Pipeline Technical Resources

Pipeline Construction: FAQs

These Frequently Asked Questions (FAQs) and their responses are intended to provide insight into PHMSA's approach to the issues they describe. They are intended to facilitate understanding of the code, enhance communication with all stakeholders, and provide information to operators concerning PHMSA's inspection approach. Nothing in these FAQs alters the content of the code, constitutes new requirements, or represents interpretations of the code. Official written interpretations may be requested in accordance with 49 CFR 190.11.

Here you will find a listing of the most frequently asked questions (FAQs) related to Pipeline Construction. You may browse the complete listing of FAQs below, or download the entire set of FAQs in pdf format.

1. Why are there so many construction issues lately?

There was a boom in pipeline construction from 2007 through 2011. As a result, there have been more inspections of pipelines under construction.

It is possible that the increased number of construction problems is simply the result of more miles of pipe being constructed. PHMSA's inspection findings, however, indicate that some construction concerns could be laying the foundation for future problems with pipeline integrity. The high rate of construction could have stretched the construction resources thin and added pressures to finish a job with fewer resources. Attention to quality by all involved in the process of pipeline construction is needed to assure quality pipe and minimize future problems.

Revised: 6/15/12

---

2. What kinds of issues has PHMSA found?

PHMSA construction inspections have found issues in all areas associated with pipeline construction. Pipeline coating has been the area where the most issues have been identified. In the course of inspecting 35 pipeline construction projects, PHMSA has identified problems in these areas:

Issue Area	No. of Problems
Coatings	117
Welding	87
Excavation	20
Nondestructive Testing	20
Pipe Materials	12
Bending	9
Lowering/Installation in Ditch	7
Hydrostatic Testing	4
Design	3
Miscellaneous	5

Original: 8/7/09

---

3. Why are coating issues of such concern if pipe is protected by cathodic protection?

Coating and cathodic protection (CP) are both intended to prevent external corrosion of buried pipelines. They are intended as defense-in-depth – two layers of protection. Good coating is necessary because CP is not always good enough. There may be issues that reduce the effectiveness of CP, such as shielding. There may be problems with the CP system that go undetected for some period. Experience has shown that corrosion can do significant damage to a pipeline if CP is not adequate, even for a period of a few months. It is necessary to assure that pipeline coating is good to provide continued assurance of protection against corrosion even if CP problems occur.

Original: 8/7/09

---

4. What is the cause of recent pipeline construction issues?

There are several causes. Pipeline material issues can result from problems that occur at the mills where steel is made and where it is made into pipe. Issues that occur at the construction site can result from poor/wrong materials or from poor construction practices.

Original: 8/7/09

---

5. Don't pipeline standards provide enough guidance for construction?

There have been recent advances in pipeline technology, including for example more use of high-strength steels. There are some instances in which the standards need to catch up to current practice. The standards do provide adequate guidance for many issues. PHMSA's evaluation of many of its inspection findings from construction projects has found that the details specified in the standards are often not realized in the installed pipe.

Original: 8/7/09

---

6. Aren't construction procedures adequate?

PHMSA has found that the procedures for most pipeline construction projects are adequate and reflect the recommendations of consensus standards. The procedures are not always followed, though. This could be a result of inadequate training or understanding of the procedures by those who must implement them.

Original: 8/7/09

---

7. Isn't Quality Control supposed to find problems?

Quality Control (QC) is used on pipeline construction projects to assure that the quality of construction meets required specifications. It is an extra layer of defense beyond having adequate procedures and doing things correctly. QC can find problems, which are indicative of problems in the construction. The correct response is to identify the reasons why the construction problems are occurring and correct them. It is not acceptable to simply rely on QC to find problems as the only means of assuring quality construction.

Original: 8/7/09

---

8. Are pipeline construction personnel adequately qualified?

The personnel qualification requirements in PHMSA regulations apply to operators of pipelines, not to construction personnel. The owners of pipeline projects are responsible for assuring that their construction personnel are adequately qualified. Deficiencies in personnel qualification – lack of understanding of what they are supposed to do – has been found to be a contributing factor to many construction inspection deficiencies.

Original: 8/7/09

---

9. Don't high-strength steels make pipelines safer?

Pipelines are designed with a safety margin. As high-strength steels are used, new pipelines are being designed to use thinner-walled and higher strength steel pipe, and may operate at higher pressures. It is thus important to assure that the high-strength pipe material meets specifications to assure that the required safety margin is maintained.

Revised: 6/15/12

---

10. What kinds of pipe material problems have been seen?

In some pipeline construction projects, the material properties of the high-strength steel have been found to vary among the many sections, or "joints," of pipe that are purchased. A principal property is the yield strength, the amount of stress that the steel can withstand before it begins to yield, changing its shape/physical dimensions. Some pipe joints have been found to have a yield strength as much as 15 percent below that specified. Pipeline design, including the required safety margin, generally assumes that the pipe is as strong as the specification requires. Pipe that is below specification values thus can reduce the safety margins.

Revised: 6/15/12

---

11. How have pipeline construction problems been identified?

Some problems have been identified by PHMSA safety inspectors reviewing procedures and observing pipeline construction. Problems have also been identified through testing done to verify pipeline construction. This has included failures experienced during hydrostatic testing (e.g., failure of welds, expansion of pipe and fittings that has exceeded its yield strength). Problems with pipeline coating have been identified using a number of types of indirect examinations that are designed to find "holidays" or damage to the pipeline coating. Post-construction inspections with in-line inspection tools (sometimes called "smart pigs") have also found problems such as denting and gouges.

Revised: 6/15/12

---

12. What kinds of problems have led to coating issues?

The single most-significant cause of identified coating problems has been failure to follow manufacturer's instructions and operator procedures. This problem has been identified in instances in which field-applied coatings have been identified as inadequate. It has also been identified in inadequate inspections of coatings using electronic defect detectors (commonly known as "jeeping"). Failure to properly prepare the pipe surface, removing all dirt and rust, has also resulted in problems.

Revised: 6/15/12

---

13. What kinds of problems have led to welding issues?

Again, the most significant cause of welding issues is failure to follow procedures. Problems with pre-heating and pipe alignment (misalignment of the pipe bevels) have also contributed to inadequate welds.

Revised: 6/15/12

---

14. Isn't non-destructive testing required after welding? Why is it not finding the problems?

Non-destructive testing (NDT) is required following welding. Ultrasonic inspection and radiographic inspection (similar to X-rays) are the most common techniques used. These inspection techniques are designed to find gaps in the weld and foreign materials (i.e., inclusions) in the weld metal.

Welds in high-strength steels are more susceptible to hydrogen-induced cracking. Hydrogen from the welding rods dissolves in the molten weld metal. This hydrogen comes out of solution as the metal cools. If all of the hydrogen is not allowed to escape, it can result in delayed cracking of the finished weld. In some recent cases, reviews of NDT records following weld failures have found that there were no cracks or inclusions in the welds. In these cases, it is likely that hydrogen-assisted cracking occurred after the post-welding NDT was done.

Original: 8/7/09

---

15. Can welders be qualified to work on any pipeline project?

Pipeline safety regulations make assuring proper qualification of welders the responsibility of the pipeline operator. Welders are often contract personnel who work on many pipelines for different operators. Pipeline operators can, and sometimes do, run joint qualification programs, but the responsibility remains with each individual operator to assure its welders are qualified.

Original: 8/7/09

---

16. Isn't there a way to reduce the amount of hydrogen that dissolves in weld metal and thus reduce the incidence of hydrogen-assisted cracking?

Yes. Hydrogen is present in the coating of the most commonly-used welding electrodes. Low-hydrogen electrodes exist and are beginning to be used in pipeline construction welding. The extent to which low-hydrogen electrodes are used remains small, however. Proper heat treatment, including time at temperature to allow hydrogen to diffuse out of the weld metal, can also help reduce hydrogen-assisted cracking.

Original: 8/7/09

---

17. Is there any pattern to the welding problems that have been identified?

Pipeline construction welding problems have been found most often on projects involving new, high-strength steels.

Original: 8/7/09

---

18. Can better management practices help assure quality?

Yes. Application of Quality Management Systems (QMS) can help assure quality. QMS is more than QA/QC of the finished product. It includes assuring that procedures are correct, reflect the provisions of relevant standards, and are followed during construction.

Original: 8/7/09

---

19. How can we assure that coating is not damaged during direct bore and similar installations?

Use of indirect assessments such as direct current voltage gradient (DCVG) following installation has identified instances of coating damage resulting from installation.

Original: 8/7/09

---

20. What kinds of problems have been noted during State inspections of pipeline construction?

The most common findings from State pipeline construction inspections have included:

- Poorly Qualified Construction Personnel
- Poorly Qualified Inspectors by Operators
- Storage and Handling of Pipe
- Improper Procedures
- Failure to Follow Procedures
- Lack of Procedures
- Span of Control of Inspectors Used by Operators

Original: 8/7/09

21. How does a pipeline operator control material problems that occur during steel and pipe manufacturing?

Pipeline operators need to assure that their specifications are adequate. They must also assure that steel and pipe mills, fitting and hot bend manufacturers have, and follow, quality management programs designed to ensure the production of quality materials (pipe, steel, fittings, and hot bends). Finally, operators need to inspect the materials that they receive, including during manufacturing, carefully to assure that their specifications have been met.

