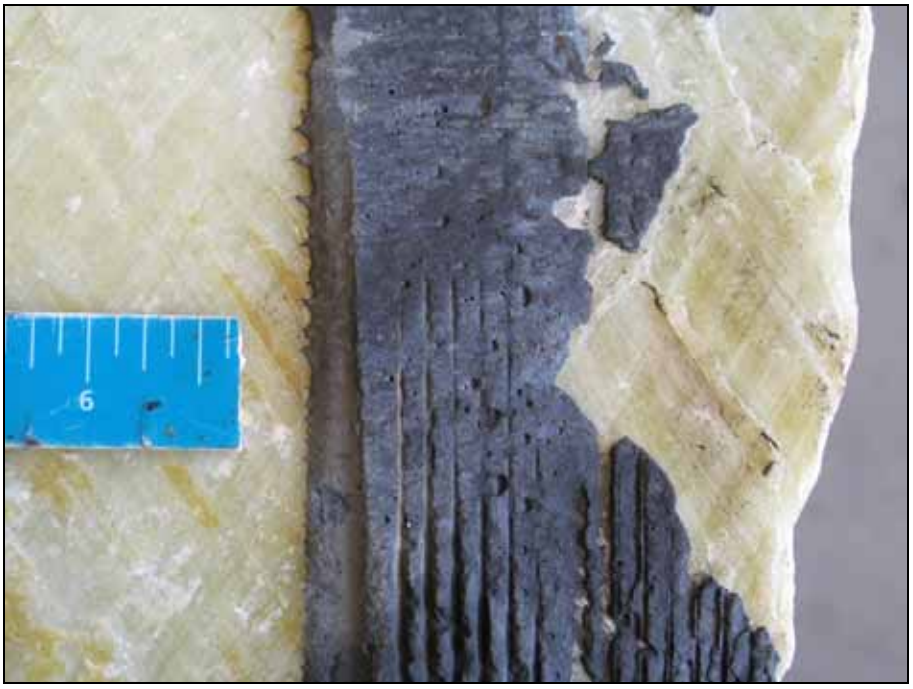


Figure 20 – Failed 6’ Pup: Bottom Closer-Up View. Note Thread Wear

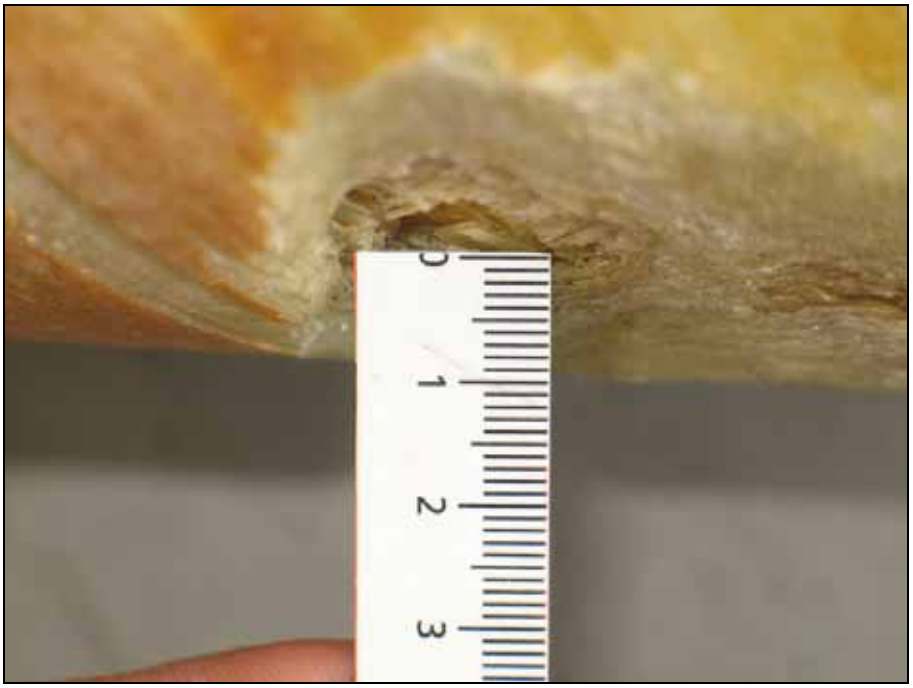


Figure 21 – Failed 6’ Pup: Pipe Wear At 6 O’Clock Position

Figure 22 – Failed 6’ Pup: Overview Of Fracture Surface

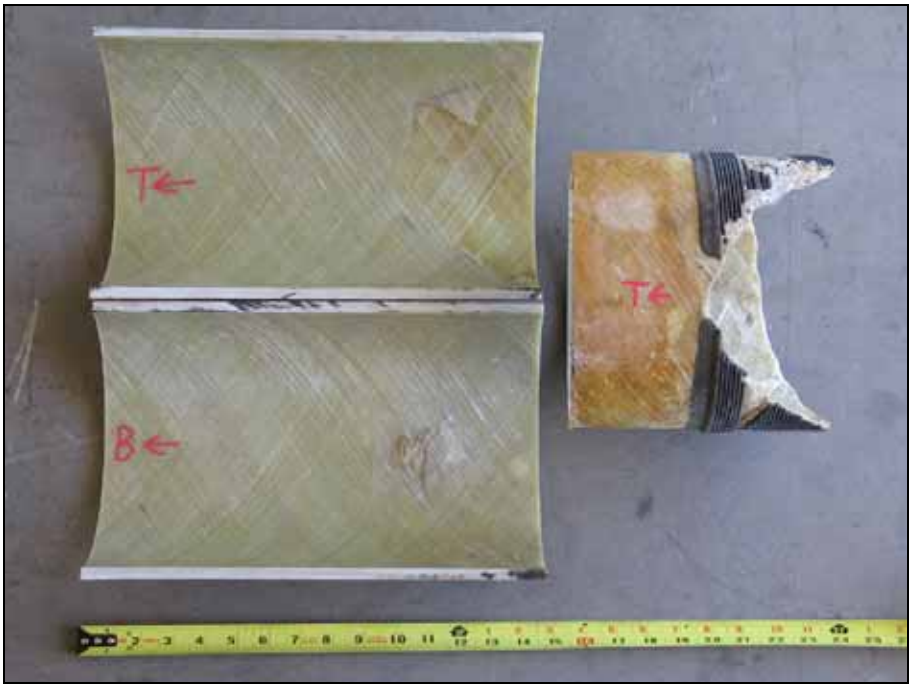


Figure 23 – Failed 6’ Pup Split For Examination Of Internal Surface

Figure 24 – Failed 6’ Pup: Damage On Internal Surface In The Area Of Wear On External Surface: Top View

Figure 25 – Failed 6’ Pup: Damage On Internal Surface In The Area Of Wear On External Surface: Side View

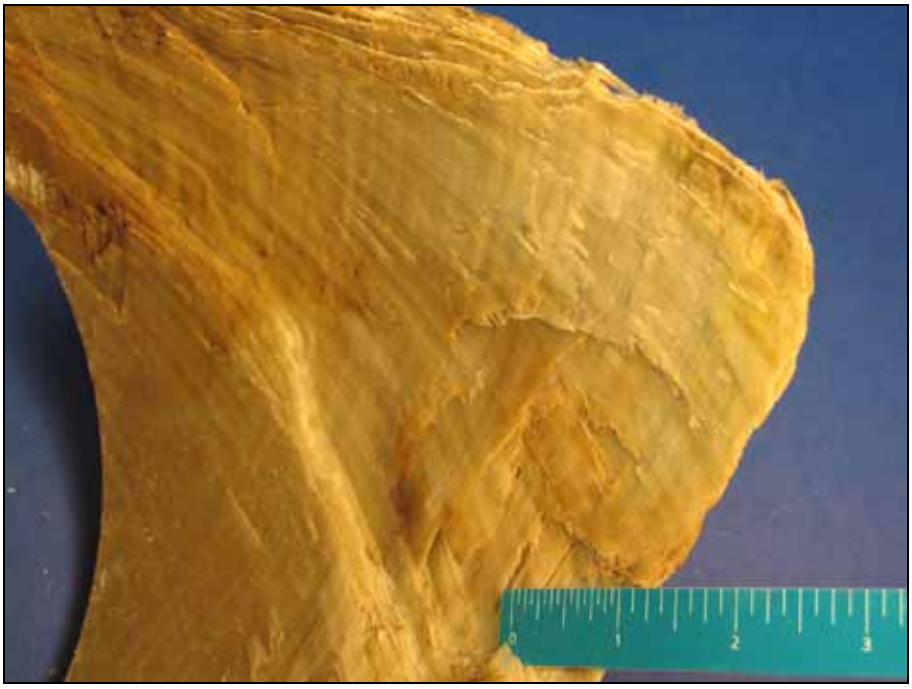


Figure 26 – Failed 6’ Pup: Wear On Internal Surface Close To Fracture Surface

Figure 27 – Failed 6’ Pup: Wear On Internal Surface Close To Fracture Surface

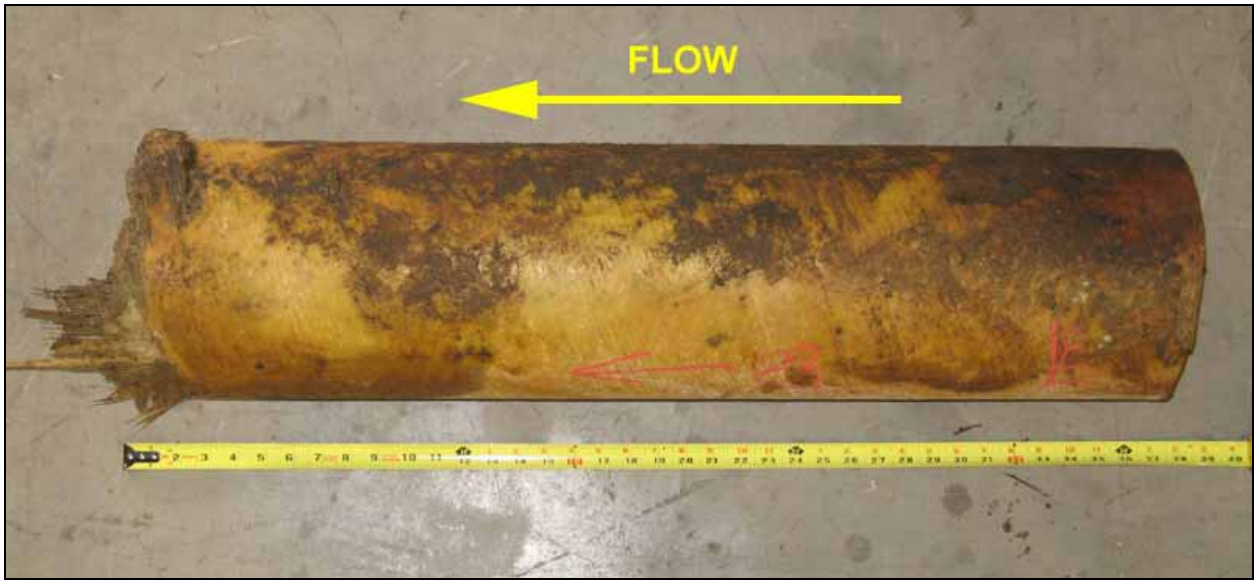


Figure 28 – Failed 9’ Riser Pup As Received: Side View

Figure 29 – Failed 9’ Riser Pup As Received: Fracture Surface

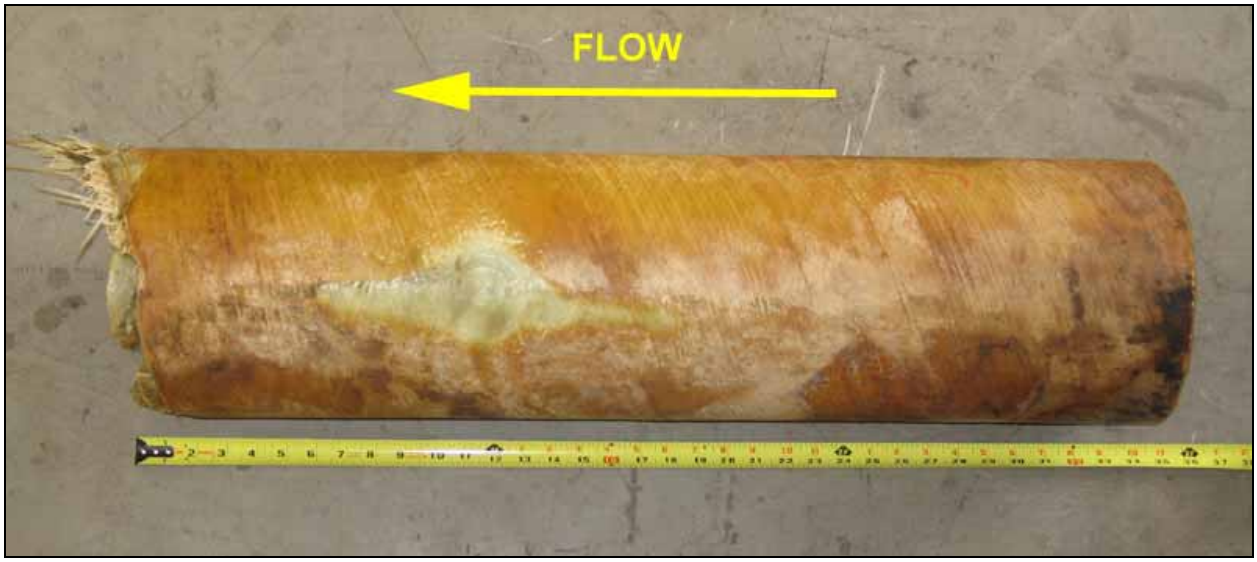


Figure 30 – Failed 9’ Riser Pup After Cleaning: Side View

Figure 31 – Failed 9’ Riser Pup: Surface Wear

Figure 32 – Failed 9’ Riser Pup: Closer View Of Surface Wear

Figure 33 – Failed 9’ Riser Pup Split For Examination Of Internal Surface

Figure 34 – Failed 9’ Riser Pup: Closer View Of Internal Surface

Figure 35 – Failed 9’ Riser Pup, Cleaned Fracture Surface: Overview

Figure 36 – Failed 9’ Riser Pup, Cleaned Fracture Surface: Closer View

Figure 37 – Failed 9’ Riser Pup, Cleaned Fracture Surface: Closer View

Figure 38 – Failed 9’ Riser Pup, Cleaned Fracture Surface: Post-Fracture Deformation

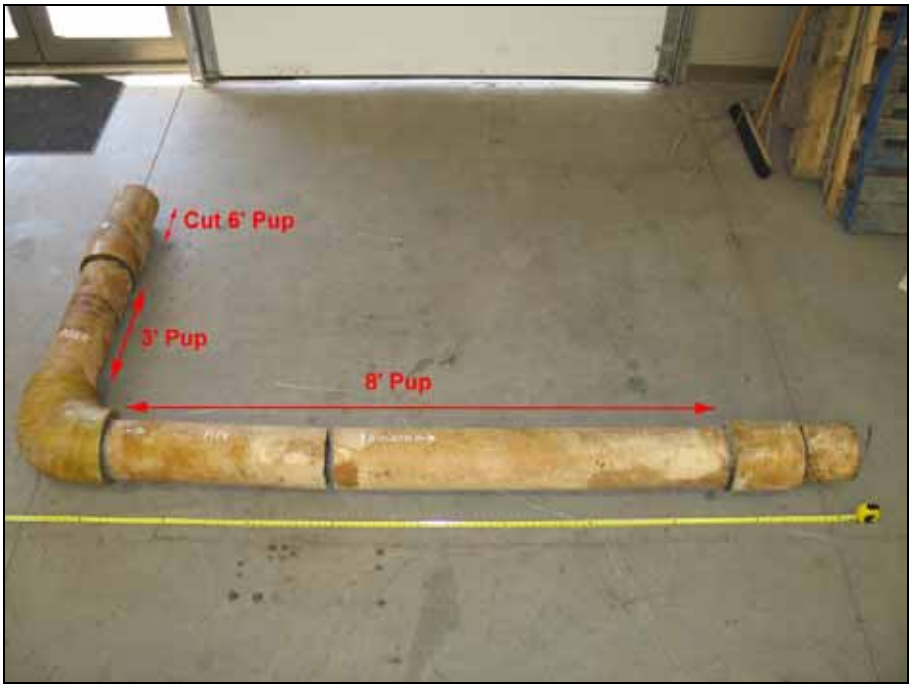


Figure 39 – Line 116: Riser Sections As Received

Figure 40 – Line 116: Closer View Of Riser Elbow Connections

Figure 41 – Line 116: Separated Riser Elbow

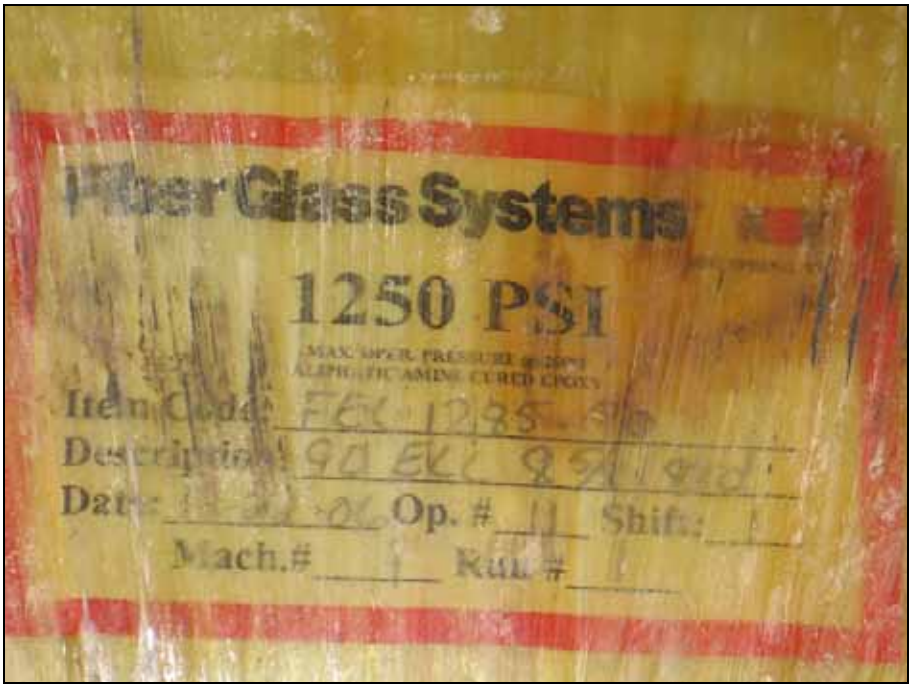


Figure 42 – Line 116: Identification Sheet On Riser Elbow

Figure 43 – Line 116: Internal Surface Of Riser Elbow “As Received” (Riser End)

Figure 44 – Line 116: Internal Surface Of Riser Elbow As Received (Pipeline End)

Figure 45 – Line 116: Internal Surface Of Riser Elbow After Cleaning

Figure 46 – Line 116: Bottom Surface Of Riser Elbow

Figure 47 – Line 116: 9' Horizontal Pup To Elbow Connection At The 12 O'clock Position. This Location Corresponded To Failure Initiation In Line 117.

Figure 48 – Line 116: Internal Surface Of Vertical Riser Pups

Figure 49 – Line 116: Internal Surface Of Horizontal 8’ Pup

Figure 50 – Line 116: LPI Of Riser Elbow: Side View

Figure 51 – Line 116: LPI Of Riser Elbow: Front View

Figure 52 – Line 116: LPI Of Riser Elbow: Side View

Figure 53 – Line 116: LPI Of Riser Elbow: Rear View

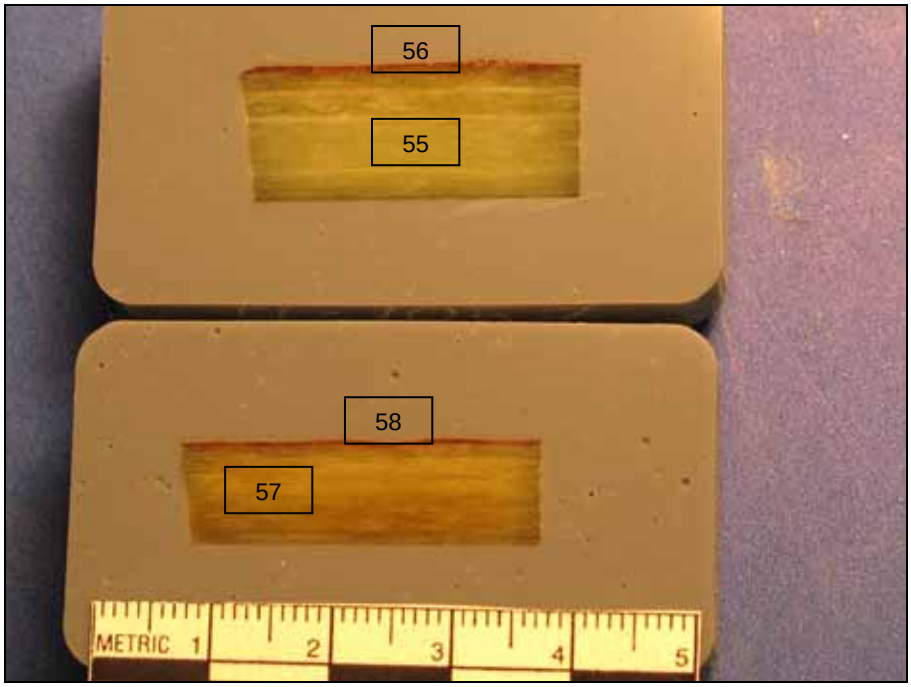


Figure 54 – STAR Pipe Pup Cross-Sections Ready For Examination: Top – Failed 9' Riser Pup; Bottom – Failed 6' Horizontal Pup

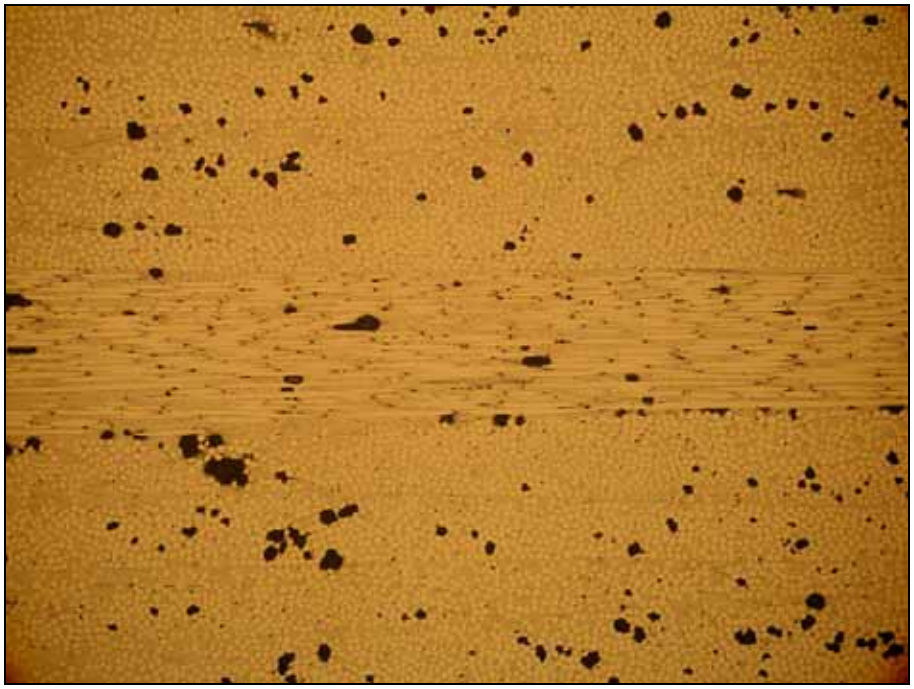


Figure 55 – Microstructure Of Failed 9' Riser Pup. Mag. 50X. Note Layer In The Middle With Specific Winding Direction

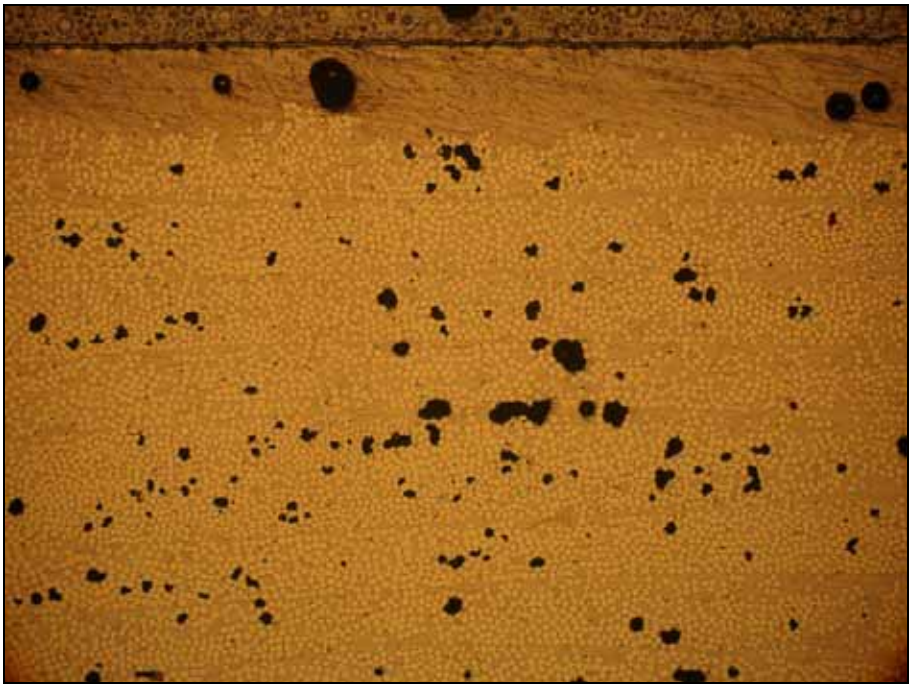


Figure 56 – Microstructure Of Failed 9’ Riser Pup Close To External Surface. Mag. 50X.

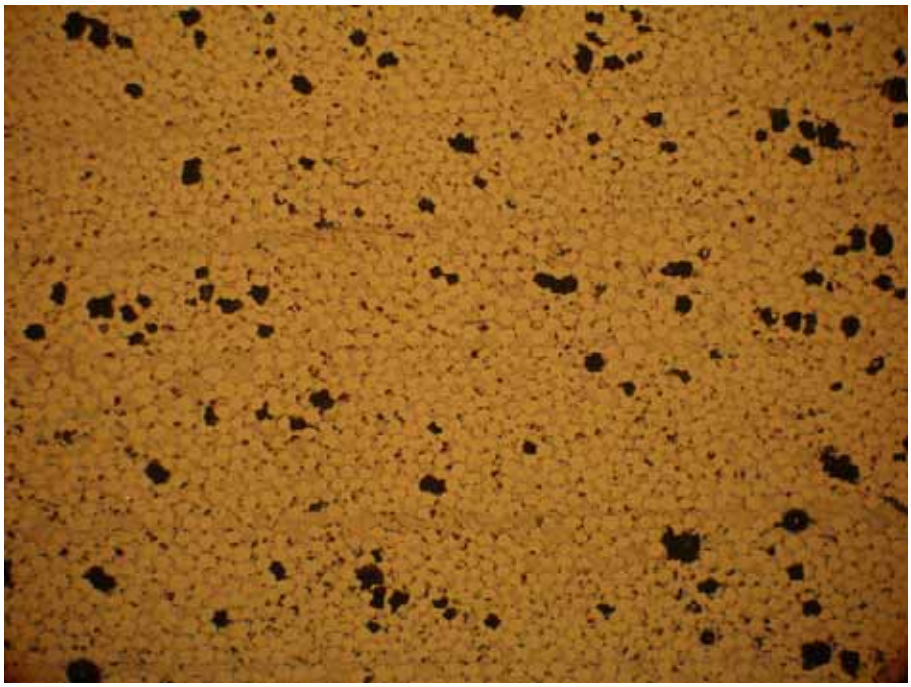


Figure 57 – Microstructure Of Failed 6’ Pup In The Middle. Mag. 100X.

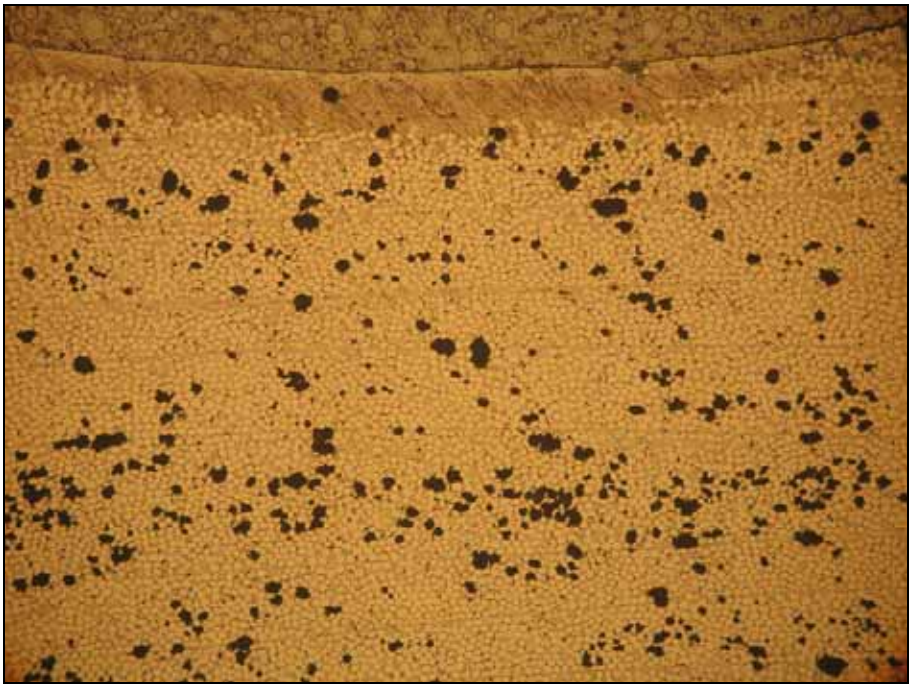


Figure 58 – Microstructure Of Failed 6’ Riser Pup Close To External Surface. Mag. 50X.

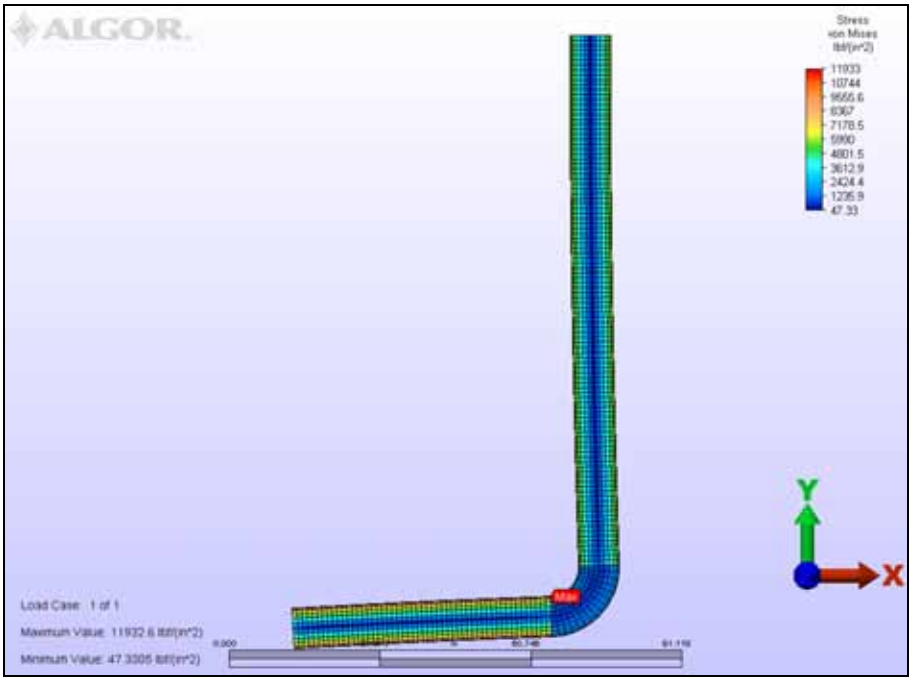


Figure 59 – Results of FEA Calculations: Von Mises Stress Distribution In The Riser: Overview

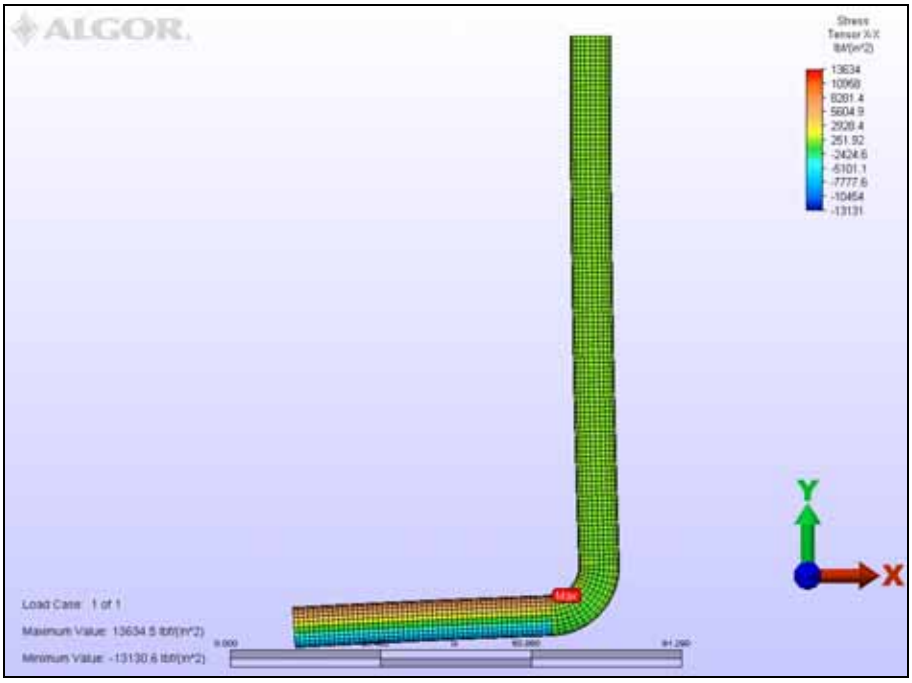


Figure 60 – Results Of FEA Calculations: Stress Distribution In The Axial Direction: Overview

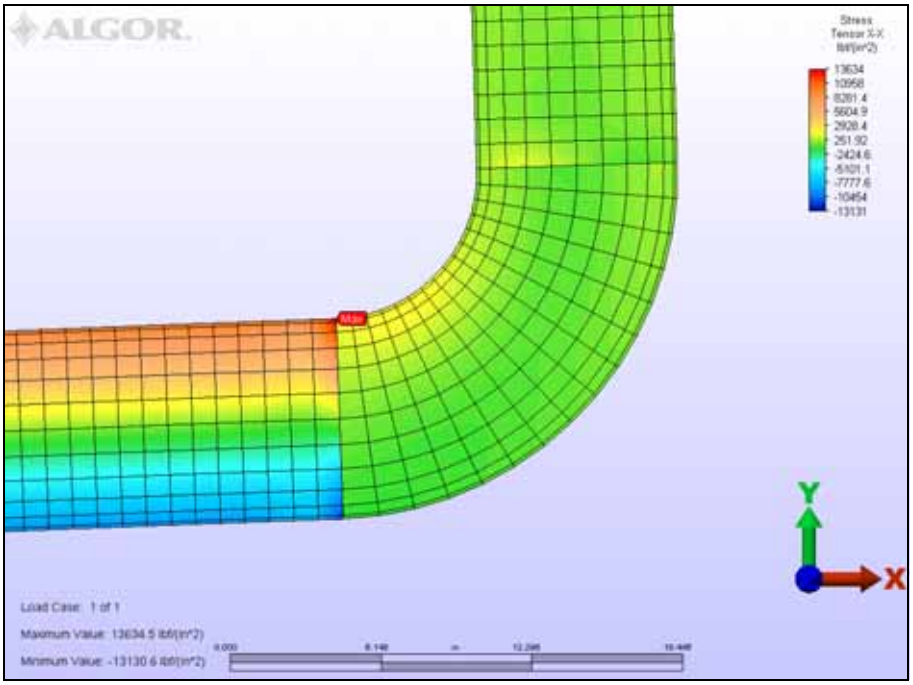


Figure 61 – Results Of FEA Calculations: Stress Distribution In The Axial Direction: Closer View

Figure 62 – Slurry Around Location Of Failure

Figure 63 – Aerial Photograph Of Failure Site.
Anisotropic Distribution Of Fire Remnants (Spill On One Side)

Appendix 1

Field Photographs of the Incident


WARNING
CRUDE
OIL
PIPELINE


06/27/2011


06/27/2011

Appendix 2

Manufacturer's Specification of STAR™ Aliphatic Amine Line Pipe

STAR™ Aliphatic Amine Line Pipe *(High Pressure - STANDARD DESIGN - Product Data)*

Product Description

- Pressure - Up to 4000 psi (27,6 MPa)
- Resin System - Aliphatic Amine Cured Epoxy
- Reinforcement - Premium Fiberglass
- Joining Systems - API 8rd Threaded and Mechanical O-Ring (SSS)
- Joint Length - 30 Feet (9,1 mts) Nominal
  Random Lengths of 20 to 32 Feet (6,1 to 9,8 mts)
- Temperature - Up to 200° F (93.3° C) Maximum
- Sizes - 1½ through 8 inches - API 8rd Thread
  8, 10 and 12 inches - SSS Thread
- Fittings - A variety of filament wound API 5B threaded and SSS fittings are available. Purchase all fittings by thread size and design pressure rating only.

High Pressure Design ≥ 500 psi

- Design Life - 20 years at full rating
- Design Temperature - 150° F (65.6° C)
- Wall Thickness - Nominal
- Hoop Stress - Average Long Term Hydrostatic Strength (LTHS), ASTM D2992-B
- 100% Factory Hydrotest - All products are tested at a minimum of 1.25 x the series rated pressure at 150° F (65.6° C)
- Non API Design

Flow Factors

- Hazen Williams C=150
- Absolute Roughness = 0.00021 in. (0.00533 mm)

Nominal Moduli

- Modulus of Elasticity
  Hoop - 3.3 x 10^6 psi (22,8 GPa)
  Axial - 2.0 x 10^6 psi (13,8 GPa)
- Poisson's Ratio (Minor) = 0.39

Physical Properties

- Density = 124 lbs/cu ft (1986 kgs/cu m)
- Specific Gravity = 1.99

Thermal Properties

- Coefficient of Thermal Conductivity
  0.23 BTU/(ft•hr•°F) (0.4 W/(m•C°))
- Coefficient of Thermal Expansion
  8.7 x 10^{-6} in/in/°F (15,7 x 10^{-6} mm/mm/°C)

Benefits

- Corrosion Control
- Reduced Installation Costs
- Improved Flow Efficiency
- Reduced Paraffin & Scale Build-Up
- Reduced Maintenance Cost

Applications

- Production Lines or Injection Lines
- Transfer Lines or Disposal Lines
- Oil, Gas, Saltwater, CO_2 and H_2S

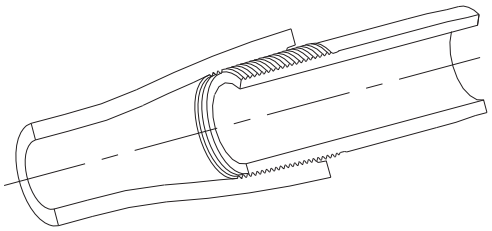
Performance Ratings vs. Temperature

(ASTM D 2992-B)	73.4° F (23° C)	150° F (65.6° C)	180° F (82.2° C)	200° F (93.3° C)
11.4 Year Life, LTHS	26,353 (181,7)	22,203 (153,1)	20,578 (141,9)	19,494 (134,4)
20 Year Life, LTHS	26,004 (179,3)	21,404 (147,6)	19,602 (135,2)	18,401 (126,9)
20 Year Life, LCL (Lower Confidence Limit)	24,596 (169,6)	20,335 (140,2)	18,666 (128,7)	17,554 (121,0)

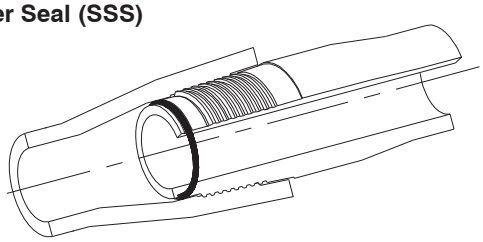
* 150° F and 180° F data are interpolated

Joining System

Advanced Composite Thread (ACT) or Precision Ground Thread (PGT)



Star Super Seal (SSS)