Revised: 6/15/12

22. What kinds of pipe material problems have been found?

Material deficiencies identified in pipe for new pipeline construction projects include:

- Incorrect chemical composition
- Low and variable yield strength
- Laminations and Inclusions
- Incorrect pipe bevel ends – high/low and flat spots on pipe ends

Revised: 6/15/12

23. What factors can contribute to low and variable yield strength?

Factors that can affect yield strength include:

- Wrong heat chemistry from steel supplier
- Pipe test locations for yield/ultimate tensile strengths at steel and pipe mills
- Plate/coil ordered under strength based on the type pipe rolling process
- Incorrect plate/coil rolling process
- Improper plate/coil cooling rates
- Plate/coil switch at pipe mill

Original: 8/7/09

24. What kind of fitting and hot bend material problems have been found?

Material deficiencies identified in fittings and hot bends for new pipeline construction projects include:

- Low and variable yield strength
- Incorrect strength/grade of material used for manufacturing the fitting
- Incorrect pipe bevel ends – high/low and misalignment of hot bend ends

Original: 6/15/12

Pipeline Construction: Miscellaneous

The following is a summary listing of typical issues that have been identified by PHMSA inspections of new pipeline construction projects. Identified problems have primarily been due to a failure to implement existing industry standards, manufacturer's recommendations, and federal regulations. Some of these issues are discussed in more detail on other Pipeline Construction web pages, but are repeated here in order to provide a consolidated list.

Pipe and Miscellaneous Issues

Pipe
- Pit defects in the pipe body
- Laminations
- Pipe sizing issues and variability/damage to pipe ends
- Low tensile strength and/or thin wall in some pipe

Hydrostatic Testing
- Poor test in winter due to freezing of pressure equipment
- Cracks discovered in girth welds during hydro test
- Improper pressure maintenance during hydro test
- Long seam failure

Design
- Incorrect pipe wall thickness for class location
- Inadequate testing documentation for pipeline components

Bending
- Ripples out of tolerance
- Pipe seam not in neutral axis
- Inadequate construction specification
- Not using internal mandrel when required by procedures
- Not following procedures

Lowering
- Inadequate boom spacing per the ECA requirements
- Unrepaired coating defects at lowering

Operation - Insufficient line markers

Inadequate Operator Qualification Documentation If Applicable

Post Construction Documentation

End Facing

Stringing - Long seam alignment/orientation

Coating

Fusion Bonded Epoxy Issues
- Coating over mud or rust
- Application temperature too hot or cold
- Heat damage to the factory FBE coating
- Failing to follow manufacturer's instructions
- Sand blast technique - no correct bevel / no overlap at factory coating
- Coating in high wind with blowing dirt
- Water in the pipe during heating – does allow for uniform heating
- Coating specifications not available to inspectors
- Girth weld coating not fully bonded to pipe

Melt Stick
- Failing to follow manufacturer's instructions
- Not adequately heating pipe before application
- Inadequate surface preparation - abrasion
- Use on defects larger than 0.5 in^2
- Application over two part epoxy
- Improper accelerated drying by patting
- Use on bare metal

Electronic Defect Detectors (Jeeping)
- Failing to follow manufacturer's instructions
- Low voltage setting on holiday detector
- Inadequate training of inspectors and contractors
- Jeeping over tape and fiberboard stuck to the pipe
- Failing to adequately clean the pipe before jeeping
- Failing to visually inspect pipe for coating defects
- Using damaged (bent) detector springs
- High resistance in electrical circuit
- Jeeping at too fast a speed per the spec or manufacturer
- Jeeping over coating repairs before they are dry
- Detector failing to identify defects
- Detector not calibrated per manufacturer

Two Part Epoxy Issues
- Failing to follow manufacturer's instructions
- Inadequate surface prep - abrasion
- Application after epoxy starts to set
- Inadequate mixing of the epoxy
- Applying above or below recommended temp - or not pre-heating pipe
- Using unapproved IR temperature sensors

Welding	
Mechanized Welding • Coating damage caused by welding band • Incomplete weld procedure qualification • Pre-heat crew not using Tempilstiks • Pipe size - Hi-Lo alignment issues • NDT falling behind main gang • Lack of padding between pipe and skids • Incorrect or inadequate placement of skid cribbing • Lack of inspector oversight • Not following procedures • Incorrect pre-heat or interpass temp • Improper use of Tempilstik - too near weld • Amps and Volts measured at machine not weld (only long leads) • Moving pipe during root bead welding • Initial high defect rates • Inadequate defect repair tracking • Inadequate quality and documentation of MUT	**Manual Welding** • Not following procedures • Lack of inspector oversight • Early clamp release • Arc burns due to poor welding practices • Incorrect pre-heat or interpass temp • Inadequate visual weld inspection • Improper storage of low hydrogen rods • Welding inspectors not in possession of welding procedures • Use of 'hinging' technique to aid with pipe line-up • Pipe size - Hi-Lo alignment issues • Improper gas flow rate for gas shielded processes • Inadequate defect repair tracking • Incomplete qualification documents for welders • Amps and Volts measured at machine not weld (for long leads) • Inadequate defect removal on repair welds

Excavation	
• Inadequate use of rock shield, padding machines or selective backfill • Insufficient burial depth(to code or waiver) • Ditch profile not matching pipeline causing inadequate support • Dents caused by placing pipe on rocks	• Erosion of cover at streams • Insufficient pipeline weights • Excavating over the pipe without adequate protection from rocks, etc. • Not reviewing as-built drawings for parallel pipelines • No One-Call notifications

Nondestructive Testing	
• Essential wire or hole not visible on radiograph • Testing to achieve only the minimum requirements of 192 or 195 • Poor radiographic technique - not meeting 1104 requirements • Not meeting the minimum 10% NDT requirements	• NDT records not adequate or up to date • Incomplete qualification documents for technicians • Inadequate interpretation of radiographic results • Film density not in spec

From Attachment INTERVENORS.VGS.1-114.1 (2014 Inspection Reports).pdf

______

ML-DAILY INSPECTOR REPORTS 2014 (348 pages):

Start date: 8-20-2014
End date: 11-20-2014

______

I did not witness any of the tie in made. Eds crew built a trench plug at sta#546+57 area. Doug Mabee with VHB agreed with location. They then x-rayed welds, coated and jeeped them and covered 38' of pritec pipe with rock shield and backfilled trench. Pritec pipe was installed from sta#546+86 to 547+24 for 38'. Cook clearing ground up trees from sta#349+00 to 351+00 with one operator working. Over and Under environmental crew flagged and unloaded jersey barriers on Essex exit 10 at bore site sta# 239+00 .I did not witness all activities today as I was covering 4 crews.

Inspector J.R. Kelch, 9 / 5 / 2014 (p 32 of 348)

______

…. Was not able to witness all activities today. Crews were spread out too far and both were performing critical task.

Inspector J.R. Kelch, 9 / 12 / 2014 (page 50 of 348)

______

…. RTD-TI 360 was coated by Mikes crew with no coating inspector present, using canusa sleeve. Was not present for all activities as crews are spread out.

Inspector J.R. Kelch, 9 / 13 / 2014 (p 53 of 348)

______

…. Did not witness all activities as most of the day was spent at Alder brook creek crossing.

Inspector J.R. Kelch, 9 / 5 / 2014, (p 56 of 348)

______

…. Was not able to cover all activities today with 4 crews.

Inspector J.R. Kelch, 9 / 16 / 2014 (p 58 of 348)

———

…. Was not able to watch all activities covering 4 crews.

Inspector J.R. Kelch, 9 / 17 / 2014 (p 62 of 348)

———

…. Ed also turned in extra depth of trenching of 4' at sta 545+58 to 546+50 for 90' with the reason that after crossing Allen Brook they had to go deeper to get under Vermont Gases plastic line…. Did not get to watch all activities with 4 crews.

Inspector J.R. Kelch, 9 / 18 / 2014 (p 64 of 348)

———

.... Ed's crew had 2 welds today that were not covered by welding inspectors busy at other locations. Not able to cover all activities due to having 4 crews.

Inspector J.R. Kelch, 9 / 24 / 2014 (p 80 of 348)

———

.... Did not witness all activities with 4 crews today. Had 1 weld not covered by inspection today.

Inspector J.R. Kelch, 9 / 25 / 2014 (p 83 of 348)

———

.... Was not able to witness all activities today with 3 crews to cover.

Inspector J.R. Kelch, 9 / 27 / 2014 (p 89 of 348)

———

…. Could not witness all activity with 4 crews to watch today.

Inspector J.R. Kelch, 9 / 29 / 2014 (p 92 of 348)

———

.... Was not able to cover all activities as crews are spread from Mt.View to Mill Pond Rd.