• Refer to Page 6 for Joining System specifications

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NOV Fiber Glass Systems

SIZE (in)		Product Code	PIPE DIMENSIONS (NOMINAL)										Minimum Bending Radius		Maximum Deflection	
			Inside Diameter		Outside Diameter		Wall Thickness		Pipe Weight		Connection Diameter					
Pipe	Thread		In	(mm)	In	(mm)	In	(mm)	lbs/ft	(kg/m)	In	(mm)	Ft	(m)	In/jt	(cm/jt)
Series 500 - PGT (All Sizes) or SSS (8", 10", 12")																
3	3 1/2	I0530	2.94	(74,7)	3.07	(78,0)	0.07	(1,8)	0.70	(1,0)	4.20	(106,7)	154	(46,9)	34	(86,4)
4	4 1/2	I0540	3.85	(97,8)	4.01	(101,9)	0.08	(2,0)	1.20	(1,8)	5.45	(138,4)	201	(61,3)	26	(66,0)
5	[TC]5 1/2	I0550	4.74	(120,4)	4.91	(124,7)	0.09	(2,3)	1.80	(2,7)	6.25	(158,8)	246	(75,0)	21	(53,3)
6	6 5/8	I0560	5.93	(150,6)	6.15	(156,2)	0.11	(2,8)	2.10	(3,1)	7.10	(180,3)	308	(93,9)	17	(43,2)
8	8 5/8	I0580	7.74	(196,6)	8.03	(204,0)	0.15	(3,8)	3.90	(5,8)	9.25	(235,0)	401	(122,2)	13	(33,0)
8	8SS[5]	I0577	7.74	(196,6)	8.01	(203,5)	0.14	(3,6)	3.50	(5,2)	9.39	(238,5)	401	(122,2)	13	(33,0)
10	10SS[5]	I0598	9.84	(249,9)	10.20	(259,1)	0.18	(4,6)	6.60	(9,8)	12.10	(307,3)	510	(155,4)	10	(25,4)
12	12SS[5]	I05B8	11.81	(300,0)	12.23	(310,6)	0.21	(5,3)	8.60	(12,8)	14.10	(358,1)	611	(186,2)	9	(22,9)
Series 800 - ACT, PGT (All Sizes) or SSS (8", 10", 12")																
2	2 3/8	I0820	1.94	(49,3)	2.11	(53,6)	0.08	(2,0)	0.50	(0,7)	3.05	(77,5)	105	(32,0)	49	(124,5)
2 1/2	2 7/8	I0825	2.37	(60,2)	2.53	(64,3)	0.08	(2,0)	0.60	(0,9)	3.55	(90,2)	127	(38,7)	41	(104,1)
3	3 1/2	I0830	2.94	(74,7)	3.11	(79,0)	0.09	(2,3)	0.90	(1,3)	4.25	(108,0)	156	(47,5)	33	(83,8)
4	4 1/2	I0840	3.85	(97,8)	4.08	(103,6)	0.12	(3,0)	1.60	(2,4)	5.55	(141,0)	204	(62,2)	26	(66,0)
5	[TC]5 1/2	I0850	4.74	(120,4)	5.02	(127,5)	0.14	(3,6)	2.50	(3,7)	6.25	(158,8)	251	(76,5)	21	(53,3)
6	6 5/8	I0855	5.50	(139,7)	5.83	(148,1)	0.17	(4,3)	3.10	(4,6)	7.35	(186,7)	292	(89,0)	18	(45,7)
6	6 5/8	I0860	5.93	(150,6)	6.27	(159,3)	0.17	(4,3)	3.10	(4,6)	7.30	(185,4)	314	(95,7)	17	(43,2)
8	8 5/8	I0880	7.74	(196,6)	8.18	(207,8)	0.22	(5,6)	5.80	(8,6)	9.55	(242,6)	409	(124,7)	13	(33,0)
8	8SS[5]	I0877	7.74	(196,6)	8.18	(207,8)	0.22	(5,6)	5.50	(8,2)	9.63	(244,6)	409	(124,7)	13	(33,0)
10	10SS[5]	I0898	9.84	(249,9)	10.41	(264,4)	0.28	(7,1)	9.70	(14,4)	12.35	(313,7)	520	(158,5)	10	(25,4)
12	12SS[5]	I08B8	11.81	(300,0)	12.48	(317,0)	0.33	(8,4)	12.50	(18,6)	14.40	(365,8)	624	(190,2)	8	(20,3)
Series 1000 - ACT (All Sizes) , PGT (All Sizes Except 8") or SSS (8", 10", 12")																
2	2 3/8	I1020	1.94	(49,3)	2.11	(53,6)	0.08	(2,0)	0.50	(0,7)	3.10	(78,7)	105	(32,0)	49	(124,5)
2 1/2	2 7/8	I1025	2.37	(60,2)	2.54	(64,5)	0.09	(2,3)	0.70	(1,0)	3.55	(90,2)	127	(38,7)	41	(104,1)
3	3 1/2	I1030	2.94	(74,7)	3.15	(80,0)	0.11	(2,8)	1.00	(1,5)	4.30	(109,2)	158	(48,2)	33	(83,8)
4	4 1/2	I1040	3.85	(97,8)	4.13	(104,9)	0.14	(3,6)	1.90	(2,8)	5.60	(142,2)	206	(62,8)	25	(63,5)
5	[TC]5 1/2	I1050	4.74	(120,4)	5.09	(129,3)	0.17	(4,3)	2.90	(4,3)	6.25	(158,8)	254	(77,4)	21	(53,3)
6	6 5/8	I1055	5.50	(139,7)	5.91	(150,1)	0.21	(5,3)	3.70	(5,5)	7.45	(189,2)	296	(90,2)	18	(45,7)
6	6 5/8	I1060	5.93	(150,6)	6.38	(162,1)	0.22	(5,6)	4.10	(6,1)	7.50	(190,5)	319	(97,2)	16	(40,6)
8	8 5/8	I1080	7.74	(196,6)	8.29	(210,6)	0.28	(7,1)	7.10	(10,6)	9.75	(247,7)	415	(126,5)	13	(33,0)
8	8SS[5]	I1077	7.74	(196,6)	8.29	(210,6)	0.28	(7,1)	6.90	(10,3)	9.79	(248,7)	415	(126,5)	13	(33,0)
10	10SS[5]	I1098	9.84	(249,9)	10.56	(268,2)	0.36	(9,1)	11.80	(17,6)	12.50	(317,5)	528	(160,9)	10	(25,4)
12	12SS[5]	I10B8	11.81	(300,0)	12.65	(321,3)	0.42	(10,7)	15.30	(22,8)	14.70	(373,4)	633	(192,9)	8	(20,3)
Series 1250 - ACT (All Sizes) , PGT (2", 2½", 3" and 4" Sizes) or SSS (8", 10", 12")																
2	2 3/8	I1220	1.94	(49,3)	2.13	(54,1)	0.10	(2,5)	0.60	(0,9)	3.15	(80,0)	107	(32,6)	49	(124,5)
2 1/2	2 7/8	I1225	2.37	(60,2)	2.58	(65,5)	0.11	(2,8)	0.80	(1,2)	3.60	(91,4)	129	(39,3)	40	(101,6)
3	3 1/2	I1230	2.94	(74,7)	3.22	(81,8)	0.14	(3,6)	1.30	(1,9)	4.35	(110,5)	161	(49,1)	32	(81,3)
4	4 1/2	I1240	3.85	(97,8)	4.19	(106,4)	0.17	(4,3)	2.30	(3,4)	5.70	(144,8)	210	(64,0)	25	(63,5)
5	[TC]5 1/2	I1250	4.74	(120,4)	5.18	(131,6)	0.22	(5,6)	3.50	(5,2)	6.45	(163,8)	259	(78,9)	20	(50,8)
6	6 5/8	I1255	5.50	(139,7)	6.00	(152,4)	0.25	(6,4)	4.50	(6,7)	7.57	(192,3)	300	(91,4)	17	(43,2)
6	7	I1260	5.93	(150,6)	6.48	(164,6)	0.27	(6,9)	5.20	(7,7)	8.00	(203,2)	324	(98,8)	16	(40,6)
8	8 5/8	I1280	7.74	(196,6)	8.44	(214,4)	0.35	(8,9)	8.80	(13,1)	10.00	(254,0)	422	(128,6)	12	(30,5)
8	8SS[5]	I1277	7.74	(196,6)	8.45	(214,6)	0.36	(9,1)	8.60	(12,8)	10.00	(254,0)	422	(128,6)	12	(30,5)
10	10SS[5]	I1298	9.84	(249,9)	10.74	(272,8)	0.45	(11,4)	14.50	(21,6)	12.80	(325,1)	537	(163,7)	10	(25,4)
12	12SS[5]	I12B8	11.81	(300,0)	12.89	(327,4)	0.54	(13,7)	19.20	(28,6)	15.00	(381,0)	645	(196,6)	8	(20,3)
Series 1500 - ACT (All Sizes) or PGT (2", 2½", 3" and 4" Sizes)																
1 1/2	1.90	I1515	1.44	(36,6)	1.60	(40,6)	0.08	(2,0)	0.40	(0,6)	2.70	(68,6)	80	(24,4)	64	(162,6)
2	2 3/8	I1520	1.94	(49,3)	2.17	(55,1)	0.12	(3,0)	0.70	(1,0)	3.20	(81,3)	109	(33,2)	48	(121,9)
2 1/2	2 7/8	I1525	2.37	(60,2)	2.62	(66,5)	0.13	(3,3)	1.00	(1,5)	3.67	(93,2)	131	(39,9)	40	(101,6)
3	3 1/2	I1530	2.94	(74,7)	3.26	(82,8)	0.16	(4,1)	1.50	(2,2)	4.42	(112,3)	163	(49,7)	32	(81,3)
4	4 1/2	I1540	3.85	(97,8)	4.28	(108,7)	0.22	(5,6)	2.70	(4,0)	5.80	(147,3)	214	(65,2)	24	(61,0)
5	[TC]5 1/2	I1550	4.74	(120,4)	5.27	(133,9)	0.26	(6,6)	4.20	(6,2)	6.60	(167,6)	263	(80,2)	20	(50,8)
6	6 5/8	I1555	5.50	(139,7)	6.11	(155,2)	0.31	(7,9)	5.50	(8,2)	7.74	(196,6)	306	(93,3)	17	(43,2)
6	7	I1560	5.93	(150,6)	6.59	(167,4)	0.33	(8,4)	6.30	(9,4)	8.20	(208,3)	330	(100,6)	16	(40,6)
8	8 5/8	I1574	7.43	(188,7)	8.27	(210,1)	0.42	(10,7)	10.50	(15,6)	10.25	(260,4)	414	(126,2)	13	(33,0)
8	9 5/8	I1580	7.74	(196,6)	8.59	(218,2)	0.43	(10,9)	12.10	(18,0)	11.40	(289,6)	430	(131,1)	12	(30,5)

(Metric Conversions are in Parentheses)

SIZE (in)		STAR™ RATED PRESSURES[4]						Ultimate[2] Pressure ASTM D-1599		Collapse Rating		Short Term Tensile Rating		Maximum Support Span		Threaded Adapter Product Code
		Static[1] 150° F (65.6° C)		Static[1] 180° F (82.2° C)		Static[1] 200° F (93.3° C)										
Pipe	Thread	psi	(MPa)	psi	(MPa)	psi	(MPa)	psi	(MPa)	psi	(MPa)	Lbs	(kgs)	Ft	(m)	
Series 500 - PGT (All Sizes) or SSS (8", 10", 12")																
3	3 1/2	500	(3,4)	450	(3,1)	400	(2,8)	1400	(9,7)	30	(0,2)	1700	(771)	10	(3,1)	35NU
4	4 1/2	500	(3,4)	450	(3,1)	400	(2,8)	1300	(9,0)	30	(0,2)	2900	(1315)	11	(3,4)	45NU
5	TC5 1/2	500	(3,4)	450	(3,1)	400	(2,8)	1100	(7,6)	16	(0,1)	3600	(1633)	12	(3,7)	55NR
6	6 5/8	500	(3,4)	450	(3,1)	400	(2,8)	1100	(7,6)	16	(0,1)	5800	(2631)	13	(4,0)	65NS
8	8 5/8	500	(3,4)	450	(3,1)	400	(2,8)	1200	(8,3)	18	(0,1)	10300	(4672)	15	(4,6)	85NU
8	8SS[5]	500	(3,4)	450	(3,1)	400	(2,8)	1100	(7,6)	15	(0,1)	9600	(4355)	15	(4,6)	088R
10	10SS[5]	500	(3,4)	450	(3,1)	400	(2,8)	1100	(7,6)	16	(0,1)	15900	(7212)	17	(5,2)	05AR
12	12SS[5]	500	(3,4)	450	(3,1)	400	(2,8)	1100	(7,6)	15	(0,1)	22400	(10161)	18	(5,5)	05CR
Series 800 - ACT, PGT (All Sizes) or SSS (8", 10", 12")																
2	2 3/8	800	(5,5)	700	(4,8)	650	(4,5)	2600	(17,9)	190	(1,3)	1400	(635)	9	(2,8)	23NR
2 1/2	2 7/8	800	(5,5)	700	(4,8)	650	(4,5)	2200	(15,2)	110	(0,8)	1800	(816)	10	(3,1)	27NU
3	3 1/2	800	(5,5)	700	(4,8)	650	(4,5)	1800	(12,4)	60	(0,4)	2300	(1043)	10	(3,1)	35NU
4	4 1/2	800	(5,5)	700	(4,8)	650	(4,5)	1900	(13,1)	80	(0,6)	4200	(1905)	12	(3,7)	45NU
5	TC5 1/2	800	(5,5)	700	(4,8)	650	(4,5)	1800	(12,4)	70	(0,5)	6100	(2767)	13	(4,0)	55NR
6	6 5/8	800	(5,5)	700	(4,8)	650	(4,5)	1800	(12,4)	70	(0,5)	8300	(3765)	14	(4,3)	65NU
6	6 5/8	800	(5,5)	700	(4,8)	650	(4,5)	1800	(12,4)	60	(0,4)	9200	(4173)	15	(4,6)	65NS
8	8 5/8	800	(5,5)	700	(4,8)	650	(4,5)	1800	(12,4)	60	(0,4)	15800	(7167)	17	(5,2)	85NR
8	8SS[5]	800	(5,5)	700	(4,8)	650	(4,5)	1800	(12,4)	60	(0,4)	15600	(7076)	17	(5,2)	088R
10	10SS[5]	800	(5,5)	700	(4,8)	650	(4,5)	1800	(12,4)	60	(0,4)	25600	(11612)	19	(5,9)	N/A
12	12SS[5]	800	(5,5)	700	(4,8)	650	(4,5)	1700	(11,7)	60	(0,4)	36100	(16375)	20	(6,2)	N/A
Series 1000 - ACT (All Sizes) , PGT (All Sizes Except 8") or SSS (8", 10", 12")																
2	2 3/8	1000	(6,9)	900	(6,2)	850	(5,9)	2600	(17,9)	190	(1,3)	1400	(635)	9	(2,8)	23NR
2 1/2	2 7/8	1000	(6,9)	900	(6,2)	850	(5,9)	2300	(15,9)	130	(0,9)	1900	(862)	10	(3,1)	27NU
3	3 1/2	1000	(6,9)	900	(6,2)	850	(5,9)	2200	(15,2)	120	(0,8)	2800	(1270)	11	(3,4)	35NU
4	4 1/2	1000	(6,9)	900	(6,2)	850	(5,9)	2200	(15,2)	130	(0,9)	5000	(2268)	12	(3,7)	45NU
5	TC5 1/2	1000	(6,9)	900	(6,2)	850	(5,9)	2200	(15,2)	120	(0,8)	7500	(3402)	14	(4,3)	55NR
6	6 5/8	1000	(6,9)	900	(6,2)	850	(5,9)	2300	(15,9)	130	(0,9)	10400	(4717)	15	(4,6)	65NU
6	6 5/8	1000	(6,9)	900	(6,2)	850	(5,9)	2300	(15,9)	130	(0,9)	12000	(5443)	15	(4,6)	65NR
8	8 5/8	1000	(6,9)	900	(6,2)	850	(5,9)	2200	(15,2)	120	(0,8)	19800	(8981)	17	(5,2)	N/A
8	8SS[5]	1000	(6,9)	900	(6,2)	850	(5,9)	2200	(15,2)	120	(0,8)	19900	(9027)	17	(5,2)	N/A
10	10SS[5]	1000	(6,9)	900	(6,2)	850	(5,9)	2200	(15,2)	120	(0,8)	32500	(14742)	20	(6,2)	N/A
12	12SS[5]	1000	(6,9)	900	(6,2)	850	(5,9)	2200	(15,2)	120	(0,8)	45800	(20775)	22	(6,8)	N/A
Series 1250 - ACT (All Sizes) , PGT (2", 2½", 3" and 4" Sizes) or SSS (8", 10", 12")																
2	2 3/8	1250	(8,6)	1100	(7,6)	1050	(7,2)	3100	(21,4)	310	(2,1)	1700	(771)	9	(2,8)	23NR
2 1/2	2 7/8	1250	(8,6)	1100	(7,6)	1050	(7,2)	2800	(19,3)	230	(1,6)	2300	(1043)	10	(3,1)	27NU
3	3 1/2	1250	(8,6)	1100	(7,6)	1050	(7,2)	2900	(20,0)	250	(1,7)	3700	(1678)	11	(3,4)	35NU
4	4 1/2	1250	(8,6)	1100	(7,6)	1050	(7,2)	2800	(19,3)	230	(1,6)	6100	(2767)	13	(4,0)	45NU
5	TC5 1/2	1250	(8,6)	1100	(7,6)	1050	(7,2)	2800	(19,3)	240	(1,7)	9600	(4355)	14	(4,3)	55NQ
6	6 5/8	1250	(8,6)	1100	(7,6)	1050	(7,2)	2800	(19,3)	230	(1,6)	12700	(5761)	15	(4,6)	N/A
6	7	1250	(8,6)	1100	(7,6)	1050	(7,2)	2800	(19,3)	240	(1,7)	14900	(6759)	16	(4,9)	N/A
8	8 5/8	1250	(8,6)	1100	(7,6)	1050	(7,2)	2800	(19,3)	230	(1,6)	25300	(11476)	18	(5,5)	N/A
8	8SS[5]	1250	(8,6)	1100	(7,6)	1050	(7,2)	2800	(19,3)	240	(1,7)	25700	(11658)	18	(5,5)	N/A
10	10SS[5]	1250	(8,6)	1100	(7,6)	1050	(7,2)	2800	(19,3)	240	(1,7)	41400	(18779)	21	(6,5)	N/A
12	12SS[5]	1250	(8,6)	1100	(7,6)	1050	(7,2)	2800	(19,3)	240	(1,7)	59400	(26944)	23	(7,1)	N/A
Series 1500 - ACT (All Sizes) or PGT (2", 2½", 3" and 4" Sizes)																
1 1/2	1.9	1500	(10,3)	1350	(9,3)	1250	(8,6)	3400	(23,4)	440	(3,0)	1100	(499)	8	(2,5)	19NR
2	2 3/8	1500	(10,3)	1350	(9,3)	1250	(8,6)	3600	(24,8)	500	(3,4)	2100	(953)	10	(3,1)	23NR
2 1/2	2 7/8	1500	(10,3)	1350	(9,3)	1250	(8,6)	3300	(22,8)	390	(2,7)	2800	(1270)	11	(3,4)	27NU
3	3 1/2	1500	(10,3)	1350	(9,3)	1250	(8,6)	3300	(22,8)	400	(2,8)	4400	(1996)	12	(3,7)	35NU
4	4 1/2	1500	(10,3)	1350	(9,3)	1250	(8,6)	3400	(23,4)	420	(2,9)	7700	(3493)	13	(4,0)	45NS
5	TC5 1/2	1500	(10,3)	1350	(9,3)	1250	(8,6)	3400	(23,4)	410	(2,8)	11700	(5307)	15	(4,6)	55NP
6	6 5/8	1500	(10,3)	1350	(9,3)	1250	(8,6)	3400	(23,4)	410	(2,8)	15700	(7122)	16	(4,9)	N/A
6	7	1500	(10,3)	1350	(9,3)	1250	(8,6)	3400	(23,4)	410	(2,8)	18200	(8256)	17	(5,2)	N/A
8	8 5/8	1500	(10,3)	1350	(9,3)	1250	(8,6)	3400	(23,4)	430	(3,0)	29200	(13245)	19	(5,9)	N/A
8	9 5/8	1500	(10,3)	1350	(9,3)	1250	(8,6)	3400	(23,4)	410	(2,8)	31100	(14107)	19	(5,9)	N/A

(Metric Conversions are in Parentheses)

N/A - Not Available (Repair Joint Required)