Inspector J.R. Kelch, 10 / 6 / 2014 (p 110 of 348)

———

______

.... Did not witness all activities with 4 crews.

Inspector J.R. Kelch, 10 / 7 / 2014 (p 112 of 348)

______

.... Was not able to cover all activities today with 4 crews to watch over.

Inspector J.R. Kelch, 10 / 8 / 2014 (p 116 of 348)

______

…. Was not able to cover all activities today with 4 crews to watch over.

Inspector J.R. Kelch, 10 / 8 / 2014 (p 119 of 348)

______

.... Was not able to cover all activities today with 4 crews to watch over.

Inspector J.R. Kelch, 10 / 9 / 2014 (p 122 of 348)

______

.... Was not able to witness all activities due to watching 4 crews.

Inspector J.R. Kelch, 10 / 20 / 2014 (p 131 of 348)

______

.... Not able to witness all activities watching over 4 crews in different locations.

Inspector J.R. Kelch, 10/ 22 / 2014 (p 137 of 348)

______

…. Did not witness all activities today with four crews, two of them lowering in ml.

Inspector J.R. Kelch, 10 / 27 / 2014 (p 140 of 348)

______

....Was unable to cover all task with four crews today.

Inspector J.R. Kelch, 10/ 29 / 2014 (p 146 of 348)

______

_____

…. Was not able to witness all activities today with 4 crews working.

Inspector J.R. Kelch, 10 / 30 / 2014 (p 149 of 348)

_____

…. Not able to witness all activities with 4 crews.

Inspector J.R. Kelch, 10 / 17 / 2014 (p 161 of 348)

_____

…. Unable to witness all activities today due to 4 crews.

Inspector J.R. Kelch, 11 / 5 / 2014 (p 170 of 348)

_____

…. Could not cover all activities with 4 crews.

Inspector J.R. Kelch, 11 / 6 / 2014 (p 173 of 348)

_____

…. I try to ensure my crew's work in a safe manner and wore proper ppe. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 9 / 2 / 2014 (p 203 of 348)

_____

…. I try to ensure my crew's work in a safe manner and wore proper ppe. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 9 / 3 / 2014 (p 206 of 348)

_____

…. 3 welds were wrapped in a Canusa K-60, 4 HDD welds and 1 main line weld were R-95 coated. See coating report for details. John Pritchard's bore crew was shut down for several violations. I try to ensure my crew's work in a safe manner and wore proper ppe. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 9 / 5 / 2014 (P 209 of 348)

______

... 7 welds were wrapped in a Canusa K-60. See coating report for details. I try to ensure my crew's work in a safe manner and wore proper ppe. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp 9 / 6 / 2014 (p 212 of 348)

______

…. 1 weld was wrapped in a Canusa K-60, 7 HDD,1 main line and 1 tie in weld were coated with R-95. See coating report for details. I try to ensure my crew's work in a safe manner and wore proper ppe. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 9 / 8 / 2014 (p 215 of 348)

______

…. 4 welds were wrapped in a Canusa K- 60. See coating report for details. John Pritchards bore crew started boring at a new entry point which should put them with a much higher exit point. They currently have 40ft augered. I try to ensure my crew's work in a safe manner and wear proper ppe. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 9 / 9 / 2014 (p 218 of 348)

______

…. 3 welds were wrapped in a Canusa K-60's. See coating report for details. John Pritchard's bore crew was shut down so no progress to report. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp 9 / 12 / 2014 (p 221 of 348)

______

…. 2 welds were wrapped in a Canusa K-60's and 1 weld was coated with R-95. See coating report for details. John Pritchard's bore crew is working on mobing to the railroad bore location of Fay road. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 9 / 13 / 2014 (p 224 of 348)

______

… 3 welds were wrapped in a Canusa K-60's. See coating report for details. John Pritchard's bore crew cleared the top soil at the bore entrance pit and continued working on mobing to the railroad bore location off of Fay road @ 372+50. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 9 / 15 / 2014 (p 227 of 348)

______

Met with Kevin Ames in the morning to go over the jsa and what was today's planned work activities. 4 welds were wrapped in a Canusa K-60's and 2 welds were coated with R-95 Powercrete. See coating report for details. John Pritchard's bore crew excavated the bore pit entrance and installed 2 trench boxes off of Fay road @ 372+50. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 9 / 16 / 2014 (p 230 of 348)

______

.... 2 welds were wrapped in a Canusa K-60's and 1 weld was coated with R-95 Powercrete. See coating report for details. John Pritchard's bore crew continued to set up to bore off of Fay road @ 372+50. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 9 / 17 / 2014 (p 233)

______

….1 weld was wrapped in a Canusa K-60 and 4 welds were coated with R-95 Powercrete. See coating report for details. John Pritchard's bore crew continued to set up to bore off of Fay road @ 372+50. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp 9 / 18 / 2014 (p 236 of 348)

______

———

.... I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp 9 / 19 / 2014 (p 239 of 348)

———

Met with Kevin Ames in the morning to go over the jsa and what was today's planned work activities. Kevins crew worked on excavating and welding up pritec coated pipe. John Pritchard's crew is still at 120ft augered with 20inch casing at the bore off of Fay road @ 372+50 due to issues with the boring head(rock causing issues). 9 Canusa K-60's were applied;see coating report for details. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp 9 / 23 / 2014 (p 242 of 348)

———

….4 Canusa K-60's were applied;see coating report for details. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 9 / 24 / 2014 (p 245 of 348)

———

….1 R-95 coat was applied;see coating report for details. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 9 / 27 / 2014 (p 248 of 348)

———

…. 2 K-60 wraps were applied;see coating report for details. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 9 / 29 / 2014 (p 251 of 348)

——

…. 5 R-95 coats were applied;see coating report for details. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 9 / 30 / 2014 (p 254 of 348)

——

….4 R-95 coats & 2 Canusa K-60's were applied;see coating report for details. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 / 1 / 2014 (p 257 of 348)

——

…. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 / 2 / 2014 (p 260 of 348)

——

…. 4 welds were coated with R-95 powercrete. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 / 7 /2014 (p 263 of 348)

——

…. John Pritchard's crew has finished the bore; total length of concrete coated pipe is142.8ft. 2 welds were coated with R-95 powercrete. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 /8/ 2014 (p 266 of 348)

Met with Kevin Ames in the morning to go over the jsa and what was today's planned work activities. Kevins crew excavated and lowered in a 435ft section(see details above). John Pritchard's crew is working to mob to the next bore site off Mill pond road; slightly delayed due to the clearing of the row/access to the bore not being complete. 2 welds were wrapped in K-60's. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 / 15 / 2014 (p 269 of 348)

———

Met with Kevin Ames in the morning to go over the jsa and what was today's planned work activities. Kevins crew back filled/Rock shielded a 435ft section(see details above). John Pritchard's crew is working on digging the bore entry pit near 26+00. 2 welds were wrapped in K-60's. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 / 17 / 2014 (p 272 of 348)

———

Met with Kevin Ames in the morning to go over the jsa and what was today's planned work activities. Kevins crew excavated and lowered in a 60ft section(see details above). John Pritchard's crew continued working on digging the bore entry pit near 26+00. 2 welds were wrapped in K- 60's. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 / 18 / 2014 (p 275 of 348)

———

Met with Kevin Ames in the morning to go over the jsa and what was today's planned work activities. Kevins crew excavated and lowered in a 100ft section(see details above). John Pritchard's crew has now augered 70ft and will continue tomorrow. 2 welds were wrapped in K-60's. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 / 20 / 2014 (p 278 of 348)

…. John Pritchard's crew has dug the exit pit and punched out. They will start tomorrow on pushing the concrete coated joints. 1 weld was wrapped in a K-60. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day

Inspector Bryan Kemp, 10/21/2014 (p 281 of 348)

_____

…. John Pritchard's crew has 2 concrete coated joints now pushed and will continue this process tomorrow. 3 welds were coated in R-95 Powercrete. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 / 22 / 2014 (p 284 of 348)

_____

….1 weld was coated in R-95 Powercrete. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 / 23 / 2014 (p 287 of 348)

_____

…. John Pritchard's crew was able to get another concrete coated joint attached and pushed. We should be getting close to punching out the exit side with concrete coated pipe. 1 weld was coated in HBE 95. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 / 25 /2014 (p 290 of 348)

_____

…. 1 weld was coated in HBE 95. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 / 27 / 2014 (p 293 of 348)

_____

…. 2 welds were coated in HBE 95 and 2 welds wrapped in a K-60. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 / 28 /2014 (p 296 of 348)

_____

…. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 / 29 / 2014 (p 299 of 348)

_____

…. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 / 30 / 2014 (p 302 of 348)

_____

Met with Kevin Ames in the morning to go over the jsa and what was today's planned work activities. Kevins crew worked on ditching & welding up sections on pipe.(see details above) John Pritchard's crew is working on matting an entry way to the bore site at Rte 15 / Upper main. 4 welds wrapped in a K-60. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 10 / 31 / 2014 (p 305 of 348)

_____

Met with Kevin Ames in the morning to go over the jsa and what was today's planned work activities. Kevins crew worked on ditching & welding up sections on pipe.(see details above) John Pritchard's crew is working on matting an entry way to the bore site at Rte 15 / Upper main. 4 welds wrapped in a K-60. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 11 / 1 / 2014 (p 308 of 348)

_____

… 5 welds wrapped in a K-60. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 11 / 3 / 2014 (p 311 of 348)

_____

…. 9 welds were wrapped in a K-60 Canusa. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 11 /5 / 2014 (p 314 of 348)

_____

…. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 11 / 6 /2014 (p 317 of 348)

_____

John Pritchard's crew attempted to bore 3ft deeper which put him at 10ft but had the same issue. The soil above it started to collapse. He is now pulling out until further direction on what to do at the bore site at Rte 15 / Upper main. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 11 / 7 / 2014 (p 320 of 348)

_____

John Pritchard's crew is attempting to use a different bore head / technique at the bore site at Rte 15 / Upper main. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 11 / 8 / 2014 (p 323 of 348)

_____

John Pritchard's crews 3rd attempt to bore failed at the bore site at Rte 15 / Upper main. They are working to figure out what they are going to attempt next. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 11 / 10 / 2014 (p 326 of 348)

_____

John Pritchard's crew is working to set-up a thumper at the bore site at Rte 15 / Upper main. Coating crew coated the 2-A HDD welds. Coating report is to be turned in at a later date after final inspection is complete. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 11 / 12 / 2014 (p 329 of 348)

_____

…. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 11 / 13 / 2014 (p 332 of 348)

_____

…. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 11 / 14 / 2014 (p 335 of 348)

_____

_____

…. 3 welds were wrapped in a K-60 Canusa. See attached coating reports. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 11 / 15 / 2014 (p 337 of 348)

_____

…. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day. (

Inspector Bryan Kemp, 11 / 17 / 2014 (p 341 of 348)

_____

…. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 11 / 19 / 2014 (p 344 of 348)

_____

…. I try to ensure my crew's work in a safe manner and wear proper ppe. There are several coating crews now so I am unable to observe / report on all coating / sleeves. All reports turned in are a spot check status as I over look 3 to 5 different crews depending on the day.

Inspector Bryan Kemp, 11 / 20 / 2014 (p 347 of 348)

_____

###

Vermont Gas

ANGP
QA QC
Summary

12/21/2015

Vermont Gas

QA QC Summary

TAB 1

MEMORANDUM

To: ANGP File
From: Kristy Oxholm
Date: December 21, 2015
Re: Addison Natural Gas Project (ANGP) QA/QC Executive Summary

While no QA/QC program can assure 100% perfection on any project, Vermont Gas Systems, Inc. (VGS) has implemented QA/QC requirements to assure the highest levels of quality are adhered to. In circumstances where quality is questioned, appropriate follow-up remediation and/or mitigation is implemented.

For the 2014 construction season QA/QC requirements were incorporated into various documents, such as the construction specifications, VGS Operations & Maintenance (O&M) Manual and Addison Natural Gas Project Inspector's Manual. Part way through the project it was determined that a more robust QA/QC system would benefit VGS and ANGP.

A significantly enhanced QA/QC program was implemented with the introduction of the VGS Quality Assurance Plan in June of 2015. The framework of this plan was developed by Storti Quality Consulting. A committee of VGS representatives then worked to customize it for use within VGS. The objective of the plan is stated as:

> Vermont Gas Systems is committed to performing work to the highest standards of quality while ensuring compliance with applicable regulations, policies and procedures. The objective of this plan is to ensure that all employees and contractors performing work or constructing new transmission and distribution system share the company's commitment. The Plan provides the structure for effective quality assurance and quality control, but it is the responsibility of all employees and contractors to embrace the need for, and value of, performing work with a high degree of quality and to have a healthy questioning attitude when encountering situations or conditions that may be adverse to quality.

To reduce the need for multiple documents, applicable requirements found in the VGS O&M Manual were incorporated into the construction specifications for the 2015 construction season, In addition, the 2015 Inspector's Manual was assembled using the construction specifications to aid clarity.

One of the items included in the VGS Quality Assurance Plan is the Corrective/Preventive Actions Procedure. This procedure was implemented to address Conditions Adverse to Quality (CAQ) with Correction/Preventive Action Requests (CAR) and document remedial actions that return the condition to an acceptable quality or detail other actions that mitigate quality concerns. These CARs address CAQs which have occurred. VGS retroactively applied this procedure to items from the 2014 construction season for purposes of having consistent documentation throughout the project.

Summary

VGS identified areas which were addressed through Quality Assurance processes as well as areas in which there may be information that we do not know. To gain insight into what we don't know, interviews were conducted with members of the project management team, inspectors and contractors. The details of each identified area are included in the tabbed section of this report and are summarized here.

2014 Items

Welding (TAB 2)

There was the possibility that welders had more than one WPS available to them and could have used the incorrect procedure on some welds. Both of the procedures in question were qualified procedures. This concern broadened to include document control on VGS welding documents. ***This concern was addressed with an extensive update to the VGS welding plan and requalifying the procedures which are now in use.***

There was less than 100% inspection coverage for visual inspection of welds. There is no requirement, either contractual or statutory for visual inspection of each weld if it is inspected by non-destructive evaluation, therefore no CAR was issued. ***Welding quality has been addressed by performing 100% Radiography on the welds on this project.***

Vermont Gas

Coatings

There are 340 welds for which we have no corresponding coating report. Based on as-built records, 15 of these were coated with 2 part epoxy and the balance was coated with Canusa Sleeves. These numbers reflect having one coating inspector for three coating crews. There is no requirement, either contractual or statutory, to having a coating report for each coating application, therefore no CAR was issued. During excavation to assess the reports of trash/garbage/debris in the backfill, two of the welds with no associated coating reports were exposed. The coating appeared to be in good condition, further indicating that no CAR was necessary. ***The commissioning of the cathodic protection (CP) system and a direct assessment survey (to be conducted in the spring of 2016) provide mitigation measures to address this concern.***

Trenching & Backfill (TAB 3)

There was concern as to whether proper backfill was used in all areas where construction occurred in 2014. We are uncertain of specific locations where improper backfill may have been used. ***The only areas we are certain were an issue are a few locations that were noted during the lowering of pipe to address depth of cover issues. In those cases, any improper backfill was removed and replaced with proper backfill as part of the lowering process. No damage to the pipe or coating was noted. The caliper tool run will locate any dents or deformations that could be a result of the pipe being in contact with improper backfill. The commissioning of the cathodic protection (CP) system and a direct assessment survey (to be conducted in the spring of 2016) provide additional mitigation measures to address any concern about potential coating damage. In-line Inspection (ILI) will be used in the future to monitor any issues. A CAR will be issued at that time if appropriate.***

Reportedly there was trash/garbage/debris in backfill used in the ROW and directly over the pipe along Redmond Road. ***This was addressed by CAR 2015-004. The investigation consisted of digging test pits in the area of concern. No trash/garbage/debris was found in close proximity to the installed pipe. The commissioning of the cathodic protection (CP) system and a direct assessment survey (to be conducted in the spring of 2016) will provide additional mitigation measures to address this concern.***

Depth of Cover (TAB 4)

Pipe installed in 2014 was found to have insufficient cover in several locations. ***This issue was addressed by CAR 2015-005. The lack of proper cover was addressed by a combination of regrading, pipe lowering by cutting out sections and permit amendments. (See the CAR for more specific information). Additionally, the final as-builts for this section of ANGP will be reviewed once complete to ensure proper depth of cover as specified in permits, specifications and agreements.***

Bending

A question was raised as to whether all bends were done as required. There is not clear evidence that bends were not done correctly so no CAR was issued. ***The inspection reports do not document any incorrect bends. The caliper tool run will locate any wrinkles, dents, buckles or ovality that could be a result of incorrect bends. If necessary a CAR will be issued at that time.***

Specification Deviations (TAB 5)

It was determined that not all trench breakers were installed as required. ***This is addressed by CAR 2015-006. The corrective actions for this continue are in progress and required trench breakers will be installed in the future (see CAR for more specific information). In the interim, VGS Operations will patrol the transmission corridor on a monthly bases, not to exceed 45 days, or after any significant rain event to ensure no erosion occurs due to the lack of a trench breaker.***

<u>2015 Items</u>

Welding (TAB 6)

A determination was made that the requirements for welding line-up clamps should be more restrictive than those in the qualified welding procedures. ***Directive 2015-004 was issued requiring the line-up clamps be used unless they meet specific requirements.***

Vermont Gas

Coatings (TAB 7)

The method of pipe surface preparation for shrink sleeves was clarified by directive. ***Directive 2015-010 was issued requiring sandblasting using the SSPC-SP10 or NACE 2 – Near-White Blast Cleaning Specification.***