SIZE (in)		Product Code	PIPE DIMENSIONS (NOMINAL)										Minimum Bending Radius		Maximum Deflection	
			Inside Diameter		Outside Diameter		Wall Thickness		Pipe Weight		Connection Diameter					
Pipe	Thread		In	(mm)	In	(mm)	In	(mm)	lbs/ft	(kg/m)	In	(mm)	Ft	(m)	In/jt	(cm/jt)
Series 1750 - ACT (All Sizes) or PGT (2", 2½", 3" and 4" Sizes)																
1 1/2	1.90	I1715	1.44	(36,6)	1.63	(41,4)	0.10	(2,5)	0.50	(0,7)	2.75	(69,9)	82	(25,0)	63	(160,0)
2	2 3/8	I1720	1.94	(49,3)	2.20	(55,9)	0.13	(3,3)	0.80	(1,2)	3.25	(82,6)	110	(33,5)	47	(119,4)
2 1/2	2 7/8	I1725	2.37	(60,2)	2.67	(67,8)	0.15	(3,8)	1.20	(1,8)	3.76	(95,5)	134	(40,8)	39	(99,1)
3	3 1/2	I1730	2.94	(74,7)	3.32	(84,3)	0.19	(4,8)	1.80	(2,7)	4.52	(114,8)	166	(50,6)	31	(78,7)
4	4 1/2	I1740	3.85	(97,8)	4.36	(110,7)	0.26	(6,6)	3.30	(4,9)	5.90	(149,9)	218	(66,4)	24	(61,0)
5	[TC]5 1/2	I1750	4.74	(120,4)	5.35	(135,9)	0.30	(7,6)	4.80	(7,1)	7.00	(177,8)	267	(81,4)	19	(48,3)
6	6 5/8	I1755	5.50	(139,7)	6.21	(157,7)	0.36	(9,1)	6.30	(9,4)	7.92	(201,2)	311	(94,8)	17	(43,2)
6	7	I1760	5.93	(150,6)	6.70	(170,2)	0.38	(9,7)	7.30	(10,9)	8.39	(213,1)	335	(102,1)	16	(40,6)
8	8 5/8	I1774	7.43	(188,7)	8.42	(213,9)	0.49	(12,4)	12.20	(18,2)	10.50	(266,7)	421	(128,3)	12	(30,5)
8	9 5/8	I1780	7.74	(196,6)	8.73	(221,7)	0.50	(12,7)	13.80	(20,5)	11.60	(294,6)	437	(133,2)	12	(30,5)
Series 2000 - ACT (All Sizes) or PGT (2", 2½", 3" and 4" Sizes)																
1 1/2	1.90	I2015	1.44	(36,6)	1.67	(42,4)	0.11	(2,8)	0.60	(0,9)	2.75	(69,9)	83	(25,3)	62	(157,5)
2	2 3/8	I2020	1.94	(49,3)	2.24	(56,9)	0.15	(3,8)	0.90	(1,3)	3.30	(83,8)	112	(34,1)	46	(116,8)
2 1/2	2 7/8	I2025	2.37	(60,2)	2.72	(69,1)	0.18	(4,6)	1.40	(2,1)	3.85	(97,8)	136	(41,5)	38	(96,5)
3	3 1/2	I2030	2.94	(74,7)	3.38	(85,9)	0.22	(5,6)	2.10	(3,1)	4.63	(117,6)	169	(51,5)	31	(78,7)
4	4 1/2	I2040	3.85	(97,8)	4.43	(112,5)	0.29	(7,4)	3.70	(5,5)	6.00	(152,4)	221	(67,4)	24	(61,0)
5	[TC]5 1/2	I2050	4.74	(120,4)	5.45	(138,4)	0.36	(9,1)	5.50	(8,2)	7.00	(177,8)	273	(83,2)	19	(48,3)
6	6 5/8	I2055	5.50	(139,7)	6.33	(160,8)	0.41	(10,4)	7.30	(10,9)	8.11	(206,0)	316	(96,3)	16	(40,6)
6	7	I2060	5.93	(150,6)	6.82	(173,2)	0.44	(11,2)	8.40	(12,5)	8.59	(218,2)	341	(103,9)	15	(38,1)
8	8 5/8	I2074	7.43	(188,7)	8.57	(217,7)	0.57	(14,5)	14.00	(20,8)	10.75	(273,1)	428	(130,5)	12	(30,5)
8	9 5/8	I2080	7.74	(196,6)	8.90	(226,1)	0.58	(14,7)	16.00	(23,8)	12.00	(304,8)	445	(135,6)	12	(30,5)
Series 2250 - ACT (All Sizes) or PGT (2", 2½" and 3" Sizes)																
1 1/2	1.90	I2215	1.44	(36,6)	1.70	(43,2)	0.13	(3,3)	0.60	(0,9)	2.80	(71,1)	85	(25,9)	61	(154,9)
2	2 3/8	I2220	1.94	(49,3)	2.27	(57,7)	0.17	(4,3)	1.10	(1,6)	3.35	(85,1)	114	(34,7)	46	(116,8)
2 1/2	2 7/8	I2225	2.37	(60,2)	2.77	(70,4)	0.20	(5,1)	1.60	(2,4)	3.94	(100,1)	139	(42,4)	37	(94,0)
3	3 1/2	I2230	2.94	(74,7)	3.44	(87,4)	0.25	(6,4)	2.40	(3,6)	4.74	(120,4)	172	(52,4)	30	(76,2)
4	4 1/2	I2240	3.85	(97,8)	4.51	(114,6)	0.33	(8,4)	4.20	(6,2)	6.05	(153,7)	226	(68,9)	23	(58,4)
6	6 5/8	I2255	5.50	(139,7)	6.45	(163,8)	0.48	(12,2)	8.50	(12,6)	8.40	(213,4)	323	(98,5)	16	(40,6)
Series 2500 - ACT (All Sizes) or PGT (2", 2½" and 3" Sizes)																
1 1/2	1.90	I2515	1.44	(36,6)	1.71	(43,4)	0.14	(3,6)	0.70	(1,0)	2.84	(72,1)	86	(26,2)	60	(152,4)
2	2 3/8	I2520	1.94	(49,3)	2.32	(58,9)	0.19	(4,8)	1.20	(1,8)	3.40	(86,4)	116	(35,4)	45	(114,3)
2 1/2	2 7/8	I2525	2.37	(60,2)	2.82	(71,6)	0.23	(5,8)	1.80	(2,7)	4.03	(102,4)	141	(43,0)	37	(94,0)
3	3 1/2	I2530	2.94	(74,7)	3.51	(89,2)	0.29	(7,4)	2.80	(4,2)	4.85	(123,2)	176	(53,6)	30	(76,2)
4	4 1/2	I2540	3.85	(97,8)	4.58	(116,3)	0.37	(9,4)	4.60	(6,8)	6.11	(155,2)	229	(69,8)	23	(58,4)
6	7	I2555	5.50	(139,7)	6.56	(166,6)	0.53	(13,5)	9.70	(14,4)	9.01	(228,9)	328	(100,0)	16	(40,6)
Series 2750 - ACT (All Sizes) or PGT (2" and 2½" Sizes)																
1 1/2	1.90	I2715	1.44	(36,6)	1.74	(44,2)	0.15	(3,8)	0.80	(1,2)	2.90	(73,7)	87	(26,5)	59	(149,9)
2	2 3/8	I2720	1.94	(49,3)	2.35	(59,7)	0.21	(5,3)	1.30	(1,9)	3.49	(88,6)	118	(36,0)	44	(111,8)
2 1/2	2 7/8	I2725	2.37	(60,2)	2.87	(72,9)	0.25	(6,4)	2.00	(3,0)	4.13	(104,9)	143	(43,6)	36	(91,4)
3	3 1/2	I2730	2.94	(74,7)	3.57	(90,7)	0.32	(8,1)	3.10	(4,6)	4.98	(126,5)	179	(54,6)	29	(73,7)
3 1/2	4 1/2	I2733	3.33	(84,6)	4.04	(102,6)	0.36	(9,1)	4.30	(6,4)	6.60	(167,6)	202	(61,6)	26	(66,0)
4	5 1/2	I2740	3.85	(97,8)	4.68	(118,9)	0.42	(10,7)	5.90	(8,8)	7.29	(185,2)	234	(71,3)	22	(55,9)
Series 3000 - ACT (All Sizes) or PGT (2" and 2½" Sizes)																
1 1/2	1.90	I3015	1.44	(36,6)	1.78	(45,2)	0.17	(4,3)	0.80	(1,2)	2.98	(75,7)	89	(27,1)	58	(147,3)
2	2 3/8	I3020	1.94	(49,3)	2.40	(61,0)	0.23	(5,8)	1.50	(2,2)	3.57	(90,7)	120	(36,6)	43	(109,2)
2 1/2	2 7/8	I3025	2.37	(60,2)	2.92	(74,2)	0.28	(7,1)	2.20	(3,3)	4.23	(107,4)	146	(44,5)	36	(91,4)
3	3 1/2	I3030	2.94	(74,7)	3.63	(92,2)	0.34	(8,6)	3.40	(5,1)	5.10	(129,5)	181	(55,2)	29	(73,7)
3 1/2	4 1/2	I3033	3.33	(84,6)	4.12	(104,6)	0.40	(10,2)	4.70	(7,0)	6.65	(168,9)	206	(62,8)	25	(63,5)
4	5 1/2	I3040	3.85	(97,8)	4.75	(120,7)	0.45	(11,4)	6.40	(9,5)	7.47	(189,7)	237	(72,2)	22	(55,9)
Series 3500 - ACT (Only)																
1 1/2	1.90	I3515	1.44	(36,6)	1.85	(47,0)	0.20	(5,1)	1.00	(1,5)	3.13	(79,5)	92	(28,0)	56	(142,2)
2	2 3/8	I3520	1.94	(49,3)	2.48	(63,0)	0.27	(6,9)	1.80	(2,7)	3.75	(95,3)	124	(37,8)	42	(106,7)
2 1/2	2 7/8	I3525	2.37	(60,2)	3.04	(77,2)	0.34	(8,6)	2.70	(4,0)	4.45	(113,0)	152	(46,3)	34	(86,4)
3	[TC]4 1/2	I3530	2.94	(74,7)	3.76	(95,5)	0.41	(10,4)	4.90	(7,3)	7.00	(177,8)	188	(57,3)	28	(71,1)
3 1/2	4 1/2	I3533	3.33	(84,6)	4.26	(108,2)	0.46	(11,7)	5.40	(8,0)	6.74	(171,2)	213	(64,9)	24	(61,0)
4	5 1/2	I3540	3.85	(97,8)	4.92	(125,0)	0.54	(13,7)	7.60	(11,3)	7.86	(199,6)	246	(75,0)	21	(53,3)

(Metric Conversions are in Parentheses)

SIZE (in)		STAR™ RATED PRESSURES[4]						Ultimate[2] Pressure ASTM D-1599		Collapse Rating		Short Term Tensile Rating		Maximum Support Span		Threaded Adapter Product Code
		Static[1] 150° F (65.6° C)		Static[1] 180° F (82.2° C)		Static[1] 200° F (93.3° C)										
Pipe	Thread	psi	(MPa)	psi	(MPa)	psi	(MPa)	psi	(MPa)	psi	(MPa)	Lbs	(kgs)	Ft	(m)	
Series 1750 - ACT (All Sizes) or PGT (2", 2½", 3" and 4" Sizes)																
1 1/2	1.90	1750	(12,1)	1550	(10,7)	1450	(10,0)	4000	(27,6)	690	(4,8)	1300	(590)	8	(2,5)	19NR
2	2 3/8	1750	(12,1)	1550	(10,7)	1450	(10,0)	4100	(28,3)	720	(5,0)	2400	(1089)	10	(3,1)	23NR
2 1/2	2 7/8	1750	(12,1)	1550	(10,7)	1450	(10,0)	3900	(26,9)	630	(4,3)	3400	(1542)	11	(3,4)	27NT
3	3 1/2	1750	(12,1)	1550	(10,7)	1450	(10,0)	3900	(26,9)	640	(4,4)	5300	(2404)	12	(3,7)	35NS
4	4 1/2	1750	(12,1)	1550	(10,7)	1450	(10,0)	4000	(27,6)	690	(4,8)	9300	(4218)	14	(4,3)	45NR
5	[TC]5 1/2	1750	(12,1)	1550	(10,7)	1450	(10,0)	3900	(26,9)	620	(4,3)	13600	(6169)	15	(4,6)	N/A
6	6 5/8	1750	(12,1)	1550	(10,7)	1450	(10,0)	3900	(26,9)	630	(4,3)	18500	(8392)	17	(5,2)	N/A
6	7	1750	(12,1)	1550	(10,7)	1450	(10,0)	3900	(26,9)	640	(4,4)	21600	(9798)	17	(5,2)	N/A
8	8 5/8	1750	(12,1)	1550	(10,7)	1450	(10,0)	4000	(27,6)	680	(4,7)	34700	(15740)	19	(5,9)	N/A
8	9 5/8	1750	(12,1)	1550	(10,7)	1450	(10,0)	3900	(26,9)	630	(4,3)	36500	(16556)	19	(5,9)	N/A
Series 2000 - ACT (All Sizes) or PGT (2", 2½", 3" and 4" Sizes)																
1 1/2	1.90	2000	(13,8)	1800	(12,4)	1700	(11,7)	4700	(32,4)	1140	(7,9)	1500	(680)	9	(2,8)	19NR
2	2 3/8	2000	(13,8)	1800	(12,4)	1700	(11,7)	4600	(31,7)	1030	(7,1)	2700	(1225)	10	(3,1)	23NS
2 1/2	2 7/8	2000	(13,8)	1800	(12,4)	1700	(11,7)	4500	(31,0)	970	(6,7)	4000	(1814)	11	(3,4)	27NS
3	3 1/2	2000	(13,8)	1800	(12,4)	1700	(11,7)	4400	(30,3)	930	(6,4)	6100	(2767)	12	(3,7)	35NS
4	4 1/2	2000	(13,8)	1800	(12,4)	1700	(11,7)	4500	(31,0)	1000	(6,9)	10700	(4854)	14	(4,3)	45NR
5	[TC]5 1/2	2000	(13,8)	1800	(12,4)	1700	(11,7)	4500	(31,0)	980	(6,8)	16200	(7348)	16	(4,9)	N/A
6	6 5/8	2000	(13,8)	1800	(12,4)	1700	(11,7)	4500	(31,0)	970	(6,7)	21700	(9843)	17	(5,2)	N/A
6	7	2000	(13,8)	1800	(12,4)	1700	(11,7)	4400	(30,3)	940	(6,5)	25000	(11340)	18	(5,5)	N/A
8	8 5/8	2000	(13,8)	1800	(12,4)	1700	(11,7)	4600	(31,7)	1010	(7,0)	40300	(18280)	20	(6,2)	N/A
8	9 5/8	2000	(13,8)	1800	(12,4)	1700	(11,7)	4500	(31,0)	970	(6,7)	43000	(19505)	20	(6,2)	N/A
Series 2250 - ACT (All Sizes) or PGT (2", 2½" and 3" Sizes)																
1 1/2	1.90	2250	(15,5)	2050	(14,1)	1900	(13,1)	5300	(36,5)	1570	(10,8)	1700	(771)	9	(2,8)	19NR
2	2 3/8	2250	(15,5)	2050	(14,1)	1900	(13,1)	5100	(35,2)	1420	(9,8)	3100	(1406)	10	(3,1)	23NS
2 1/2	2 7/8	2250	(15,5)	2050	(14,1)	1900	(13,1)	5100	(35,2)	1430	(9,9)	4600	(2087)	12	(3,7)	27NR
3	3 1/2	2250	(15,5)	2050	(14,1)	1900	(13,1)	5000	(34,5)	1350	(9,3)	7000	(3175)	13	(4,0)	35NR
4	4 1/2	2250	(15,5)	2050	(14,1)	1900	(13,1)	5100	(35,2)	1430	(9,9)	12300	(5579)	15	(4,6)	N/A
6	6 5/8	2250	(15,5)	2050	(14,1)	1900	(13,1)	5100	(35,2)	1430	(9,9)	25300	(11476)	18	(5,5)	N/A
Series 2500 - ACT (All Sizes) or PGT (2", 2½" and 3" Sizes)																
1 1/2	1.9	2500	(17,2)	2250	(15,5)	2100	(14,5)	5600	(38,6)	1840	(12,7)	1900	(862)	9	(2,8)	19NR
2	2 3/8	2500	(17,2)	2250	(15,5)	2100	(14,5)	5800	(40,0)	2080	(14,3)	3600	(1633)	11	(3,4)	23NQ
2 1/2	2 7/8	2500	(17,2)	2250	(15,5)	2100	(14,5)	5700	(39,3)	1910	(13,2)	5200	(2359)	12	(3,7)	27NQ
3	3 1/2	2500	(17,2)	2250	(15,5)	2100	(14,5)	5700	(39,3)	1980	(13,7)	8200	(3720)	13	(4,0)	35NR
4	4 1/2	2500	(17,2)	2250	(15,5)	2100	(14,5)	5600	(38,6)	1900	(13,1)	13800	(6260)	15	(4,6)	N/A
6	7	2500	(17,2)	2250	(15,5)	2100	(14,5)	5600	(38,6)	1900	(13,1)	28300	(12837)	18	(5,5)	N/A
Series 2750 - ACT (All Sizes) or PGT (2" and 2½" Sizes)																
1 1/2	1.9	2750	(19,0)	2500	(17,2)	2350	(16,2)	6200	(42,7)	2470	(17,0)	2100	(953)	9	(2,8)	N/A
2	2 3/8	2750	(19,0)	2500	(17,2)	2350	(16,2)	6200	(42,7)	2540	(17,5)	3900	(1769)	11	(3,4)	N/A
2 1/2	2 7/8	2750	(19,0)	2500	(17,2)	2350	(16,2)	6200	(42,7)	2510	(17,3)	5800	(2631)	12	(3,7)	N/A
3	3 1/2	2750	(19,0)	2500	(17,2)	2350	(16,2)	6300	(43,4)	2620	(18,1)	9100	(4128)	13	(4,0)	N/A
3 1/2	4 1/2	2750	(19,0)	2500	(17,2)	2350	(16,2)	6200	(42,7)	2560	(17,7)	11600	(5262)	14	(4,3)	N/A
4	5 1/2	2750	(19,0)	2500	(17,2)	2350	(16,2)	6300	(43,4)	2650	(18,3)	15800	(7167)	15	(4,6)	N/A
Series 3000 - ACT (All Sizes) or PGT (2" and 2½" Sizes)																
1 1/2	1.9	3000	(20,7)	2700	(18,6)	2550	(17,6)	6800	(46,9)	3320	(22,9)	2400	(1089)	10	(3,1)	N/A
2	2 3/8	3000	(20,7)	2700	(18,6)	2550	(17,6)	6800	(46,9)	3300	(22,8)	4400	(1996)	11	(3,4)	N/A
2 1/2	2 7/8	3000	(20,7)	2700	(18,6)	2550	(17,6)	6800	(46,9)	3250	(22,4)	6500	(2948)	12	(3,7)	N/A
3	3 1/2	3000	(20,7)	2700	(18,6)	2550	(17,6)	6800	(46,9)	3280	(22,6)	10000	(4536)	14	(4,3)	N/A
3 1/2	4 1/2	3000	(20,7)	2700	(18,6)	2550	(17,6)	6800	(46,9)	3380	(23,3)	13100	(5942)	14	(4,3)	N/A
4	5 1/2	3000	(20,7)	2700	(18,6)	2550	(17,6)	6800	(46,9)	3290	(22,7)	17200	(7802)	15	(4,6)	N/A
Series 3500 - ACT (Only)																
1 1/2	1.9	3500	(24,1)	3150	(21,7)	2950	(20,3)	8000	(55,2)	5340	(36,8)	2900	(1315)	10	(3,1)	N/A
2	2 3/8	3500	(24,1)	3150	(21,7)	2950	(20,3)	7900	(54,5)	5250	(36,2)	5300	(2404)	11	(3,4)	N/A
2 1/2	2 7/8	3500	(24,1)	3150	(21,7)	2950	(20,3)	8100	(55,8)	5500	(37,9)	8100	(3674)	13	(4,0)	N/A
3	[TC]4 1/2	3500	(24,1)	3150	(21,7)	2950	(20,3)	7900	(54,5)	5250	(36,2)	12200	(5534)	14	(4,3)	N/A
3 1/2	4 1/2	3500	(24,1)	3150	(21,7)	2950	(20,3)	7900	(54,5)	5210	(35,9)	15700	(7122)	15	(4,6)	N/A
4	5 1/2	3500	(24,1)	3150	(21,7)	2950	(20,3)	7900	(54,5)	5260	(36,3)	21000	(9526)	16	(4,9)	N/A

(Metric Conversions are in Parentheses) *N/A - Not Available (Repair Joint Required)*

Joining System Information (API 8rd Thread and Mechanical O-Ring)

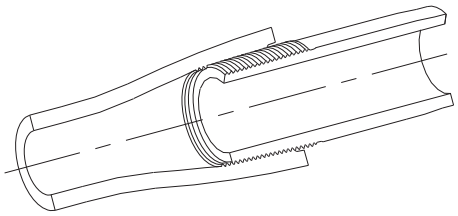
Pipe Size - Inches Joining System		1 1/2	2	2 1/2	3	4	5
Thread Size [3]		1.90" EUE 10rd	2 3/8" EUE 8rd	2 7/8" EUE 8rd	3 1/2" EUE 8rd	4 1/2" EUE 8rd	5 1/2" OD 8rd
• Pin Upset O.D.	In	2.15	2.60	3.10	3.75	4.75	5.55
	(mm)	(54,6)	(66,0)	(78,7)	(95,3)	(120,7)	(141,0)
• Thread Length	In	2.36	2.94	3.25	3.50	3.88	4.75
	(mm)	(59,9)	(74,7)	(82,6)	(88,9)	(98,6)	(120,7)
• Make Up Length Loss	In	2.06	2.56	2.86	3.13	3.50	4.38
	(mm)	(52,4)	(65,1)	(73,0)	(79,4)	(88,9)	(111,1)

(Metric Conversions are in Parentheses)

Joining System Information (API 8rd Thread and Mechanical O-Ring)

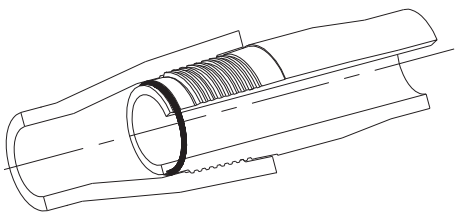
Pipe Size - Inches Joining System		6	6	8	8	8SS	10SS	12SS
Thread Size [3]		6 5/8" OD 8rd	7" OD 8rd	8 5/8" OD 8rd	9 5/8" OD 8rd	Super Seal	Super Seal	Super Seal
• Pin Upset O.D.	In	6.65	7.05	8.65	9.65	4.75	6.65	8.65
	(mm)	(168,9)	(179,1)	(219,7)	(245,1)	(120,7)	(168,9)	(219,7)
• Thread Length	In	4.25	4.88	4.85	5.13	3.88	4.25	4.85
	(mm)	(108,0)	(124,0)	(123,2)	(130,3)	(98,6)	(108,0)	(123,2)
• Make Up Length Loss	In	3.88	4.50	4.50	4.75	3.50	3.88	4.50
	(mm)	(98,4)	(114,3)	(114,3)	(120,7)	(88,9)	(98,4)	(114,3)
• O-Ring Dash Number						2-369	2-449	2-453

(Metric Conversions are in Parentheses)



API Threads

- Advanced Composite Thread (ACT) - Molded threads using a graphite, ceramic and epoxy composite for high performance applications. (Patent No's 4,999,389 & 5,179,140)
- Precision Ground Thread (PGT) - Typical ground threads produced with numerical controlled grinding equipment.
- All 1½" EUE 10rd and 2-3/8" - 4½" EUE 8rd API threads conform to API 5B Table 14, 14th Edition (L4 is minimum) and all 5½" - 9 5/8" OD 8rd casing threads conform to API 5B Table 7, 14th Edition (L4 is minimum).