Pritec patches were discovered to not be adhering appropriately to the Pritec pipe. ***CAR 2015-003 was issued. As a result of the investigation into the issue the decision was made to switch to the use of Canusa sleeves as the sole method of repair until such time as other methods may be approved. The commissioning of the cathodic protection (CP) system and a direct assessment survey (to be conducted in the spring of 2016) provide additional mitigation measures to address this concern.***

Sacrificial coatings were used over the coated welds on pipe installed by Horizontal Directional Drilling (HDD). ***Directive 2015-009 was issued to address correct installation of the additional sacrificial coating.***

The frequency of adhesion testing during winter months was addressed by increasing the frequency of those tests from October 1st through March 31st. ***Directive 2015-011 was issued.***

Trenching and Backfill (TAB 8)

Sand berms/pillows were used in some areas instead of sandbags for pipe support. ***CAR 2015-002 was issued. The use of sand berms was discontinued unless it is added to the technical specifications as an approved method of support and padding of the pipe.***

The technical specifications require the use of pipe supports in all locations unless otherwise directed by the Construction Management Team (CMT). The CMT determined that the use of pipe supports was unwarranted in the area from station 240+26 to 279+75 due to the uniform sandy condition of the trench. ***Directive 2015-005 was issued to document this direction.***

It was determined that compaction requirements in typical cross-county areas needed further clarification. ***Directive 2015-006 was issued to document this clarification.***

It was determined that the general backfill material specifications were overly restrictive. ***Directive 2015-007 was issued to change the maximum dimension for stones to clods in general backfill from 3" in the longest dimension to 6" in the longest dimension.***

Horizontal Directional Drilling (TAB 9)

The HDD installation under Route 2A and the railroad in Essex did not meet the acceptance criteria in place at the time it was installed. ***CAR 2015-008 was issued. The investigation included an indirect inspection of the pipe in question by EN Engineering. (See the CAR for more specific information). The results of the testing indicated that the pipe is acceptable. The commissioning of the cathodic protection (CP) system and a direct assessment survey (to be conducted in the spring of 2016) will provide additional mitigation measures to address this concern.***

Conclusion

VGS developed and implemented a robust Quality Assurance Plan for the Addison Natural Gas Project. The program highlighted actual and potential Condition Adverse to Quality (CAQ) that were remediated according to the Plan. With the increased investment in the QA/QC program, many potential quality issues were addressed by the use of Specification and Directives, rather than becoming conditions which required corrective actions .The commitment to quality is further evident by the fact that most issues in 2015 were addressed before they became a CAQ.

Additionally, VGS has accelerated planned mitigation measures, including the commissioning of the CP system at the time of gas-up, additional patrols and direct assessment surveys.

TAB 2

Vermont Gas

Welding Program

Rev. 5 08/17/2015

Section I. Administration of Plan

All pipeline welding at VGS shall be done in conformance with this program and API 1104 (Welding of Pipelines and Related Facilities) as incorporated by reference into 49 CFR Part 192.

This program does not cover welding done in accordance with section IX of the ASME Boiler and Pressure Vessel Code (BPVC).

The VGS Welding Program shall be reviewed periodically to ensure that all documents are relevant and current.

Section II. Abbreviations and Definitions

Codes and Compliance Administrator: Individual responsible for updating and posting welding program information in cooperation with the Welding Supervisor.

Coupon Test Report: Report showing destructive tests performed and the results thereof.

CPWI- Certified Pipeline Welding Inspector: CPWI™ is an individual who has completed the intense classroom training and testing by the National Welding Inspection School governing all of the codes and standards for pipeline construction and in-service welding.

CWI – Certified Welding Inspector: A person certified by AWS as meeting the qualification requirements of 5.2, 6.1, and 6.2 of AWS B5.1, Specification for the Qualification of Welding Inspectors.

PQR- Procedure Qualification Record: The WPS is supported by a number of documents (e.g., a record of how the weld was made, NDE, mechanical test results) which together comprise the Procedure Qualification Record. The PQR combines all of the information of the WPS and adds the test results to provide a complete document that certifies the WPS.

SMAW- Shielded Metal Arc Welding: A manual arc welding process that uses a consumable electrode coated in flux to lay the weld. An electric current, in the form of either alternating current or direct current from a welding power supply, is used to form an electric arc between the electrode and the metals to be joined. The work piece and the electrode melt forming the weld pool that cools to form a strong joint. As the weld is laid, the flux coating of the electrode disintegrates, giving off vapors that serve as a shielding gas and providing a layer of slag, both of which protect the weld area from atmospheric contamination.

VGS Welding Supervisor: Individual responsible for administering the VGS Welding Program. This is not necessarily a job title for purposes other than the administration of this program.

Welding Process: A materials joining process which produces coalescence of materials by heating them to suitable temperatures with or without the application of pressure or by the application of pressure alone and with or without the use of filler material. There are many types of welding processes. VGS uses the SMAW Process.

WPS- Welding Procedure Specification: A formal written document describing welding procedures, which provides direction to the welder for making sound and quality production welds as per the code requirements. The purpose of the document is to guide welders to the accepted procedures so that repeatable and trusted welding techniques are used.

WQR-Welder Qualification Report: Individual welders are certified with a qualification test documented in a Welder Qualification Report that shows they have the understanding and demonstrated ability to work within the specified WPS.

Section III. Welding Procedure Specifications

All welds must follow parameters in a WPS. If any changes are required new WPS must be created and tested in accordance with this section.

When a new welding procedure is required, it will be developed in accordance with API 1104 Section 5.3, using the VGS Welding Procedure Specification Form and the document Issuing a VGS Welding Procedure Specification (Appendix D).

All Welding Procedure Specifications must be supported by a Welding Procedure Qualification Record which demonstrates that welds with suitable mechanical properties and soundness can be made by the procedure. The method of conducting a Welding Procedure Qualification is detailed in Section IV.

Changes to a previously qualified WPS may be made and supported by the previous PQR unless any of the following essential variables are changed. In the case that an essential variable is changed, the procedure must be qualified according to Section IV.

WPS Essential Variables Requiring a New PQR

- Change in Welding Process
- Change in Base Material from one group to another
    - Group A – Specified minimum yield strength less than or equal to 42,000 psi.

- Group B – Specified minimum yield strength greater than 42,000 psi but less than 65,000 psi.
  - Group C – Specified minimum yield strength greater than or equal to 65,000 psi. (Each grade in Group C requires a separate PQR.)
  - Note: Welding materials of two separate groups is allowed. The procedure for the higher strength group shall be used.
- Major change in Joint Design
  - Major changes include a change from V groove to U groove.
  - Minor changes which do not constitute an essential variable include changes in the angle of bevel or the land of the welding groove.
- Change in Position from fixed to roll or vice versa.
- Change in Wall Thickness Group
  - Nominal pipe wall thickness less than 0.188 in.
  - Nominal pipe wall thickness from 0.188 in. through 0.750 in.
  - Nominal pipe wall thickness greater than 0.750 in.
- Changes in Filler Metal (Refer to Appendix B)
  - Change from one filler metal group to another
  - For Group C Materials, a change in the AWS designation of the filler material
- Change in Electrical Characteristics
  - Change from Electrode Negative to Electrode Positive or vice versa.
  - Change in current from DC to AC or vice versa.
- Increase in the maximum time between completion of the root bead and the start of the second bead.
- Change in the Direction of Welding from Uphill to Downhill or vice versa.
- Change in flux
- Change in the range for Speed of Travel
- Decrease in the specified minimum preheat temperature
- The addition of or change to Post Weld Heat Treatment Specifications

If there is no essential variable change requiring a procedure qualification, the signed WPS will be forwarded to the VGS Welding Supervisor or Codes and Compliance Administrator for issuing and posting in accordance with Section VI of this plan.

If a procedure qualification is required for a new WPS (including changes to a current WPS that include changes in essential variables, the draft WPS will be tested in accordance with Section IV of this plan.

Section IV. Procedure Qualifications

Procedure qualification involves making a procedure qualification weld and testing that weld.

When the procedure qualification weld is made, both the welder and the tester must have a copy of the draft WPS readily available for reference. The tester shall be a CWI, a CPWI or an individual qualified by appropriate training and experience and approved by the VGS Welding Supervisor. If the tester is not a VGS employee, a company representative must witness the welding and testing.

The actual welding parameters are checked and recorded at the time of welding, by the tester, to ensure the WPS is being followed. These may be recorded directly onto the VGS Weld Procedure Qualification Coupon Test Report (Appendix D) or transferred to it after being recorded elsewhere during the actual test.

Supporting documentation, such as material test reports and inspector's notes should become part of the PQR.

All testing both non-destructive and destructive, is recorded on the VGS Weld Procedure Qualification Coupon Test Report. Required tests are detailed in API 1104 Sections 5.6 and 5.8.

Once all the parameters and test results are recorded on the VGS Weld Procedure Qualification Coupon Test Report the tester shall determine, based on the test results, if the procedure is qualified, qualified with changes to the draft or disqualified and so indicate on the test report. The report shall then be signed by the tester. If the tester is not a VGS employee, the company representative witnessing the welding and testing must also sign the test report. Once signed, no changes may be made to any VGS Weld Procedure Qualification Coupon Test Report.

The VGS Weld Procedure Qualification Coupon Test Report and any additional documentation shall then be forwarded to the VGS Welding Supervisor or the VGS Codes and Compliance Administrator.

Section V. Welder Qualifications

The primary purpose for Welder Qualification is to verify the ability of an individual to execute a qualified welding procedure specification to produce a sound weld. Welders qualify to a specific welding process (i.e. SMAW), not a specific welding procedure.

There are three types of welder qualification covered by this welding plan: Single Qualification, Multiple Qualification and Requalification.

Single Qualification: A welder shall make a test weld using a qualified procedure to make a butt weld in the fixed position (per API 1104 Section 6.2.1). A welder qualified with a single qualification test shall be qualified to make butt welds within the limits of the essential variables listed below. If any of these variables change the welder must requalify.

- Change in Welding Process
- Change in the Direction of Welding from Uphill to Downhill or vice versa.
- Change in Filler Metal (Refer to Appendix B)
  - From Group 1 or 2 to Group 3
  - From Group 3 to Group 1 or 2
- Change for one outside diameter group to another
  - Outside diameter less than 2.375 in.
  - Outside diameter from 2.375 in. through 12.750 in.
  - Outside diameter greater than 12.750 in.
- Change in Wall Thickness Group
  - Nominal pipe wall thickness less than 0.188 in.
  - Nominal pipe wall thickness from 0.188 in. through 0.750 in.
  - Nominal pipe wall thickness greater than 0.750 in.
- Change in Position
  - From vertical to horizontal or vice versa
  - Note: Passing a butt weld qualification test in the fixed position with the axis inclined 45° from the horizontal plane shall be qualified to do butt welds and lap fillet welds in all positions
- Change in Joint Design

Multiple Qualification: A welder who completes the butt weld qualification test on pipe with an outside diameter greater than or equal to 12.750 in. and a full-size branch connection weld on pipe with an outside diameter greater than or equal to 12.750 in. shall be qualified to weld in all positions; on all wall thicknesses, joint designs and fittings; and on all pipe diameters.

A welder who completes the butt weld qualification test on pipe with an outside diameter less than 12.750 in. and a full-size branch connection weld on pipe with an outside diameter less than 12.750 in. shall be qualified to weld in all positions; on all wall thicknesses, joint designs and fittings; and on all pipe diameters less than or equal to the outside diameter used by the welder in the qualification tests.

To perform a multiple qualification the welder shall make two test welds using qualified procedures.

For the first test, the welder shall make a butt weld in the fixed position with the axis of the pipe either in the horizontal plane or inclined from the horizontal plane at an angle of not more than 45°. This weld shall be made on pipe with an outside diameter of at least 6.625 in. and with a wall thickness of at least 0.250 in. without a backing strip.

For the second test, the welder shall lay out, cut, fit and weld a full-sized branch-on-pipe connection. This weld shall be made on pipe with an outside diameter of at least 6.625 in. and with a wall thickness of at least 0.250 in. A full size hole shall be cut in the run. The weld shall be made with the run-pipe axis in the horizontal position and the branch-pipe extending vertically downward from the run.

If any of the following essential variables are changed, the welder must requalify:

- Change in Welding Process
- Change in the Direction of Welding from Uphill to Downhill or vice versa.
- Change in Filler Metal (Refer to Appendix A)
  - From Group 1 or 2 to Group 3
  - From Group 3 to Group 1 or 2

Requalification: A welder may not weld on pipe unless within the preceding 6 calendar months the welder has had at least one production weld tested and found acceptable under section 6 of API 1104. Alternatively, a welder may maintain qualification status by performing welds tested and found acceptable under section 6 of API 1104 at least twice each calendar year, but at intervals not exceeding 7 ½ months.

If there is a specific reason to question a welder's ability to make welds that meet the specifications s/he shall perform a requalification test.

To complete the requalification test a welder shall make a test weld using a qualified procedure to make a butt weld in the fixed position.

The Welder Continuity Report shall be used to document compliance with this section of the Welding Program.

Welder Qualification Tests

For all types of welder qualification tests, both the welder and the tester must have a copy of the WPS readily available for reference. The tester shall be a CWI, a CPWI or an individual qualified by appropriate training and experience and approved by the VGS Welding Supervisor. If the tester is not a VGS employee, a company representative must witness the welding and testing.

Prior to starting the welder qualification test(s), the welder shall be allowed reasonable time to adjust the welding equipment to be used. The welder must follow the WPS and shall use the same welding technique and proceed with the same speed s/he will use if s/he passes the test and is permitted to do production welding.

During welder qualification test(s) the following shall be verified by the tester and conformance or non-conformance to the parameters will be noted on the Welder Qualification Checklists.

1. Preheat
2. Pipe end damage and cleanliness
3. Proper space and alignment
4. Electrode classification, condition and diameter
5. Correct polarity
6. Proper ground connection
7. Amperage, voltage and travel speed
8. Clamp release at proper time
9. Visually inspect root pass for cracks, burn-through, etc.
10. Welder identification

During the welding test(s), the tester shall record the following parameters. These may be recorded directly onto the VGS Welder Qualification Report (Appendix D) or transferred to it after being recorded elsewhere during the actual test.

- Pipe Outside Diameter
- AWS Class
- Direction of Travel

The tester shall visually examine all test welds. For a qualification test weld to be acceptable it shall be free from cracks, inadequate penetration and burn-through, and must present a neat workman-like appearance. The depth of undercutting adjacent to the final bead on the outside of the pipe shall not be more than 1/32 in. or 12.5% of the pipe wall thickness, whichever is smaller, and there shall not be more than 2 in. of undercutting in any continuous 12 in. length of weld.

The tester shall examine test weld to ensure that they are acceptable according the requirements set forth in API 1104 Section 6.2.1 (Single Qualification and Requalification) or Section 6.3.1 (Multiple Qualification).

All testing (visual, destructive and non-destructive [optional]) shall be recorded on the VGS Welder Qualification Report in accordance with the instruction document Issuing a VGS Welder Qualification Report (Appendix D).

Once the parameters and test results are recorded on the VGS Welder Qualification Report, the tester shall determine, based on the test results and the Welder Qualification Checklist, if the welder is qualified or disqualified and so indicate on the test report. The report shall then be signed by the tester. If the tester is not a VGS employee, the company representative witnessing the welding and testing must also sign the test report.

The VGS Welder Qualification Test Report, the Welder Qualification Checklist and any additional documentation shall then be forwarded to the VGS Welding Supervisor or the VGS Codes and Compliance Administrator.

Section VI. Recordkeeping

When any completed document/form is received by the VGS Welding Supervisor or the VGS Codes and Compliance Administrator, s/he will check if for completeness and accuracy. If there are any discrepancies on the document/form, it will be returned for clarification.

Completed forms will be scanned and placed in an appropriate folder on the VGS shared drive. This folder will be set up in a manner that will allow all VGS employees access to the information (see specific information below). Access for any purpose other than viewing and printing will be limited to the VGS Welding Supervisor, the VGS Codes and Compliance Administrator and the IT Department.

The following folders will be maintained on the VGS Shared Drive:

Welding Procedure Specifications: All current, qualified procedures will be maintained in this folder. Everyone will have view/print access. Any and all production welding shall be performed using a WPS from this folder.

Procedure Qualification Records: A PQR supporting each WPS in the above folder will be maintained in this folder. Everyone will have view/print access.

Qualified Welders: A list of all currently qualified welders will be maintained in this folder. Additionally this folder will contain the most recent qualification test for each qualified welder. Everyone will have view/print access.

Welder Qualification Records: Historical WQR records will be maintained in this folder. This folder will have access restricted to the VGS Welding Supervisor, the VGS Codes and Compliance Administrator and the IT Department.

Retired Welding Procedure Specification and Procedure Qualification Records: Historical WPS and PQR records will be maintained in this folder. This folder will have access restricted to the VGS Welding Supervisor, the VGS Codes and Compliance Administrator and the IT Department.

Section VII. Production Welding

All production welding must be done in accordance with a qualified Welding Procedure Specification. A copy of the relevant Welding Procedure Specifications will be issued to the welder to reference during any welding operations. The welder will verify through appropriate document control procedures that the WPS is current.

During production welding, the following shall be verified during the first weld of the day and at least once more during the day if additional production welds are performed.