Star Super Seal (SSS)

- Fast, Reliable Installation
- Proprietary Self Restrained Mechanical O-Ring Seal
  - 2"-6" 4 Threads per inch
  - 8"-12" 2 Threads per inch
- All Weather Connection
- Standard O-Rings are Standard Nitrile for applications up to 150° F (65.6° C)
- Special O-Rings available for high concentrations of CO_2, H_2S and other special applications.

Corresponding Numbered Notes:

1. **STATIC PRESSURE RATING** - Maximum operating pressure at design temperature.

2. **ULTIMATE PRESSURE** - The typical mode of failure for pressure is weep.

3. **API CONNECTIONS** - All products are produced integral joint unless indicated (TC) Threaded and Coupled. Any order may include up to 15% threaded and coupled pipe. All 1½" EUE 10rd and 2 3/8" - 4½" EUE 8rd API threads conform to API 5B Table 14, 14th Edition (L4 is minimum) and all 5½" - 9 5/8" OD 8rd casing thread conform to API 5B Table 7, 14th Edition (L4 is minimum).

4. **CYCLIC PRESSURE** - Consult a NOV Fiber Glass Systems technical services personnel in applications where pressure fluctuations of more than 20 percent of the steady pressure rating are anticipated.

5. **O-RINGS** - Standard commercial 70 durometer nitrile unless otherwise specified. Refer to Section 2.5 of the NOV Fiber Glass Systems Threaded Line Pipe Installation and Application Practices for additional o-ring specifications.

Pipe Capacity

Size		Inside Diameter		Capacity	
Pipe	Thread	in	(mm)	Bbls/1,000 ft.	(m^3/km)
1 1/2	1.90	1.44	(36,6)	2.00	(1,0)
2	2 3/8	1.94	(49,3)	3.70	(1,9)
2 1/2	2 7/8	2.37	(60,2)	5.40	(2,8)
3	3 1/2	2.94	(74,7)	8.40	(4,4)
4	4 1/2	3.85	(97,8)	14.40	(7,5)
5	5 1/2	4.74	(120,4)	21.80	(11,4)
6	6 5/8	5.50	(139,7)	29.40	(15,3)
6	6 5/8	5.93	(150,6)	34.20	(17,8)
6	7	5.93	(150,6)	34.20	(17,8)
8	8 5/8	7.43	(188,7)	53.70	(28,0)
8	8 5/8	7.74	(196,6)	58.10	(30,3)
8	9 5/8	7.74	(196,6)	58.10	(30,3)
8	8SS	7.74	(196,6)	58.10	(30,3)
10	10SS	9.84	(249,9)	94.10	(49,1)
12	12SS	11.81	(300,0)	135.50	(70,7)

15HR-0001 / 15HR-0005
LICENSEE Q1 RATED

QMS REGISTERED ISO 9001:2000

www.fiberglasssystems.com

P.O. Box 37389, 2425 SW 36th Street
San Antonio, Texas 78237 USA
Phone: 1 (210) 434-5043
Fax: 1 (210) 434-7543

NOV Fiber Glass Systems

O1300 Issued August 2009 - Supersedes March 2006

From: Al Mack [al.mack@westernfiberglass.net]
Sent: July 6, 2011 7:59 AM
To: Alex Tatarov
Subject: RE: Information request - RUSH

8" Series 1250 Standard Design Aliphatic Amine

		Min	Nom	Max
ID	in	---- 7.74 fixed ----		
OD	in	8.37	8.44	8.51
t	in	0.317	0.352	0.387
TG	° C	93	N/A	N/A
% Glass	%	N/A	79.4	N/A

From: Alex Tatarov [mailto:atatarov@skystone.ca]
Sent: Tuesday, July 05, 2011 8:55 PM
To: al.mack@westernfiberglass.net
Subject: Information request - RUSH
Importance: High

Hi Al,

I called you yesterday regarding the info for 8 inch STAR™ Aliphatic Amine Line Pipe, schedule 1250, and you helped me by directing to the proper document. Thank you.

I have several questions which still require answers:

- What are tolerances on the diameter and the wall thickness?
- What is the minimum acceptable wall thickness of the 8" schedule 1250 pipe?
- What is the specified glass transition temperature?
- What is the specified glass-epoxy ratio?

Could you please pass this information to me ASAP, as this project is a big rush?

Best regards,

Alex Tatarov, Ph.D., P.Eng.
Senior Engineer
Skystone Engineering
McCall Court, 330, 4311-12 Street NE
Calgary, AB T2E 4P9
(403) 221-0240 Direct
(403) 510-4394 Mobile
(403) 216-3485 Main
(403) 216-3486 Fax
www.skystone.ca

Appendix 3

Fluid Analysis

AGAT® Laboratories

WATER ANALYSIS

Container Identification	Previous Number	Laboratory Number
PB1A	03W062456B	03W062456A

Operator Name
PENGROWTH CORPORATION

Unique Well Identifier	Well Name	Elevation
04-14-063-11W5	JUDY CREEK 04-14-063-11W5	KB m GRD m

Field or Area	Pool or Zone	Sampler's Company
JUDY CREEK	"A" POOL	SAME

Test Type	Test No.	Test Recovery	Name of Sampler

Test Interval or Perfs	Sampling Point
	WELLHEAD

	Separator	Reservoir	Source	Sampled	Received
Pressure (kPa)					
Temperature					

Date Sampled	Date Received	Date Reported	Entered By	Certified By
Oct 21, 2003	Oct 30, 2003	Nov 10, 2003	ML	ML

Other Information

Cations

ION	mg/L	Mass Fraction	mmol/L
Na	46802.0	0.360	2035.8
K	828.0	0.006	21.2
Ca	2810.0	0.022	70.1
Mg	375.0	0.003	15.4
Fe	0.8	TRACE	TRACE
Total Cations			2228.1

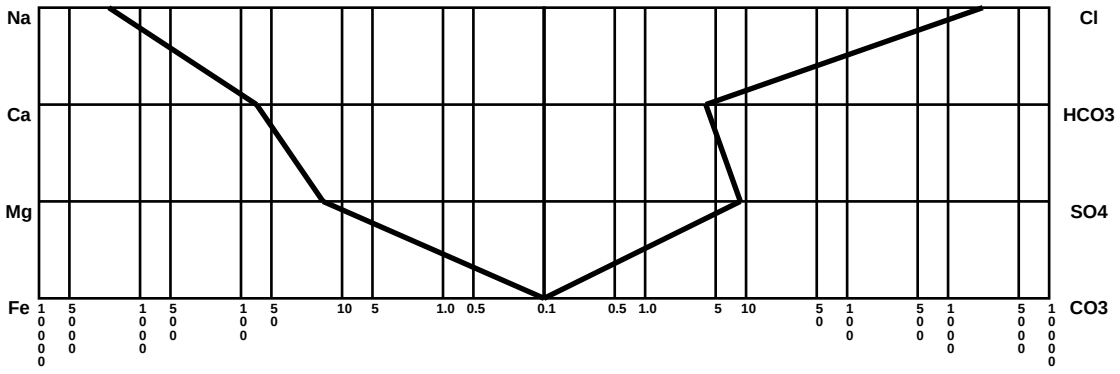
Anions

ION	mg/L	Mass Fraction	mmol/L
Cl	77975.0	0.600	2199.4
HCO3	243.7	0.002	4.0
SO4	843.0	0.006	8.8
CO3	Nil	Nil	Nil
OH	Nil	Nil	Nil
Total Anions			2221.0

Other Measurements

Measurement	Value
Total Dissolved Solids (Calculated) mg/L	129877
Observed pH	6.93
H2S (25°C) mg/L	0.00
Relative Density (25°C)	1.050
Resistivity/OHM·m (25°C)	0.070
Salinity %	13.42

Logarithmic Pattern mmol/L



AGAT® Laboratories

WATER ANALYSIS

Container Identification
PB1A

Operator Name	Laboratory Number
PENGROWTH CORPORATION	06W194726A

Unique Well Identifier	Well Name	Elevation			
14-20-063-11W5		KB m		GRD m	

Field or Area	Pool or Zone	Sampler's Company
JUDY CREEK	NOT AVAILABLE	

Test Type	Test No.	Test Recovery	Name of Sampler

Test Interval or Perfs		Sampling Point		Separator	Reservoir	Source	Sampled	Received
		NOT AVAILABLE	Pressure (kPa)					
			Temperature					

Well License	Date Sampled	Date Received	Date Reported	Entered By	Certified By
		Nov 06, 2006	Nov 08, 2006	FM	FM

Other Information

Note: Sampling Point, Unique Well Identifier and/or Pool or Zone information was unavailable at time of reporting. This information is integral to AGAT's WebFLUIDs, a comparison, history and trending analysis system.

Cations

ION	mg/L	mmol/L	meq/L
Na	29600.0	1287.5	1287.5
K	474.0	12.1	12.1
Ca	1810.0	45.2	90.3
Mg	360.0	14.8	29.6
Ba	21.0	0.2	0.3
Sr	89.0	1.0	2.0
Fe	1.6	0.0	TRACE
Total Cations			1421.9

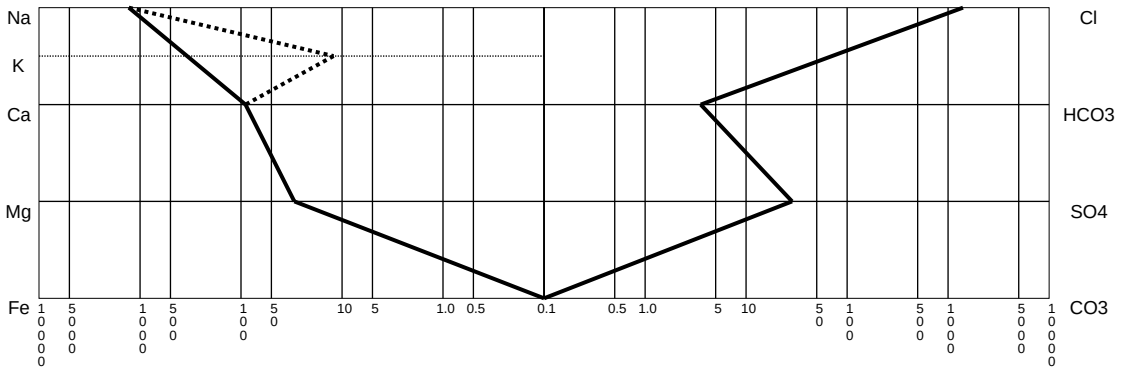
Anions

ION	mg/L	mmol/L	meq/L
Cl	49772.0	1403.9	1403.9
Br	123.0	1.5	1.5
I	27.5	0.2	0.2
HCO3	217.2	3.6	3.6
SO4	1370.0	14.3	28.5
CO3	Nil	Nil	Nil
OH	Nil	Nil	Nil
Total Anions			1437.7

Other Measurements

Measurement	Value
Total Dissolved Solids (Calculated) mg/L	83865
Total Dissolved Solids (110) mg/L	87420
Total Dissolved Solids (180) mg/L	84450
Total Dissolved Solids (at Ignition) mg/L	81780
Observed pH	7.32
H2S (25°C) mg/L	N/D
Relative Density (25°C)	1.047
Refractive Index (25°C)	1.3450
Resistivity/OHM·m (25°C)	0.137
Salinity %	8.59

Stiff Diagram (meq/L)



AGAT® Laboratories

GAS ANALYSIS

Container Identification	Previous Number	Laboratory Number
AGAT 348	04G102316F	04G103254J

Operator Name
PENGROWTH CORPORATION

Unique Well Identifier	Well Name	Elevation
14-25-063-11W5	SATELLITE 08-26-063-11W5	KB m	GRD m

Field or Area	Pool or Zone	Sampler's Company
JUDY CREEK	"A" POOL	SAME

Test Type	Test No.	Test Recovery	Name of Sampler
			RS

Test Interval or Perfs	Sampling Point
	PRODUCED GAS

	Separator	Reservoir	Source	Sampled	Received
Pressure (kPa)			1610	1610	1800
Temperature			58	58	21

Date Sampled	Date Received	Date Reported	Entered By	Certified By
Nov 18, 2004	Nov 19, 2004	Nov 29, 2004	CP	CP

Other Information

COMP	MOLE FRACTION		PETROLEUM LIQUID
	AIR FREE AS RECEIVED	AIR FREE ACID GAS FREE	mL / m³
H2	TRACE	TRACE	
He	0.0007	0.0007	
N2	0.0297	0.0302	
CO2	0.0158	0.0000	
H2S	0.0000	0.0000	
C1	0.6105	0.6204	
C2	0.2263	0.2299	
C3	0.0683	0.0694	250.8
IC4	0.0089	0.0090	38.8
NC4	0.0234	0.0238	98.5
IC5	0.0052	0.0053	25.4
NC5	0.0057	0.0058	27.6
C6	0.0031	0.0031	17.0
C7+	0.0024	0.0024	15.2
Total	1.0000	1.0000	473.3

Comparibly different from most recent sample:
H2S,C1,C2,C3,C7

GROSS HEATING VALUE MJ/m³
15° C AND 101.325 kPa

Air Free As Received	Moisture & Acid Gas Free	C7+, Air Free As Received
51.24	52.05	0.51

RELATIVE DENSITY (CALCULATED)

Moisture Free	Moisture & Acid Gas Free	C7+, Moisture Free	C7+, Portion Whole Density
0.840	0.829	3.581	0.009

PSEUDO CRITICAL PROPERTIES (CALCULATED)

As Sampled		Acid Gas Free	
pPc (abs) kPa	pTc K	pPc (abs) kPa	pTc K
4597	240.8	4552	239.8

RELATIVE MOLECULAR MASS

Total Gas	C_7^+
24.3	103.7

VAPOUR PRESSURE (Pentanes +)	H2S g/m³
89.84 kPa	0.00

AGAT® Laboratories

GAS ANALYSIS

Container Identification
AGAT 4000074

Operator Name	Previous Number	Laboratory Number
PENGROWTH CORPORATION	04G104065Y	05G141733I

Unique Well Identifier	Well Name	Elevation			
14-26-063-11W5	SATELLITE 05-35-063-11W5	KB m		GRD m	

Field or Area	Pool or Zone	Sampler's Company
JUDY CREEK	"A" POOL	SAME

Test Type	Test No.	Test Recovery	Name of Sampler

Test Interval or Perfs		Sampling Point
		PRODUCED GAS

	Separator	Reservoir	Source	Sampled	Received
Pressure (kPa)			1705	1705	1700
Temperature			27	27	21

Well License	Date Sampled	Date Received	Date Reported	Entered By	Certified By
	Oct 20, 2005	Oct 21, 2005	Nov 02, 2005	GE	GE

Other Information

COMP	MOLE FRACTION		PETROLEUM LIQUID
	AIR FREE AS RECEIVED	AIR FREE ACID GAS FREE	mL / m³
H2	0.0001	0.0001	
He	0.0015	0.0015	
N2	0.0327	0.0334	
CO2	0.0208	0.0000	
H2S	0.0000	0.0000	
C1	0.6450	0.6588	
C2	0.1812	0.1850	
C3	0.0762	0.0778	279.8
IC4	0.0083	0.0085	36.2
NC4	0.0204	0.0208	85.9
IC5	0.0039	0.0040	19.1
NC5	0.0043	0.0044	20.8
C6	0.0026	0.0027	14.3
C7+	0.0030	0.0030	19.1
Total	1.0000	1.0000	475.2

Comparibly different from most recent sample:
C1,C2,C7

GROSS HEATING VALUE MJ/m³
15º C AND 101.325 kPa

Air Free As Received	Moisture & Acid Gas Free	C7+, Air Free As Received
49.49	50.53	0.64

RELATIVE DENSITY (CALCULATED)

Moisture Free Specific Gravity	Moisture & Acid Gas Free Specific Gravity	C7+, Moisture Free
0.821	0.807	3.621

DENSITY

C7+, Portion Whole Density	C7+ Density (kg/m3)	Total Sample Density (kg/m3)
0.011	694.7	1.006

PSEUDO CRITICAL PROPERTIES (CALCULATED)

As Sampled		Acid Gas Free	
pPc (abs) kPa	pTc K	pPc (abs) kPa	pTc K
4594	235.7	4535	234.3

RELATIVE MOLECULAR MASS

Total Gas	C_7+
23.8	104.9

VAPOUR PRESSURE (Pentanes +)

81.63 kPa

H_2S g/m³

0.00

AGAT® Laboratories

GAS ANALYSIS

Container Identification
4300

Operator Name	Previous Number	Laboratory Number
PENGROWTH CORPORATION	07G240035G	08G305882F

Unique Well Identifier	Well Name	Elevation			
		KB m		GRD m	
100/14-29-063-10W5/00	ESSO UNIT JUDY 14-29-63-10				

Field or Area	Pool or Zone	Sampler's Company
JUDY CREEK	"A" POOL	SAME

Test Type	Test No.	Test Recovery	Name of Sampler

Test Interval or Perfs mKB		Sampling Point
		PRODUCED GAS

	Separator	Reservoir	Source	Sampled	Received
Pressure (kPa)			1620	1620	1
Temperature			20	20	21

Well License	Date Sampled	Date Received	Date Reported	Entered By	Certified By
0134544	Nov 18, 2008	Nov 20, 2008	Nov 28, 2008	GE	GE

Other Information

COMP	MOLE FRACTION		PETROLEUM LIQUID
	AIR FREE AS RECEIVED	AIR FREE ACID GAS FREE	mL / m³
H2	0.0003	0.0003	
He	0.0006	0.0006	
N2	0.0339	0.0344	
CO2	0.0157	0.0000	
H2S	0.0000	0.0000	
C1	0.7426	0.7546	
C2	0.1385	0.1407	0.0
C3	0.0506	0.0514	185.8
IC4	0.0043	0.0044	18.8
NC4	0.0093	0.0094	39.1
IC5	0.0015	0.0015	7.3
NC5	0.0014	0.0014	6.8
C6	0.0007	0.0007	3.8
C7+	0.0006	0.0006	4.0
Total	1.0000	1.0000	265.6

Comparibly different from most recent sample:
C1,C2,C3

GROSS HEATING VALUE MJ/m³
15° C AND 101.325 kPa

Air Free As Received	Moisture & Acid Gas Free	C7+, Air Free As Received
44.41	45.10	0.13

RELATIVE DENSITY (CALCULATED) DENSITY

Moisture Free	Moisture & Acid Gas Free	C7+, Moisture Free	C7+, Portion Whole Density	C7+ Density (kg/m3)	Total Sample Density(kg/m3)
0.728	0.715	3.783	0.002	700.8	0.891

PSEUDO CRITICAL PROPERTIES (CALCULATED)

As Sampled		Acid Gas Free	
pPc (abs) kPa	pTc K	pPc (abs) kPa	pTc K
4605.9	219.3	4561.8	218.0

RELATIVE MOLECULAR MASS

Total Gas	C_7+
21.1	109.6

VAPOUR PRESSURE (Pentanes +)

92.84 kPa

H_2S g/m³

0.00

AGAT® Laboratories

GAS ANALYSIS

Container Identification
AGAT 5004230

Operator Name	Previous Number	Laboratory Number
PENGROWTH CORPORATION	06G188481I	07G243534A

Unique Well Identifier	Well Name	Elevation			
100/14-30-063-10W5/00	ESSO UNIT JUDY 14-30-63-10	KB m		GRD m	

Field or Area	Pool or Zone	Sampler's Company
JUDY CREEK	"A" POOL	SAME

Test Type	Test No.	Test Recovery	Name of Sampler

Test Interval or Perfs mKB		Sampling Point
		PRODUCED GAS

	Separator	Reservoir	Source	Sampled	Received
Pressure (kPa)			1421	1421	1450
Temperature			40	40	21

Well License	Date Sampled	Date Received	Date Reported	Entered By	Certified By
0136578	Oct 02, 2007	Oct 04, 2007	Oct 16, 2007	GE	GE

Other Information
SATELLITE 05-32-063-10W5, ANNUAL

COMP	MOLE FRACTION		PETROLEUM LIQUID
	AIR FREE AS RECEIVED	AIR FREE ACID GAS FREE	mL / m³
H2	0.0001	0.0001	
He	0.0011	0.0011	
N2	0.0287	0.0292	
CO2	0.0166	0.0000	
H2S	0.0000	0.0000	
C1	0.6395	0.6502	
C2	0.1897	0.1929	0.0
C3	0.0700	0.0712	257.1
IC4	0.0092	0.0094	40.2
NC4	0.0244	0.0248	102.7
IC5	0.0056	0.0057	27.4
NC5	0.0064	0.0065	30.9
C6	0.0042	0.0043	23.1
C7+	0.0045	0.0046	28.9
Total	1.0000	1.0000	510.3

Comparibly different from most recent sample:
C1,C2,C7

GROSS HEATING VALUE MJ/m³
15° C AND 101.325 kPa

Air Free As Received	Moisture & Acid Gas Free	C7+, Air Free As Received
51.06	51.92	0.97

RELATIVE DENSITY (CALCULATED) DENSITY

Moisture Free	Moisture & Acid Gas Free	C7+, Moisture Free	C7+, Portion Whole Density	C7+ Density (kg/m3)	Total Sample Density(kg/m3)
0.837	0.826	3.643	0.016	695.5	1.025

PSEUDO CRITICAL PROPERTIES (CALCULATED)

As Sampled		Acid Gas Free	
pPc (abs) kPa	pTc K	pPc (abs) kPa	pTc K
4579.2	238.7	4531.8	237.6

RELATIVE MOLECULAR MASS

Total Gas	C_7+
24.2	105.5

VAPOUR PRESSURE (Pentanes +)

80.16 kPa

H_2S g/m³

0.00

AGAT® Laboratories

GAS ANALYSIS

Container Identification
AGAT #NN1

Operator Name	Laboratory Number
PENGROWTH GAS CORPORATION	99G43191O

Unique Well Identifier	Well Name	Elevation			
14-32-063-10W5	14-32 SATELLITE	KB m		GRD m	

Field or Area	Pool or Zone	Sampler's Company
JUDY CREEK	"A" POOL	SAME

Test Type	Test No.	Test Recovery	Name of Sampler
			RS

Test Interval or Perfs mKB		Sampling Point
		PRODUCED GAS

	Separator	Reservoir	Source	Sampled	Received
Pressure (kPa)			1025	1025	1100
Temperature			40	40	21

Well License	Date Sampled	Date Received	Date Reported	Entered By	Certified By
	Sep 27, 1999	Oct 01, 1999	Oct 05, 1999	PL	

Other Information

COMP	MOLE FRACTION		PETROLEUM LIQUID
	AIR FREE AS RECEIVED	AIR FREE ACID GAS FREE	mL / m³
H2	TRACE	TRACE	
He	0.0004	0.0004	
N2	0.0213	0.0216	
CO2	0.0160	0.0000	
H2S	0.0000	0.0000	
C1	0.5315	0.5403	
C2	0.3216	0.3268	
C3	0.0700	0.0711	257.1
IC4	0.0084	0.0085	36.7
NC4	0.0194	0.0197	81.6
IC5	0.0033	0.0034	16.1
NC5	0.0036	0.0037	17.4
C6	0.0023	0.0023	12.6
C7+	0.0022	0.0022	13.8
Total	1.0000	1.0000	435.3

GROSS HEATING VALUE MJ/m³
15° C AND 101.325 kPa

Air Free As Received	Moisture & Acid Gas Free
53.41	54.27

RELATIVE DENSITY (CALCULATED)

Moisture Free	Moisture & Acid Gas Free
0.867	0.857

Total Sample Density(kg/m3)
1.062

PSEUDO CRITICAL PROPERTIES (CALCULATED)

As Sampled		Acid Gas Free	
pPc (abs) kPa	pTc K	pPc (abs) kPa	pTc K
4645	250.2	4601	249.3

RELATIVE MOLECULAR MASS

Total Gas	C_7+
25.1	102.8

VAPOUR PRESSURE (Pentanes +)

83.51 kPa

H_2S g/m³

0.00

AGAT® Laboratories

GAS ANALYSIS

Container Identification
AGAT #NN1

Operator Name	Laboratory Number
PENGROWTH GAS CORPORATION	99G43191O

Unique Well Identifier	Well Name	Elevation			
14-32-063-10W5	14-32 SATELLITE	KB m		GRD m	

Field or Area	Pool or Zone	Sampler's Company
JUDY CREEK	"A" POOL	SAME

Test Type	Test No.	Test Recovery	Name of Sampler
			RS

Test Interval or Perfs		Sampling Point
		PRODUCED GAS

	Separator	Reservoir	Source	Sampled	Received
Pressure (kPa)			1025	1025	1100
Temperature			40	40	21

Well License	Date Sampled	Date Received	Date Reported	Entered By	Certified By
	Sep 27, 1999	Oct 01, 1999	Oct 05, 1999	PL	

Other Information

COMP	MOLE FRACTION		PETROLEUM LIQUID
	AIR FREE AS RECEIVED	AIR FREE ACID GAS FREE	mL / m³
H2	TRACE	TRACE	
He	0.0004	0.0004	
N2	0.0213	0.0216	
CO2	0.0160	0.0000	
H2S	0.0000	0.0000	
C1	0.5315	0.5403	
C2	0.3216	0.3268	
C3	0.0700	0.0711	257.1
IC4	0.0084	0.0085	36.7
NC4	0.0194	0.0197	81.6
IC5	0.0033	0.0034	16.1
NC5	0.0036	0.0037	17.4
C6	0.0023	0.0023	12.6
C7+	0.0022	0.0022	13.8
Total	1.0000	1.0000	435.3

GROSS HEATING VALUE MJ/m³
15° C AND 101.325 kPa

Air Free As Received	isture & Acid Gas Free
53.41	54.27

RELATIVE DENSITY (CALCULATED)

Moisture Free	Moisture & Acid Gas Free
0.867	0.857

Total Sample Density(kg/m3)
1.062

PSEUDO CRITICAL PROPERTIES (CALCULATED)

As Sampled		Acid Gas Free	
pPc (abs) kPa	pTc K	pPc (abs) kPa	pTc K
4645	250.2	4601	249.3

RELATIVE MOLECULAR MASS

Total Gas	C_7+
25.1	102.8

VAPOUR PRESSURE (Pentanes +)

83.51 kPa

H_2S g/m³

0.00

ProTrend

C7+ Gas Analysis Report

Pengrowth Corporation

Sample Point Code	Sample Point Name	Sample Point Location
13104G	Pengrowth Judy Creek 16-35-063-11W5 Gas Prod	16-35-063-11W5

Associated Well Location	GR Elev(m)	KB Elev(m)	License #	Pool/Zone
00/16-35-063-11W5/00	1,032.70	1,036.30		Beaverhill Lake A

Source Laboratory	Lab File No	Container Identity	Sampler
Core Laboratories Canada	1488-52136-10-1	V0011803	Pengrowth

District	Area Name	Field Name	Facility Name
Swan Hills Trend	Judy Creek	Judy Creek	Pengrowth Judy Creek 2 11-06-064-10W5 MWE

Operator	Analyst	Date Sampled	Date Received	Date Reported
Pengrowth Corporation	CR	Dec 1, 2010	Dec 3, 2010	Dec 14, 2010

Intervals (m)	Gas Rate E³m³d	Press kPa @ Temp °C Source Conditions	Press kPa @ Temp °C Container When Sampled	Press kPa @ Temp °C Container When Received
2,601.6 - 2,631.0		1450 @ 50		1386 @ 22
-	Oil Rate m³d			
-	Water Rate m³d	Pengrowth Judy Creek 16-35-063-11W5 (Well Name)	Gas Product at 8-35 (Lab Source Description)	

Component	Mol Fraction	Liquid Recovery L/1000m³
H2	0.0001	
He	0.0006	
N2	0.0262	
CO2	0.0150	
H2S	0.0002	
C1	0.6183	
C2	0.2453	871.7
C3	0.0484	177.9
IC4	0.0066	28.8
NC4	0.0182	76.6
IC5	0.0047	22.9
NC5	0.0057	27.6
C6	0.0046	25.3
C7	0.0061	37.6
TOTAL	1.0000	1,268.3

ProTrend Calculated Total Sample Properties

Calculated at standard conditions 101.325 kPa & 15.0°C

Density kg/m³	Relative Density	Molecular Mass
1.016	0.8293	24.0

Gross Heating Value MJ/m³	Pseudo Critical Press kPa (Abs)	Pseudo Critical Temp K
50.94	4,603.3	239.6

H2S PPM	H2S Method
200.00	Other

Observed C7+ Sample Properties

Density kg/m³ (Liq)	Relative Density (Gas)	Molecular Mass
738.800		98.1

PROTREND STATUS:
Passed By Validator

DATA SOURCE:
Imported

PASSED BY VALIDATOR REASON:
Close enough to be considered reasonable.

VALIDATOR COMMENTS:
ok

Source	Date	Notes
CORE Laboratories	Dec 14, 2010	H2S determined in the field = 200 ppm

Pengrowth Corporation

Sample Point Code	Sample Point Name	Sample Point Location
12833G	Pengrowth Judy Creek 06-36-063-11W5 Gas Prod	06-36-063-11W5

Associated Well Location	GR Elev(m)	KB Elev(m)	License #	Pool/Zone
00/06-36-063-11W5/00	1,005.00	1,011.80		Beaverhill Lake A

Source Laboratory	Lab File No	Container Identity	Sampler
Core Laboratories Canada	0111-52136-11-4	V0001020	Pengrowth

District	Area Name	Field Name	Facility Name
Swan Hills Trend	Judy Creek	Judy Creek	Pengrowth Judy Creek 2 11-06-064-10W5 MWE

Operator	Analyst	Date Sampled	Date Received	Date Reported
Pengrowth Corporation	MF	Jan 20, 2011	Jan 28, 2011	Feb 1, 2011

Intervals (m)	Gas Rate E³m³d	Press kPa @ Temp °C Source Conditions	Press kPa @ Temp °C Container When Sampled	Press kPa @ Temp °C Container When Received
2,563.0 - 2,586.0		1570 @ 63		1404 @ 22
-	Oil Rate m³d			
-	Water Rate m³d	Pengrowth Judy Creek 06-36-063-11W5 (Well Name)	08-35-63-11 Satellite (Lab Source Description)	

Component	Mol Fraction	Liquid Recovery L/1000m³
H2	0.0000	
He	0.0004	
N2	0.0381	
CO2	0.0153	
H2S	0.0004	
C1	0.5215	
C2	0.3179	1,129.7
C3	0.0527	193.7
IC4	0.0077	33.6
NC4	0.0212	89.2
IC5	0.0055	26.8
NC5	0.0066	31.9
C6	0.0053	29.1
C7	0.0074	45.6
TOTAL	1.0000	1,579.6

ProTrend Calculated Total Sample Properties
Calculated at standard conditions 101.325 kPa & 15.0°C

Density kg/m³	Relative Density	Molecular Mass
1.089	0.8889	25.7

Gross Heating Value MJ/m³	Pseudo Critical Press kPa (Abs)	Pseudo Critical Temp K
53.68	4,600.8	250.2

H2S PPM	H2S Method
400.00	Other

Observed C7+ Sample Properties

Density kg/m³ (Liq)	Relative Density (Gas)	Molecular Mass
734.800		98.7

PROTREND STATUS:
Passed By Validator

DATA SOURCE:
Imported

PASSED BY VALIDATOR REASON:
Operating conditions have changed, analysis change expected

VALIDATOR COMMENTS:
Resample consistent with previous failed sample suggesting change in operating conditions.

Source	Date	Notes
CORE Laboratories	Feb 1, 2011	H2S determined in the field = 400 ppm

Pengrowth Corporation

Sample Point Code	Sample Point Name	Sample Point Location
12886G	Pengrowth Judy Creek 08-35-063-11W5 Gas Prod	08-35-063-11W5

Associated Well Location	GR Elev(m)	KB Elev(m)	License #	Pool/Zone
00/08-35-063-11W5/00	1,035.50	1,042.30		Beaverhill Lake A

Source Laboratory	Lab File No	Container Identity	Sampler
Core Laboratories Canada	0111-52136-11-3	V0007966	Pengrowth

District	Area Name	Field Name	Facility Name
Swan Hills Trend	Judy Creek	Judy Creek	Pengrowth Judy Creek 2 11-06-064-10W5 MWE

Operator	Analyst	Date Sampled	Date Received	Date Reported
Pengrowth Corporation	CR	Jan 19, 2011	Jan 28, 2011	Feb 1, 2011

Intervals (m)	Gas Rate E³m³d	Press kPa @ Temp °C Source Conditions	Press kPa @ Temp °C Container When Sampled	Press kPa @ Temp °C Container When Received
2,595.0 - 2,640.5		1470 @ 70		1317 @ 22
-	Oil Rate m³d			
-	Water Rate m³d	Well Name: Pengrowth Judy Creek 08-35-063-11W5	Lab Source Description: 8-35-63-11 Satellite	

Component	Mol Fraction	Liquid Recovery L/1000m³
H2	0.0000	
He	0.0004	
N2	0.0214	
CO2	0.0149	
H2S	0.0004	
C1	0.5205	
C2	0.3063	1,088.5
C3	0.0558	205.0
IC4	0.0087	38.0
NC4	0.0254	106.9
IC5	0.0082	40.0
NC5	0.0108	52.3
C6	0.0107	58.7
C7	0.0165	101.6
TOTAL	1.0000	1,691.0

ProTrend Calculated Total Sample Properties
Calculated at standard conditions 101.325 kPa & 15.0°C

Density kg/m³	Relative Density	Molecular Mass
1.151	0.9393	27.2

Gross Heating Value MJ/m³	Pseudo Critical Press kPa (Abs)	Pseudo Critical Temp K
57.71	4,575.0	258.7

H2S PPM	H2S Method
350.00	Other

Observed C7+ Sample Properties

Density kg/m³ (Liq)	Relative Density (Gas)	Molecular Mass
737.600		99.3

PROTREND STATUS:
Passed By Validator

DATA SOURCE:
Imported

PASSED BY VALIDATOR REASON:
Operating conditions have changed, analysis change expected

VALIDATOR COMMENTS:
Resample is consistent with previous failed sample suggesting operating condition change

Source	Date	Notes
CORE Laboratories	Feb 1, 2011	H2S determined in the field = 350 ppm

AGAT® Laboratories

HYDROCARBON LIQUID ANALYSIS

Container Identification	Laboratory Number
PB1	04C85999A

Operator Name
PENGROWTH CORPORATION

Unique Well Identifier	Well Name	Elevation			
NOT AVAILABLE		KB m		GRD m	

Field or Area	Pool or Zone	Sampler's Company
	NOT APPLICABLE	SAME

Test Type	Test No.	Test Recovery	Name of Sampler

Test Interval or Perfs		Sampling Point

	Separator	Reservoir	Source	Sampled	Received
Pressure (kPa)					
Temperature					

Date Sampled	Date Received	Date Reported	Entered By	Certified By
Jun 08, 2004	Jun 10, 2004	Jun 17, 2004	CT	ES

Other Information
TIME:22:00hrs . SP: A AND B POOL QUENCH OIL

Note: Sampling Point, Unique Well Identifier and/or Pool or Zone information was unavailable at time of reporting. This information is integral to AGAT's WebFLUIDs, a comparison, history and trending analysis system.

COMP.	MOLE FRACTION	MASS FRACTION	VOLUME FRACTION
N2	0.0000	0.0000	0.0000
CO2	0.0000	0.0000	0.0000
H2S	0.0000	0.0000	0.0000
C1	0.0000	0.0000	0.0000
C2	0.0032	0.0006	0.0013
C3	0.0099	0.0026	0.0041
IC4	0.0093	0.0032	0.0046
NC4	0.0327	0.0112	0.0156
IC5	0.0231	0.0098	0.0128
NC5	0.0290	0.0123	0.0159
C6	0.0540	0.0269	0.0330
C7+	0.8388	0.9334	0.9127
TOTAL	1.0000	1.0000	1.0000

Observed Properties of C7+ Residue (15/15° C)

Density	Relative Density	API @ 15°
836.3 kg/m³	0.8371	37.5

Relative Molecular Mass
189.4

Calculated Properties of Total Sample (15/15° C)

Density	Relative Density	API @ 15°
817.6 kg/m³	0.8183	41.4

Relative Molecular Mass	Gas Equivalency
170.2	113.6

Calculations for C6 and C7 are based on Boiling Point Grouping. If Carbon Number Grouping had been done, the mole fractions would be (C6: 0.1077) (C7+:0.7851)

AGAT® Laboratories

PROPERTIES OF C6+ FRACTION

File No.	Company	UWI / LSD
04C85999A	PENGROWTH CORPORATION	NOT AVAILABLE

BOILING POINT RANGE (C)	COMPONENT		MOLE FRACTION	MASS FRACTION	VOLUME FRACTION
36.1 - 68.9	HEXANES	C6	0.0498	0.0252	0.0311
68.9 - 98.3	HEPTANES	C7	0.1136	0.0852	0.0911
98.3 - 125.6	OCTANES	C8	0.1242	0.1062	0.1106
125.6 - 150.6	NONANES	C9	0.0988	0.0948	0.0967
150.6 - 173.9	DECANES	C10	0.0723	0.0770	0.0772
173.9 - 196.1	UNDECANES	C11	0.0512	0.0599	0.0594
196.1 - 215.0	DODECANES	C12	0.0397	0.0506	0.0495
215.0 - 235.0	TRIDECANES	C13	0.0298	0.0411	0.0399
235.0 - 252.2	TETRADECANES	C14	0.0244	0.0362	0.0348
252.2 - 270.6	PENTADECANES	C15	0.0271	0.0431	0.0411
270.6 - 287.8	HEXADECANES	C16	0.0159	0.0269	0.0255
287.8 - 302.8	HEPTADECANES	C17	0.0159	0.0287	0.0270
302.8 - 317.2	OCTADECANES	C18	0.0112	0.0214	0.0201
317.2 - 330.0	NONADECANES	C19	0.0090	0.0181	0.0169
330.0 - 344.4	EICOSANES	C20	0.0075	0.0159	0.0148
344.4 - 357.2	HENEICOSANES	C21	0.0061	0.0135	0.0125
357.2 - 369.4	DOCOSANES	C22	0.0045	0.0104	0.0096
369.4 - 380.0	TRICOSANES	C23	0.0042	0.0101	0.0093
380.0 - 391.1	TETRACOSANES	C24	0.0028	0.0072	0.0066
391.1 - 401.7	PENTACOSANES	C25	0.0019	0.0049	0.0045
401.7 - 412.2	HEXACOSANES	C26	0.0016	0.0044	0.0040
412.2 - 422.2	HEPTACOSANES	C27	0.0012	0.0033	0.0030
422.2 - 431.7	OCTACOSANES	C28	0.0003	0.0010	0.0009
431.7 - 441.1	NONACOSANES	C29	0.0002	0.0007	0.0006
441.1 - PLUS	TRIACONTANES	C30+	0.0189	0.0597	0.0541

BOILING POINT RANGE (C)	Aromatics		MOLE FRACTION	MASS FRACTION	VOLUME FRACTION
80.0	BENZENE	C6	0.0009	0.0005	0.0004
110.6	TOLUENE	C7	0.0178	0.0123	0.0104
136.2	ETHYLBENZENE	C8	0.0038	0.0030	0.0025
138.4 - 144.4	XYLENES	C8	0.0188	0.0149	0.0126
168.9	1,2,4 TRIMETHYLBENZENE	C9	0.0208	0.0187	0.0158

BOILING POINT RANGE (C)	Naphthenes		MOLE FRACTION	MASS FRACTION	VOLUME FRACTION
48.9	CYCLOPENTANE	CC5	0.0042	0.0017	0.0019
72.2	METHYLCYCLOPENTANE	MCC5	0.0337	0.0212	0.0205
81.1	CYCLOHEXANE	CC6	0.0191	0.0120	0.0113
101.1	METHYLCYCLOHEXANE	MCC6	0.0416	0.0306	0.0293

The above hexanes plus values are based upon a measured mass fraction and a calculated mole fraction, and assume a total hydrocarbon recovery from the chromatographic system.