11. Preheat
12. Pipe end damage and cleanliness
13. Proper space and alignment
14. Electrode classification, condition and diameter
15. Correct polarity
16. Proper ground connection
17. Amperage, voltage and travel speed
18. Clamp release at proper time
19. Visually inspect root pass for cracks, burn-through, etc.
20. Welder identification

APPENDIX A
REVISION LOG

Revision 1	Date 06/12/2015
Miscellaneous	Minor changes for clarity or grammar which do not effect procedures
Section IV	Added language disallowing changes to any signed Procedure Qualification Test Record
Appendix A	Added Revision Log
Appendix B	Appendix A was renamed Appendix B
Appendix C	VGS Welding Document Numbering System was removed from Appendix D and is now Appendix C
Appendix D	Appendix B was renamed Appendix D
Appendix D Issuing a VGS WPS	Added language requiring WPS to include all electrode diameters that may be used; Added language requiring that any changes found necessary to a draft WPS during testing be made prior to the WPS being signed and issued.
Appendix D Weld Procedure Coupon Test Report	Modified form to include enough samples for testing procedures on large diameter pipe.
Appendix D	Removed Weld Procedure Qualification Checklist as it is not a required document, rather a note taking aid.
Appendix D Welder Qualification Report	Modified form to remove calculations for tensile test, as they are not required for welder qualification. Added enough samples for testing welders on large diameter pipe.

Revision 2	Date 07/27/2015
Miscellaneous	Minor changes for clarity or grammar which do not effect procedures
Title	Retitled document
Section II	Added definitions for CPWI and CWI
Section III	Added language requiring all weld follow WPS parameters
Section IV	Removed references to Weld Procedure Qualification Checklist which was removed from Appendix D in Revision 1
Section IV and Appendix D VGS Weld Procedure Qualification Coupon Test Instruction and Report	Added "qualified with changes to the draft" to options for completing VGS Weld Procedure Qualification Coupon Test Report
Section V	Added language specifically requiring that WPS be followed during qualification testing.
Section V	Changed required parameter from "Rod Diameter" to "Pipe Outside Diameter" to correct previous error
Appendix D	Added language in reference to Preheat section in WPS forms to define allowable methods and controls.

Revision 3	Date 08/03/2015
Section I	Added language specifying that this plan does not cover ASME welding
Section VII	Added section on production welding
Title	Reverted to original title

APPENDIX A
REVISION LOG

	Revision 4	**Date 08/05/2015**
Section V	Modified Welder Qualification Tests subsection to include Welder Qualification Checklist	
Appendix D	Added Welder Qualification Checklist	

	Revision 5	**Date 08/17/2015**
Section V	Modified Requalification language and clarified requirements	
Appendix D	Added Welder Continuity Record	

	Revision 6	**Date XX/XX/XX**

	Revision 7	**Date XX/XX/XX**

	Revision 8	**Date XX/XX/XX**

Appendix B

Table 1—Filler Metal Groups

Group	AWS Specification	AWS Classification Electrode	Flux [c]
1	A5.1	E6010, E6011	
	A5.5	E7010, E7011	
2	A5.5	E8010, E8011, E9010	
3	A5.1 or A5.5	E7015, E7016, E7018	
	A5.5	E8015, E8016, E8018	
		E9018	
4 [a]	A5.17	EL8	P6XZ
		EL8K	F6X0
		EL12	F6X2
		EM5K	F7XZ
		EM12K	F7X0
		EM13K	F7X2
		EM15K	
5 [b]	A5.18	ER70S-2	
	A5.18	ER70S-6	
	A5.28	ER80S-D2	
	A5.28	ER90S-G	
6	A5.2	RG60, RG65	
7	A5.20	E61T-GS [d]	
		E71T-GS [d]	
8	A5.29	E71T8-K6	
9	A5.29	E91T8-G	

NOTE Other electrodes, filler metals, and fluxes may be used but require separate procedure qualification.

[a] Any combination of flux and electrode in Group 4 may be used to qualify a procedure. The combination is identified by its complete AWS classification number, such as F7A0-EL12 or F6A2-EM12K. Only substitutions that result in the same AWS classification number are permitted without requalification.

[b] A shielding gas (see 5.4.2.10) is required for use with the electrodes in Group 5.

[c] In the flux designation, the X can be either an A or P for as-welded or postweld heat treated.

[d] For root pass welding only.

APPENDIX C

VGS Welding Document Numbering System

WPS -VGS-X65-1:2014-1

Type of document: WPS – Welding Procedure Specification
PQR – Procedure Qualification Record
WQR – Welder Qualification Record

WPS-VGS-X65-1:2014-1

Vermont Gas Systems

WPS-VGS-X65-1:2014-1

Type of material

WPS-VGS-X65-1:2014-1

Procedure number: 1 – Branch
2 – Butt
3 - Delay
Additional numbers to be assigned as needed

WPS-VGS-X65-1:2014-1

Year and version. The year of issue and the version. Additional versions of a WPS may be issued based on one PQR.

The revision number shall be shown in the lower left hand corner of the document. This should not be confused with the version number. A revision would be a change to a specific version. All documents shall be issued initially as Revision 0.

Weld Procedure Qualification Coupon Test Report

Test/Report Number shall be the six digit date, followed by a dash and a number indicating the number of the test on that day. i.e. 040815-1, 040815-2, etc.

Appendix D

Issuing a VGS Welding Procedure Specification

1. Title the WPS to make it clear what the specification covers. There is no specific convention for naming, as the numbering system will be the method of document control.

2. Assign WPS number based on the VGS Welding Document Number System (Appendix C).

3. If WPS is being issued based on a previously performed Procedure Qualification Record, fill in the Supporting Procedure Qualification Record Number.

   If WPS is being issued pending Procedure Qualification testing, note "Pending Qualification" in place of a supporting Qualification Record Number.

4. Fill out welding information on the WPS form as follows:

   - Select type of shielding
     - Flux – Cellulose
     - Flux – Iron Powder
   - Select Pipe Material Type
     - Group A – Specified minimum yield strength less than or equal to 42,000 psi.
     - Group B – Specified minimum yield strength greater than 42,000 psi but less than 65,000 psi.
     - Group C – Specified minimum yield strength greater than or equal to 65,000 psi. Each grade of group C materials requires a separate qualification test. For Group C materials specify the grade.
   - Select Pipe Diameter range
   - Select Wall Thickness range
   - Select Filler Metal Group(s)
     - Select all filler metal groups to be used in this procedure. Specify designations within each group.
   - Specify Preheat instructions. If no preheat is required this must be noted.
   - Specify Postheat instructions. If no postheat is required this must be noted.
   - Sketch joint design if not using a form prepopulated with sketch.
   - For bead 1, 2 and 3+ specify the following paremeters:
     - Specify Electrode size (enter all diameters that may be used)
     - Specify Electrode designation
     - Specify Voltage Range

- Specify Amperage Range
- Select AC or DC Current
- Select Electrode Positive or Electrode Negative Polarity
- Select Uphill or Downhill Direction of Travel
- Specify Travel Speed Range

- Specify allowable time lapses.
  - Bead 1 to Bead 2
  - Bead 2 to each subsequent Bead
- Select Line Up Clamps specifications. (If clamp is allowed but not required "Not Required" should be checked, along with allowable clamp type.)
- Select allowable tools for cleaning and grinding.

5. If WPS is being issued pending Procedure Qualification testing, the procedure should not be signed. It should be issued clearly marked "DRAFT" (either by ink stamp or water mark). The WPS will then be tested. If required, changes to the draft WPS shall be updated with any changes found to be necessary during testing and then issued per the VGS Welding Procedure Qualification document. The WPS shall then be signed and dated by the preparer and forwarded to an Operations Supervisor or Manager for review and approval.

   If WPS is being issued based on a previously performed Procedure Qualification Record the Preparer should sign and date the WPS and forward to an Operation Supervisor or Manager for review and approval.

6. Once the WPS has been reviewed and approved, forward it to the VGS Welding Supervisor or Codes and Compliance Administrator for issuing and posting.

WELDING PROCEDURE SPECIFICATION

Vermont Gas

TITLE

WPS #

Supporting Procedure Qualification Record:

In accordance with API 1104

Welding Process: SMAW Position: Fixed Joint Design: V Bevel (see sketch) Minimum # Passes: 3 Shielding:

Pipe Material Description: ☐ Group A ☐ Group B ☐ Group C : Specify

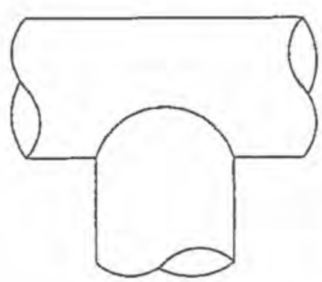
Diameter: ☐ OD < 2.375 Inches ☐ OD 2.375 to 12.750 Inches ☐ OD > 12.750 Inches

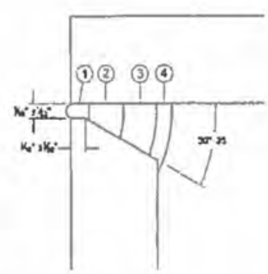
Wall Thickness(es): ☐ Nominal WT < 0.188 In ☐ Nominal WT 0.188 to 0.750 In ☐ Nominal WT > 0.750 In

Filler Metal Group(s): ☐ Group 1 ☐ Group 2 ☐ Group 3

Preheat: Flame heat; Monitor using temperature crayons, pyrometer or infrared thermometer

Postheat: Flame heat; Monitor using temperature crayons, pyrometer or infrared thermometer