AGAT® Laboratories

OIL ANALYSIS

Container Identification	Laboratory Number
PB1	04O85999A

Operator Name
PENGROWTH CORPORATION

Unique Well Identifier	Well Name	Elevation			
Not Available		KB m		GRD m	

Field or Area	Pool or Zone	Sampler's Company
	NOT AVAILABLE	SAME

Test Type	Test No.	Test Recovery	Name of Sampler

Test Interval or Perfs		Sampling Point

	Separator	Reservoir	Source	Sampled	Received
Pressure (kPa)					
Temperature					

Date Sampled	Date Received	Date Reported	Entered By	Certified By
Jun 08, 2004	Jun 10, 2004	Jun 18, 2004	EC	ES

Other Information
TIME:22:00hrs, SP: A AND B POOL QUENCH OIL

Note: Sampling Point, Unique Well Identifier and/or Pool or Zone information was unavailable at time of reporting. This information is integral to AGAT's WebFLUIDs, a comparison, history and trending analysis system.

Sample Properties

B.S.& W. (Volume Fraction)

Water	Sediment	Total
Trace	0.006	0.006

Free Sediment
1.00 vol %

Density - After Cleaning

API Gravity @ 15°C	Relative	Absolute kg/m³
41.10	0.8198	819.1

Total Sulphur Mass Fraction
0.00178

Viscosity

Temp °C	Absolute mPa°s	Kinematic mm²°s-1
25	2.44	3.00
38	1.85	2.30
50	1.47	1.85

Distillation

Characterization Factor
11.9

Other Comments:

BS&W performed on oil portion only.

AGAT® Laboratories

WATER ANALYSIS

Container Identification	Laboratory Number
PB2B	04W085999B

Operator Name
PENGROWTH CORPORATION

Unique Well Identifier	Well Name	Elevation			
		KB m		GRD m	

Field or Area	Pool or Zone	Sampler's Company
	NOT APPLICABLE	SAME

Test Type	Test No.	Test Recovery	Name of Sampler
		SP:7-6 PWIP DISCHARGE PUMP P4E	

Test Interval or Perfs		Sampling Point
		DISCHARGE PUMP

	Separator	Reservoir	Source	Sampled	Received
Pressure (kPa)					
Temperature					

Date Sampled	Date Received	Date Reported	Entered By	Certified By
Jun 08, 2004	Jun 10, 2004	Jun 14, 2004	LN	LN

Other Information

Cations

ION	mg/L	Mass Fraction	mmol/L
Na	20734.0	0.328	901.9
K	339.0	0.005	8.7
Ca	1550.0	0.025	38.7
Mg	241.0	0.004	9.9
Fe	0.2	TRACE	TRACE
Total Cations			1007.7

Anions

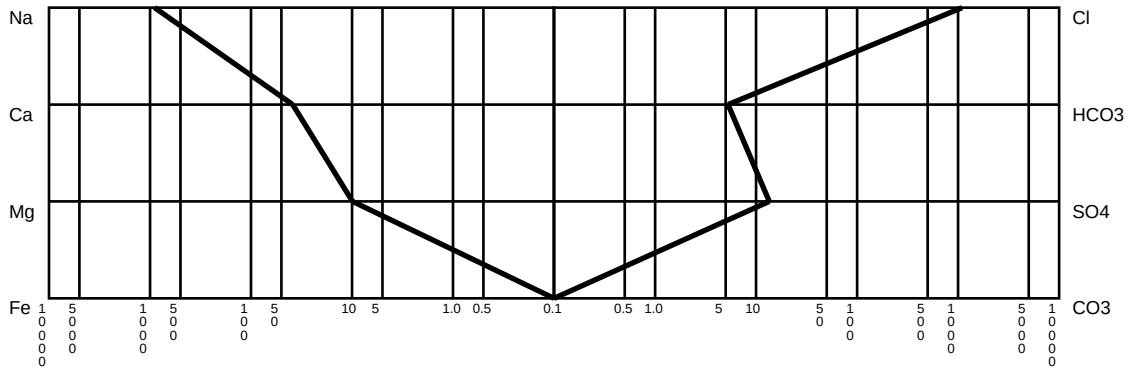
ION	mg/L	Mass Fraction	mmol/L
Cl	38738.0	0.613	1092.7
HCO3	322.1	0.005	5.3
SO4	1298.5	0.021	13.5
CO3	Nil	Nil	Nil
OH	Nil	Nil	Nil
Total Anions			1125.0

Other Measurements

Measurement	Value
Total Dissolved Solids (Calculated) mg/L	63222
Observed pH	7.30
H2S (25°C) mg/L	N/D
Relative Density (25°C)	1.046
Resistivity/OHM·m (25°C)	0.145
Salinity %	6.69

Total Dissolved Solid= 68200 mg/L.
Volatlie Dissolved Solid= 66900 mg/L.

Logarithmic Pattern mmol/L



AGAT® Laboratories

HYDROCARBON LIQUID ANALYSIS

Container Identification	Laboratory Number
PB1	04C85999A

Operator Name
PENGROWTH CORPORATION

Unique Well Identifier	Well Name	Elevation			
NOT AVAILABLE		KB m		GRD m	

Field or Area	Pool or Zone	Sampler's Company
	NOT APPLICABLE	SAME

Test Type	Test No.	Test Recovery	Name of Sampler

Test Interval or Perfs		Sampling Point

	Separator	Reservoir	Source	Sampled	Received
Pressure (kPa)					
Temperature					

Date Sampled	Date Received	Date Reported	Entered By	Certified By
Jun 08, 2004	Jun 10, 2004	Jun 17, 2004	CT	ES

Other Information
TIME:22:00hrs . SP: A AND B POOL QUENCH OIL

Note: Sampling Point, Unique Well Identifier and/or Pool or Zone information was unavailable at time of reporting. This information is integral to AGAT's WebFLUIDs, a comparison, history and trending analysis system.

COMP.	MOLE FRACTION	MASS FRACTION	VOLUME FRACTION
N2	0.0000	0.0000	0.0000
CO2	0.0000	0.0000	0.0000
H2S	0.0000	0.0000	0.0000
C1	0.0000	0.0000	0.0000
C2	0.0032	0.0006	0.0013
C3	0.0099	0.0026	0.0041
IC4	0.0093	0.0032	0.0046
NC4	0.0327	0.0112	0.0156
IC5	0.0231	0.0098	0.0128
NC5	0.0290	0.0123	0.0159
C6	0.0540	0.0269	0.0330
C7+	0.8388	0.9334	0.9127
TOTAL	1.0000	1.0000	1.0000

Observed Properties of C7+ Residue (15/15° C)

Density	Relative Density	API @ 15°
836.3 kg/m³	0.8371	37.5

Relative Molecular Mass
189.4

Calculated Properties of Total Sample (15/15° C)

Density	Relative Density	API @ 15°
817.6 kg/m³	0.8183	41.4

Relative Molecular Mass	Gas Equivalency
170.2	113.6

Calculations for C6 and C7 are based on Boiling Point Grouping. If Carbon Number Grouping had been done, the mole fractions would be (C6: 0.1077) (C7+:0.7851)

AGAT® Laboratories

PROPERTIES OF C6+ FRACTION

File No.	Company	UWI / LSD
04C85999A	PENGROWTH CORPORATION	NOT AVAILABLE

BOILING POINT RANGE (C)	COMPONENT		MOLE FRACTION	MASS FRACTION	VOLUME FRACTION
36.1 - 68.9	HEXANES	C6	0.0498	0.0252	0.0311
68.9 - 98.3	HEPTANES	C7	0.1136	0.0852	0.0911
98.3 - 125.6	OCTANES	C8	0.1242	0.1062	0.1106
125.6 - 150.6	NONANES	C9	0.0988	0.0948	0.0967
150.6 - 173.9	DECANES	C10	0.0723	0.0770	0.0772
173.9 - 196.1	UNDECANES	C11	0.0512	0.0599	0.0594
196.1 - 215.0	DODECANES	C12	0.0397	0.0506	0.0495
215.0 - 235.0	TRIDECANES	C13	0.0298	0.0411	0.0399
235.0 - 252.2	TETRADECANES	C14	0.0244	0.0362	0.0348
252.2 - 270.6	PENTADECANES	C15	0.0271	0.0431	0.0411
270.6 - 287.8	HEXADECANES	C16	0.0159	0.0269	0.0255
287.8 - 302.8	HEPTADECANES	C17	0.0159	0.0287	0.0270
302.8 - 317.2	OCTADECANES	C18	0.0112	0.0214	0.0201
317.2 - 330.0	NONADECANES	C19	0.0090	0.0181	0.0169
330.0 - 344.4	EICOSANES	C20	0.0075	0.0159	0.0148
344.4 - 357.2	HENEICOSANES	C21	0.0061	0.0135	0.0125
357.2 - 369.4	DOCOSANES	C22	0.0045	0.0104	0.0096
369.4 - 380.0	TRICOSANES	C23	0.0042	0.0101	0.0093
380.0 - 391.1	TETRACOSANES	C24	0.0028	0.0072	0.0066
391.1 - 401.7	PENTACOSANES	C25	0.0019	0.0049	0.0045
401.7 - 412.2	HEXACOSANES	C26	0.0016	0.0044	0.0040
412.2 - 422.2	HEPTACOSANES	C27	0.0012	0.0033	0.0030
422.2 - 431.7	OCTACOSANES	C28	0.0003	0.0010	0.0009
431.7 - 441.1	NONACOSANES	C29	0.0002	0.0007	0.0006
441.1 - PLUS	TRIACONTANES	C30+	0.0189	0.0597	0.0541

BOILING POINT RANGE (C)	Aromatics		MOLE FRACTION	MASS FRACTION	VOLUME FRACTION
80.0	BENZENE	C6	0.0009	0.0005	0.0004
110.6	TOLUENE	C7	0.0178	0.0123	0.0104
136.2	ETHYLBENZENE	C8	0.0038	0.0030	0.0025
138.4 - 144.4	XYLENES	C8	0.0188	0.0149	0.0126
168.9	1,2,4 TRIMETHYLBENZENE	C9	0.0208	0.0187	0.0158

BOILING POINT RANGE (C)	Naphthenes		MOLE FRACTION	MASS FRACTION	VOLUME FRACTION
48.9	CYCLOPENTANE	CC5	0.0042	0.0017	0.0019
72.2	METHYLCYCLOPENTANE	MCC5	0.0337	0.0212	0.0205
81.1	CYCLOHEXANE	CC6	0.0191	0.0120	0.0113
101.1	METHYLCYCLOHEXANE	MCC6	0.0416	0.0306	0.0293

The above hexanes plus values are based upon a measured mass fraction and a calculated mole fraction, and assume a total hydrocarbon recovery from the chromatographic system.

AGAT® Laboratories

OIL ANALYSIS

Container Identification	Laboratory Number
PB1	04O85999A

Operator Name
PENGROWTH CORPORATION

Unique Well Identifier	Well Name	Elevation			
Not Available		KB m		GRD m	

Field or Area	Pool or Zone	Sampler's Company
	NOT AVAILABLE	SAME

Test Type	Test No.	Test Recovery	Name of Sampler

Test Interval or Perfs		Sampling Point

	Separator	Reservoir	Source	Sampled	Received
Pressure (kPa)					
Temperature					

Date Sampled	Date Received	Date Reported	Entered By	Certified By
Jun 08, 2004	Jun 10, 2004	Jun 18, 2004	EC	ES

Other Information
TIME:22:00hrs, SP: A AND B POOL QUENCH OIL

Note: Sampling Point, Unique Well Identifier and/or Pool or Zone information was unavailable at time of reporting. This information is integral to AGAT's WebFLUIDs, a comparison, history and trending analysis system.

Sample Properties

B.S.& W. (Volume Fraction)

Water	Sediment	Total
Trace	0.006	0.006

Free Sediment
1.00 vol %

Density - After Cleaning

API Gravity @ 15°C	Relative	Absolute kg/m³
41.10	0.8198	819.1

Total Sulphur Mass Fraction
0.00178

Viscosity

Temp °C	Absolute mPa°s	Kinematic mm²°s-1
25	2.44	3.00
38	1.85	2.30
50	1.47	1.85

Distillation

Characterization Factor
11.9

Other Comments:

BS&W performed on oil portion only.

AGAT® Laboratories

WATER ANALYSIS

Container Identification	Laboratory Number
PB2B	04W085999B

Operator Name
PENGROWTH CORPORATION

Unique Well Identifier	Well Name	Elevation			
		KB m		GRD m	

Field or Area	Pool or Zone	Sampler's Company
	NOT APPLICABLE	SAME

Test Type	Test No.	Test Recovery	Name of Sampler
		SP:7-6 PWIP DISCHARGE PUMP P4E	

Test Interval or Perfs		Sampling Point
		DISCHARGE PUMP

	Separator	Reservoir	Source	Sampled	Received
Pressure (kPa)					
Temperature					

Date Sampled	Date Received	Date Reported	Entered By	Certified By
Jun 08, 2004	Jun 10, 2004	Jun 14, 2004	LN	LN

Other Information

Cations

ION	mg/L	Mass Fraction	mmol/L
Na	20734.0	0.328	901.9
K	339.0	0.005	8.7
Ca	1550.0	0.025	38.7
Mg	241.0	0.004	9.9
Fe	0.2	TRACE	TRACE
Total Cations			1007.7

Anions

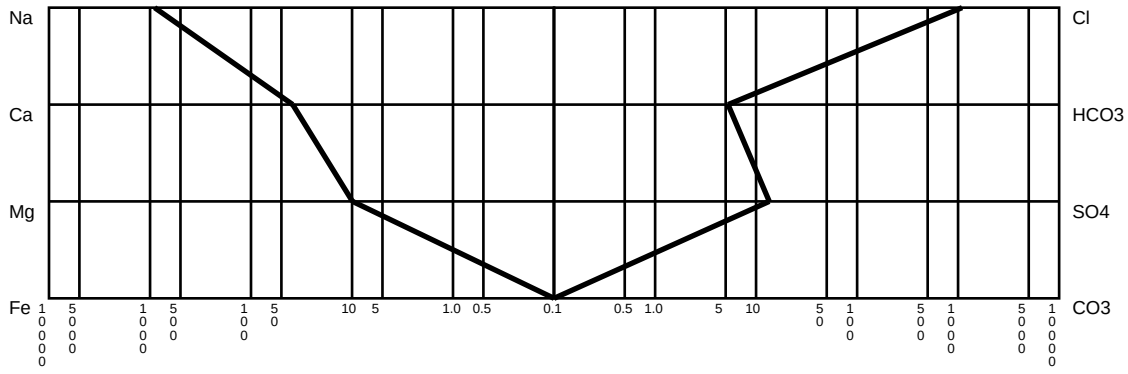
ION	mg/L	Mass Fraction	mmol/L
Cl	38738.0	0.613	1092.7
HCO3	322.1	0.005	5.3
SO4	1298.5	0.021	13.5
CO3	Nil	Nil	Nil
OH	Nil	Nil	Nil
Total Anions			1125.0

Other Measurements

Measurement	Value
Total Dissolved Solids (Calculated) mg/L	63222
Observed pH	7.30
H2S (25°C) mg/L	N/D
Relative Density (25°C)	1.046
Resistivity/OHM·m (25°C)	0.145
Salinity %	6.69

Total Dissolved Solid= 68200 mg/L.
Volatlie Dissolved Solid= 66900 mg/L.

Logarithmic Pattern mmol/L



Appendix 4

Extracts from Construction Binder

200608025

WESTERN FIBERGLASS PIPE SALES LTD.

STAR MATERIAL Q.C. REPORT

Red Deer (403) 347-4682
Estevan (306) 634-4950
www.westernfiberglass.net

PROJECT: Size 8" Star 1250 series 2987 meters
CONSTRUCTION DATES: Jan. 15 to Feb. 13 2007
CUSTOMER: Pengrowth Corporation
AREA: Judy Creek Ab.
CONTACT: Randy Sutherland
LOCATION: 8-35 to 13-36-63-11 W5
TELEPHONE NO: (780) 333-7232
FIELD CONTACT: Troy Schnurer
FAX NO: (780) 333-7115
CONTRACTOR: Flint

MATERIAL AND PRODUCT INFORMATION:

THREAD SIZE	DESCRIPTION	MAX. OPER. TEMP.	MAX. TEST PRESSURE
8-5/8"	Star Aliphatic Amine 8rd. thread line pipe	93 C	8612 KPA
	(mm) ID-74.7 OD-85.9 WT-5.6 MIN/WT-5.04		
8-5/8"	Flanges Aliphatic Amine 8rd. thread ansi 300/600	93 C	8612 KPA
8-5/8"	Fittings Aliphatic Amine 8rd. thread	93 C	8612 KPA
8-5/8"	Pup Joints Aliphatic Amine 8rd. thread	93 C	8612 KPA
	Bolt up (studs B7M nuts 2HM Gaskets flex .316		
	Thread Sealant Jet Lube STARtec		
	Tracer wire #10 poly coated copper		

GENERAL STATEMENTS:

All complete prefabricated fiberglass spools have been tested to the factory recommended maximum test pressures for a minimum of 4 hours at Western Fiberglass / Red Deer, Alberta; In accordance with CSA Z-66.2 and will be accompanied by a copy of the pressure gage calibration test certificate.

Any field fabrication, alterations or incomplete spools will be documented in the accompanying Quality Control Drawings and may be (re) pressure tested on location if requested by the customer.

All Western Fiberglass Manufactured fiberglass pup joints are pressure tested to the maximum allowed pressure at Western Fiberglass and will be accompanied by a Pup Joint Quality Control Sheet.

Please call me if you have any questions or concerns.
Sincerely,

Allan Mack
Western Fiberglass Pipe Sales Ltd.

WESTERN FIBERGLASS PIPE SALES LTD.

PIPELINE ISTALLATION Q.C. REPORT

Red Deer (403) 347-4682
Estevan (306) 634-4950
www.westernfiberglass.net

CUSTOMER: Pengrowth AREA: Judy Creek DATE (M/D/Y): Jan 17/07
LOCATION (FROM): 13-36-63-11 LOCATION (TO): 8-35-63-11 CONTRACTOR: Flint.

	SIZE (INCH)	SERIES	TEST PRESSURE (PSI)	BRAND
PIPE:	8 5/8	1250	1250	Star.

JOINT NUMBER	THREAD STANDOFF	QUALITY CONTROL SUPERVISER	COMMENTS
151 A	2	Corey Clark	8 5/8 1250 Star to 8 5/8 1250 Star.
152 A			
153 A			bore through beaver dam
154 A			
155 A			
156 A			- connections
157 A			150A - 161A
158 A			in casing
159 A			
160 A			
161 A			- in 12" casing
162 A			
163 A			
164 A			
165 A			
166 A			
167 A			
168 A			
169 A			
170 A			
171 A			8 5/8 1250 Star to 15' pup
172 A			15' pup to coupling
173 A			coupling to 6' pup (04-117)
174 A			6' pup to 90° elbow 1250#
175 A			90° elbow to 9' pup (05-08)
176 A			9' pup to 8" 300 flange

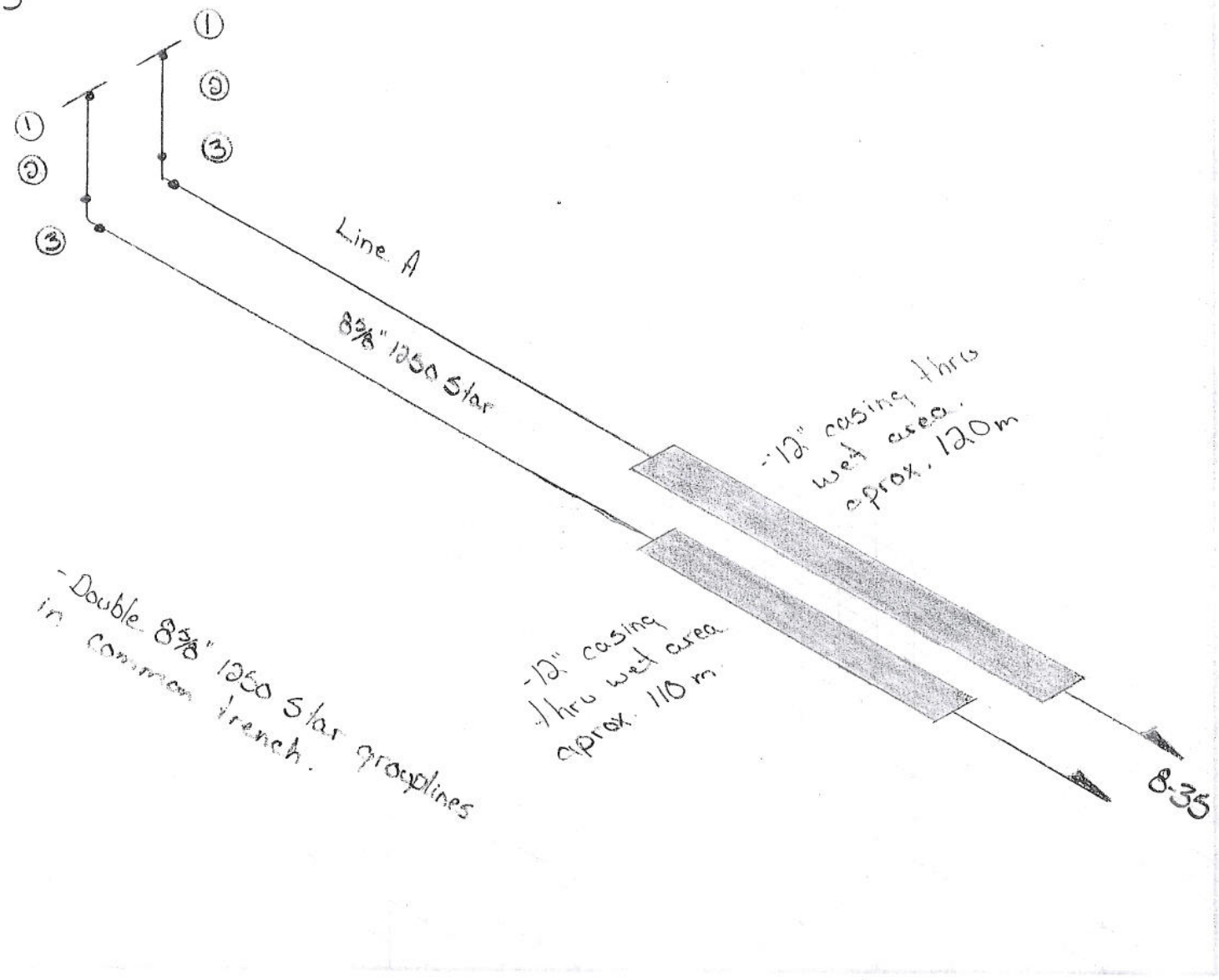
FAILER RISER - A.T.

WESTERN FIBERGLASS PIPE SALES LTD.

ESTEVAN, SK (306) 634-4950 RED DEER, AB (403) 347-4682
www.westernfiberglass.net

CUSTOMER: Pengrowth	AREA: Judy Creek	LOCATION: 13-36-63-11			PROJ./JOB #:
DATE: Jan 17/07	ISO #: 1	SPOOL #:	BONDER (1):		CODE #:
INSPECTED: Corey Clark	EPOXY USED:		BONDER (2):		CODE #:

13-36-63-11



MATERIAL			
#	QTY.	SIZE	TYPE
1	2	8"	300 flang
2	2	8⅝"	5' pup
3	2	8⅝"	90° elbow 1350
4			
5			
6			
7			
8			
9			
10			
11			
12			
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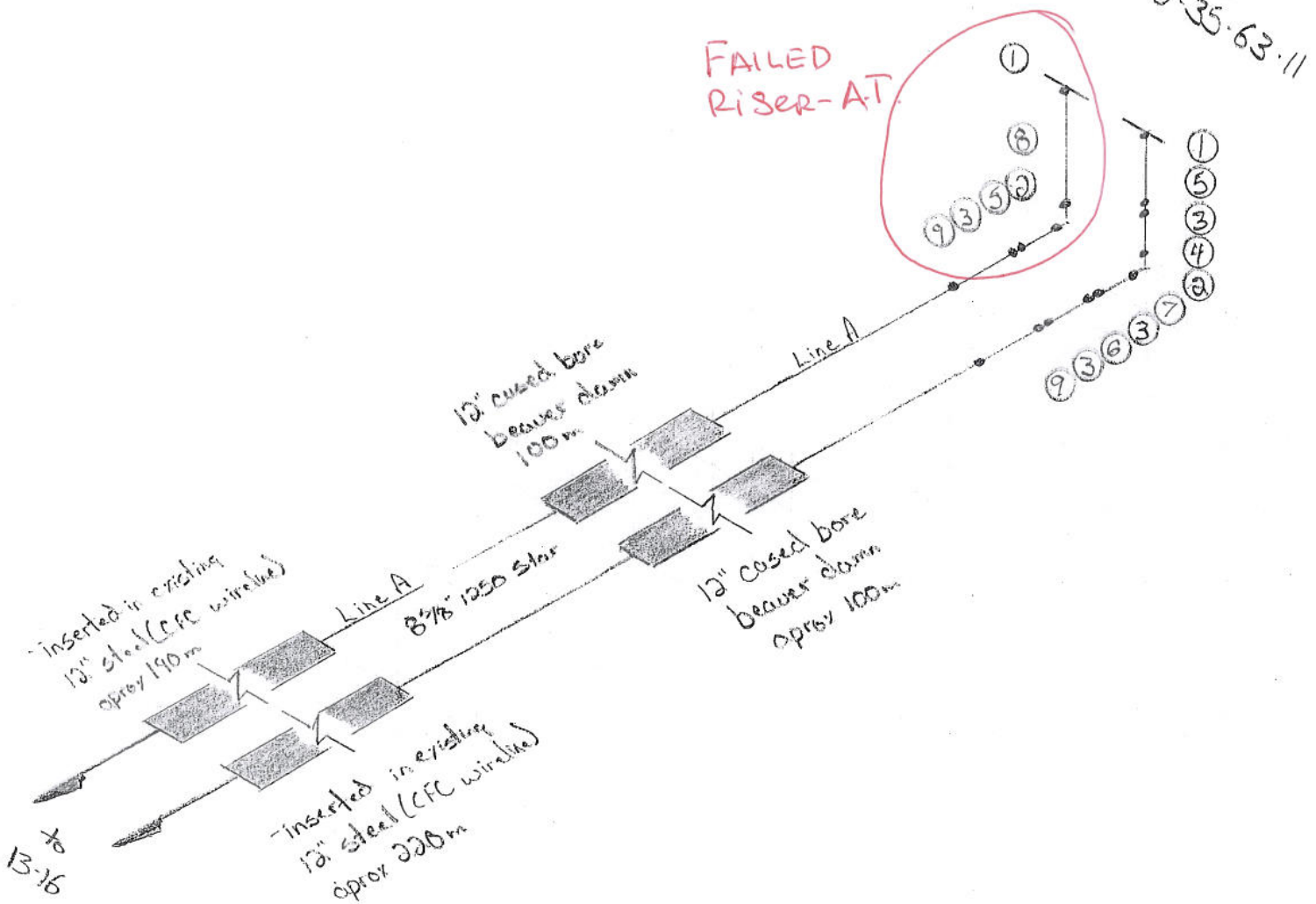
WESTERN FIBERGLASS PIPE SALES LTD.

ESTEVAN, SK (306) 634-4950 RED DEER, AB (403) 347-4682
www.westernfiberglass.net

CUSTOMER: Pengrowth	AREA: Judy Creek	LOCATION: 8-35-63-11	PROJ./JOB #:	
DATE: June 17/07	ISO #: 2	SPOOL #:	BONDER (1):	CODE #:
INSPECTED: Corey Clark	EPOXY USED:		BONDER (2):	CODE #:

8-35-63-11



MATERIAL			
#	QTY.	SIZE	TYPE
1	2	8"	300 Flange
2	2	8 5/8"	90° elbow 1250
3	4	"	couplings
4	1	"	3' pup
5	2	"	6' pup
6	1	"	7' pup
7	1	"	8' pup
8	1	"	9' pup
9	2	"	12' pup
10			
11			
12			
13			
14			
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36			

Appendix 5

Sequence of Events at Time of Incident

Attendees:	Ken Workman	Warren Hill	Jeff Whatmore
	Norm Bachand	Shawn Ryan	Pat Gaultier
	Don Craig	Kris McPherson	John Hestermann
	Kaila Lewis	Randy Trofimuk	David MacLeod
	Shelley MacLean	Carolyn Thomas	Dale Babiak

- **11:30** – power outage: 6-35 Atco substation voltage regulator failure – south A & B pool affected by power as well as main facility 7-6 PC and miscible
- **11:35** - Field shutdowns were sent - equipment that had power out would have never seen the remote shutdown (about 50% of wells did not shutdown with the remote s/d in the north loop) they were manually shut-in
- **11:40** - PC blocked in the inlets to deal with high level of the process vessels
- **11:45** - PC ESD due to low instrument air
- In holding pattern until power came on about 2:30
- **2:30** - power was restored,
- **2:30** - getting rid of high levels in inlet separator
- **4:00** - opening up inlets smoke was seen from the CCR
- **4:15** - Randy Trofimuk arrived at 8-35 to determine if there was a failure – there were flames 30 ft. in the air – Randy notified CCR of failure
- **4:17** - Greg McKay and Blaine Williams responded – offered assistance with both track hoe and sand bags/manpower. Ops accepted their assistance sent to south side of the fire to contain release
- **4:25** - Roadblocks set up by Covolt
- **4:29** - Warren alerted Eric and Norm and John .
- **4:35** - Warren received call from Swan Hills Fire Chief and he was asking if we needed assistance. We said Yes.
- **4**:**37** – Shawn was notified and initiated dispatching additional cleanup crews and equipment
- **4:45** - Kaila went and located David and shut-in the 2 grouplines at 13-36 from 8-35 manifold to prevent back flow to the break site.
- **4:45** - Eric shut in group valves at 8-26, 4-24, 2-22. Warren resent shutdown commands to all individual wells.
- **4:45** - Randy shut in 8-33 group line, 8-28 inlet to the 8-33 manifold and B pool group line at 8-33 manifold
- **4:45** – John called Ken – Ken called Dale, Randy and Jim and initiated ERP
- **4:50** - Pat and David shut in groupline at 5-35 sat. and 8-35 sat.
- **5:06** - Randy Trofimuk contacted Fortis to isolate power if they had to, did not need to isolate
- **5:15** - Isolated leak – flames died down
- **5:17** - John H and SH Fire Dept. arrived at 8-35
- **5:30** - Ops arrived back at 8-35 sat., the Fire Chief showed up, SRD showed up around the same time
- **5:35** - Crews show up with sand bags to begin containment of spill
- **5:35** - Decision was made to allow fire to self extinguish
- **5:40** - Carlan throws in first boom in Judy Creek at the culvert at the main road into the PC

- **5:40 –** First Quantabs were being taken by Carlan.
- **5:45 –** Once set in place, next one set up at 70 yards downstream of spill entrance (at first beaver dam), boom was set up at 4-36 where the creek crossed the road
- **5:45 -** Hydrovacs arrived on site and started cleaning. Focus was on ditch lines residual spill.
- **5:45 -** Spot fires are extinguished by Fire Dept. with a 30 lb. ansul
- **5:45 -** Shelley, Carolyn, Norm, Shawn and Ken showed up. Doug showed up shortly after. Spill assessment commenced.
- **5:46 -** Assessed 8-35 8"fiberglass groupline failure/fuelling fire with produced water and crude oil release running down road to creek.
- **6:00 -** SH Fire Dept. Chief, SRD, ambulance left location.
- **6:46 -** Carolyn received call from ERCB. ERCB assessed it at a Level 1.
- **7:04 -** Off site Command Centre set up at Field Office
- **7:05 -** Emergency team assessed incident at a Level 1 – called Airborne for aerial surveillance
- **7:10 -** Decision made to blind both lines at 13-36 header coming from 8-35 manifold and shut every well physically that goes to every sat. Lockouts completed at satellites.
- **7:10 -** Ken provided updates to other internal Pengrowth contacts
- **7:49 -** Alberta Environment contacted Carolyn
- **8:39** – Carolyn called Alberta Environment Hotline (as requested by Alberta Environment so Environment Canada would be notified)
- **8:45 -** Carolyn, Shelley and Ken went up in the helicopter; initial assessment - could not see sheen until 6-36 lease road culvert (just under 1 km from entering Judy Creek)
- **9:00 -** Quantabs were being taken by Carlan. Samples were taken every 3 hrs. throughout the night.
- **9:05 -** Additional booms were placed at 6-36 and 8-36
- **9:26 -** OH&S called Carolyn when booms were being placed. OH&S were notified by the ERCB.
- **9:49 -** Spill volume was est. to be 80 m3
- **9:50 -** More supplies were being delivered from the city for spill containment, booms, containment socks, etc. Arrived after midnight.
- **10:00 -** Ops. returned to Command Centre to establish startup procedure of unaffected field locations. Assess potential pressure related issues due to sequence of events.
- **10:10 -** Proceeded to field to commence startup and decision was made to run with nightshift operations to monitor for leaks and kept area secured.
- **11:15 -** Dean Soucy made call to CleanHarbours
- **12:00 midnight -** Shawn ordered up additional equipment for the morning (mulcher, vac trucks, etc.)
- **12:30** – 85% of field restarted – field ops. went home for day.

Appendix 6

Material Testing Report

Alberta Innovates Technology Futures

Edmonton
250 Karl Clark Road
Edmonton, AB
Canada T6N 1E4
Tel 780.450.5111
Fax 780.450.5333

Calgary
3608 – 33 St NW
Calgary, AB
Canada T2L 2A6
Tel 403.210.5222
Fax 403.210.5380

Vegreville
P.O Bag 4000
Vegreville, AB
Canada T9C 1T4
Tel 780.632.8211
Fax 780.632.8385

Devon
C/O 250 Karl Clark Road
Edmonton, AB
Canada T6N 1E4
Tel 780.450.5111
Fax 780.450.5333

July 6, 2011

Skystone Engineering
McCall Court, 330, 4311-12 Street NE
Calgary, Alberta
T2E 4P9

TEST REPORT

Attention: Prakash Dodia

Dear Prakash,

Re: Analysis of FRP Pipe Sample. Your reference Pengrowth 11-1057.
Our Ref. #CL11-55. File #11-209.

The composite pipe sample I received from you on July 5, 2011, was analysed as per your request to determine glass transition temperature (Tg) of the material by differential scanning calorimetry (DSC). As well, the sample was analysed to determine the loss on ignition (LOI).

The Tg analysis was performed as per ASTM E1356-08 (Glass Transition Temperatures by Differential Scanning Calorimetry). The instrument used for this determination was a TA Instruments DSC Q100. The analysis parameters included a 10°C/minute heating rate to 160°C and a 50 mL/min. dry nitrogen gas purge. The instrument was calibrated as per ASTM E967 using indium and tin standards. Test specimens were obtained by collecting fine cuttings from the fibre reinforced polymer part of the pipe sample. Test specimens were encapsulated in closed aluminum pans.

The ASTM procedure used to determine the glass transition temperature (Tg) specifies that the test specimen should be put through an initial heating cycle, cooled, then re-heated to determine the Tg. However, with cured resin samples, there is a concern that the first heating cycle may cause additional post-curing of the sample, thus changing the Tg of the material. The procedure was performed as outlined in the ASTM standard, however, the Tg is also reported as determined from the first heat scan in case you wish to utilize this data instead. For each Tg event, the Tg onset, Tg midpoint, and Tg end point were determined. The ASTM standard indicates that the midpoint is usually used as the Tg, however, any of the three temperatures outlined may be referred to as the glass transition. Copies of the thermal scans are also enclosed for your information.

Lastly, the loss on ignition analysis performed on the pipe samples was performed as per ASTM D2584-08 (Ignition Loss of Cured Reinforced Resins). The result for ignition loss (average of triplicate analysis) was 18.15% for sample Pengrowth 11-1057.

. . . 2

The results contained herein relate only to the items tested. This report should only be reproduced in full and with the permission of the Alberta Innovates - Technology Futures.

As per your request, the remaining samples are being returned to you. If you have any questions, please do not hesitate to call me at (780) 450-5438.

Sincerely,

Jim Melnichuk
Advanced Materials

encl.
JM

Reviewed by
Tonya Wolfe PhD PEng
Advanced Materials

TEST RESULTS FOR DETERMINATION OF GLASS TRANSITION TEMPERATURES OF FIBRE REINFORCED RESINS

Client: Skystone Engineering
ARC Project #: CL11-55. File #11-209.
Test Method: ASTM E1356-08 (Glass Transition Temperatures by Differential Scanning Calorimetry). The instrument used for these determinations was a TA Instruments DSC Q100 with a 10°C/minute heating rate to 160°C and a 50 mL/min. dry nitrogen gas environment. The instrument was calibrated as per ASTM E967 using indium and tin standards. Test specimens were obtained by collecting fine cuttings from the fibre reinforced polymer part of each pipe sample. Test specimens were encapsulated in closed aluminum pans.

Sample #: CL11-55.1
Sample Description: Pengrowth 11-1057
Test Date: July 5, 2011

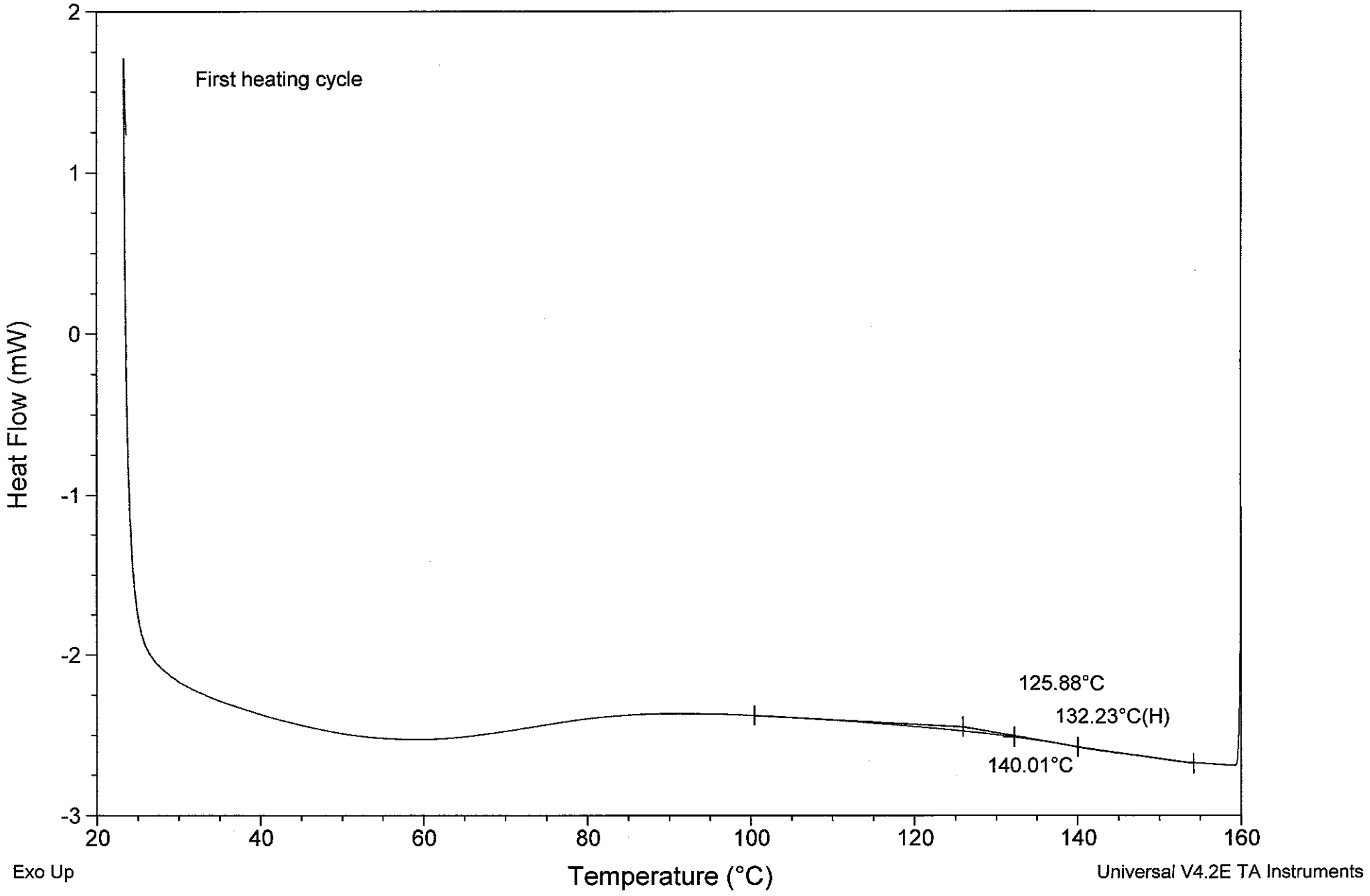
	Onset Temperature (°C)	Midpoint Temperature (°C)	Endpoint Temperature (°C)
Glass Transition Temperature as determined from first heating run	125.88	132.23	140.01
Glass Transition Temperature as determined from second heating run	121.62	130.06	138.49

Technologist Signature

Sample: Pengrowth 11-1057
Size: 11.8000 mg
Method: Ramp
Comment: ASTM E1356, 10°C/min., 50 mL/min. N2, Al pans

DSC

File: C:\TA\Data\DSC\Q100\2011\skyst-55-1.001
Operator: JM
Run Date: 05-Jul-2011 14:59
Instrument: DSC Q100 V9.6 Build 290



Sample: Pengrowth 11-1057
Size: 11.8000 mg
Method: Ramp
Comment: ASTM E1356, 10°C/min., 50 mL/min. N2, Al pans

DSC

File: C:\TA\Data\DSC\Q100\2011\skyst-55-1.001
Operator: JM
Run Date: 05-Jul-2011 14:59
Instrument: DSC Q100 V9.6 Build 290