NOT TO SCALE

Bead #	Electrode Size	Electrode Designation	Voltage Range	Current Amperage Range	Current AC/DC	Polarity	Direction of Travel	Travel Speed
1								IPM
2								IPM
3+								IPM

Time Lapse Bead 1 to Bead 2: Bead 2 to each succeeding bead:

Line Up Clamp: ☐ Internal ☐ External ☐ Not Required Removal (if used): After minimum of 50% of root bead welding

Cleaning and/or Grinding: ☐ Power Tools ☐ Hand Tools

repared by: Date/Time Field

Approved by: Date/Time Field

Rev. 1 07/29/15

WELDING PROCEDURE SPECIFICATION

Vermont Gas

TITLE

WPS #

Supporting Procedure Qualification Record:

In accordance with API 1104

Welding Process: SMAW Position: Fixed Joint Design: V Bevel (see sketch) Minimum # Passes: 3 Shielding:

Pipe Material Description: ☐ Group A ☐ Group B ☐ Group C : Specify

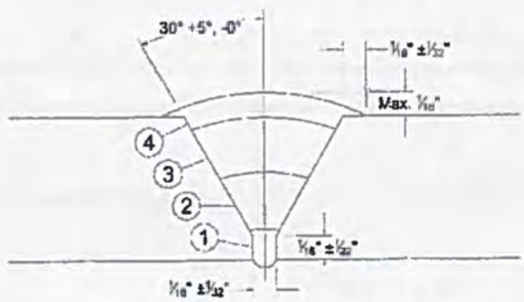
Diameter: ☐ OD < 2.375 Inches ☐ OD 2.375 to 12.750 Inches ☐ OD > 12.750 Inches

Wall Thickness(es): ☐ Nominal WT < 0.188 In ☐ Nominal WT 0.188 to 0.750 In ☐ Nominal WT > 0.750 In

Filler Metal Group(s): ☐ Group 1 ☐ Group 2 ☐ Group 3

Preheat: Flame heat; Monitor using temperature crayons, pyrometer or infrared thermometer

Postheat: Flame heat; Monitor using temperature crayons, pyrometer or infrared thermometer



NOT TO SCALE

Bead #	Electrode Size	Electrode Designation	Voltage Range	Current Amperage Range	Current AC/DC	Polarity	Direction of Travel	Travel Speed
1								IPM
2								IPM
3+								IPM

Time Lapse Bead 1 to Bead 2: Bead 2 to each succeeding bead:

Line Up Clamp: ☐ Internal ☐ External ☐ Not Required Removal (if used): After minimum of 50% of root bead welding

Cleaning and/or Grinding: ☐ Power Tools ☐ Hand Tools

Prepared by: Date/Time Field

Approved by: Date/Time Field

Rev. 1 07/29/15 Page 1 of 1

WELDING PROCEDURE SPECIFICATION

Vermont Gas

TITLE

WPS #

Supporting Procedure Qualification Record:

In accordance with API 1104

Welding Process: SMAW Position: Fixed Joint Design: V Bevel (see sketch) Minimum # Passes: 3 Shielding:

Pipe Material Description: ☐ Group A ☐ Group B ☐ Group C : Specify

Diameter: ☐ OD < 2.375 Inches ☐ OD 2.375 to 12.750 Inches ☐ OD > 12.750 Inches

Wall Thickness(es): ☐ Nominal WT < 0.188 In ☐ Nominal WT 0.188 to 0.750 In ☐ Nominal WT > 0.750 In

Filler Metal Group(s): ☐ Group 1 ☐ Group 2 ☐ Group 3

Preheat: Flame heat; Monitor using temperature crayons, pyrometer or infrared thermometer

Postheat: Flame heat; Monitor using temperature crayons, pyrometer or infrared thermometer

Bead #	Electrode Size	Electrode Designation	Voltage Range	Current Amperage Range	Current AC/DC	Polarity	Direction of Travel	Travel Speed
1								IPM
2								IPM
3+								IPM

Time Lapse Bead 1 to Bead 2: Bead 2 to each succeeding bead:

Line Up Clamp: ☐ Internal ☐ External ☐ Not Required Removal (if used): After minimum of 50% of root bead welding

Cleaning and/or Grinding: ☐ Power Tools ☐ Hand Tools

Prepared by: Date/Time Field

Approved by: Date/Time Field

Rev. 1 07/29/15

VGS Welding Procedure Qualification Record Instructions

1. Enter title of Welding Procedure Specification to be qualified.

2. Assign PQR number based on the VGS Welding Document Number System.

3. Enter the Welder(s) name(s).

4. Enter qualification date(s).

5. Attach the following documents:

   - Draft WPS (Enter number on cover sheet)
   - Procedure Qualification Test Report (Enter number on cover sheet)
   - Final WPS as issued (signed) (Enter number on cover sheet)

6. Check the following documents if available and attach to cover sheet:

   - Inspector's Notes
   - Radiographic Inspection Report
   - Material Test Report

7. Preparer should sign and date the WPS and forward to an Operations Supervisor or Manager for review and approval.

8. Once the PQR has been reviewed and approved, forward it to the VGS Welding Supervisor or Codes and Compliance Administrator for issuing and posting.

9. Information on attaching additional WPS(s) to the Welding Procedure Qualification Record is included in Issuing and Posting VGS Welding Documents procedure.

WELDING PROCEDURE QUALIFICATION RECORD

Vermont Gas

TITLE

PQR#

In accordance with API 1104

Weldor ______ Date ______

Required Attachments

Draft WPS Number ______

Procedure Qualification Test Report #: ______

Final WPS as issued (signed) ______

Additional Attachments

(if available)

- ☐ Inspector's Notes
- ☐ Procedure Qualification Checklist
- ☐ Radiographic Inspection Report
- ☐ Material Test Report

Prepared by: ______ Date/Time Field ______

Approved by: ______ Date/Time Field ______

Changes other than essential variables listed in API 1104 5.4.2 may be made in the procedure without the need for requalification. Any procedures issued without the need for requalification based on this Procedure Qualification Record must be listed below and attached to this file.

Final WPS as issued (signed)		Date	
Final WPS as issued (signed)		Date	
Final WPS as issued (signed)		Date	
Final WPS as issued (signed)		Date	
Final WPS as issued (signed)		Date	

Issuing a VGS Weld Procedure Qualification Coupon Test Report

1. Enter WPS number from the draft WPS being qualified.
2. For Test/Report Number, enter six digit date, followed by a dash and a number indicating the number of the test on that day. i.e. 040815-1, 040815-2, etc.
3. Enter date of coupon test.
4. Enter Welder's name.
5. Enter last 4 digits of welder's Social Security Number.
6. Enter welder's stencil information. If not available, stencil will be last 4 digits of welder's SSN.
7. Enter Contractor employing welder. If VGS employee, so state.
8. Enter project name if applicable. Enter N/A if qualification if not related to a specific project.
9. Enter location of test.
10. Enter weather information.
11. Enter Pipe Material Description.
12. Enter Electrical Characteristics.
13. Enter Pipe Diameter.
14. Enter Welding Machine information.
15. Enter Pipe Wall Thickness
16. Enter Preheat temperature observed. If no preheat used, enter N/A.
17. Enter Pipe Manufacturer.
18. Select Direction of Travel: Uphill, Downhill or Combination. If "Combination" is selected, enter direction for each pass in the "Notes" section below.
19. Enter Pipe Heat Number.
20. Select number of welders.
21. Enter Joint Design description.
22. Select methods of Cleaning/Grinding observed.

23. Select filler metals observed being used on root and subsequent passes.

24. Enter welding position observed.

25. Select shielding type observed being used.

26. Enter lapse time observed between passes 1 and 2, and between subsequent passes.

27. Enter information on how welder's identification was verified. (i.e. Driver's License, Passport)

28. Enter total weld time.

29. Enter Interpass Temperature observed.

30. Enter Postheat temperature observed. If no postheat used, enter N/A.

31. Enter following information as observed during the test weld:

- Weld Pass
- Electrode Type
- Rod Diameter
- Preheat Temperature
- Voltage Range
- Amperage Range
- Travel Speed
- Start and Stop times for each pass

Note: One method of measuring the travel speed that may be used is to begin timing the welding process when the welder initiates the arc and stop when the weld pass is terminated. Determine how much time elapsed along with the total length of filler metal deposited. Divide the length of filler metal in inches by the elapsed time in seconds. Multiply by 60 to determine the travel time in inches per minutes.

32. Enter following test information as required by API 1104 Section 5.6 and 5.8:

- Bend Tests
- Nick Break Tests
- Tensile Tests

33. Select whether weld was destructively tested, examined by radiography, or both. If examined by radiography, attach copy of radiography report.

34. Select whether procedure was Qualified, Qualified with Changes or Disqualified. If Qualified with Changes, note any changes made to the Draft WPS.

35. If qualified, select the qualification limitations for the test based on API 1104.

36. Person conducting the test shall sign and date form. If person conducting the test is not a VGS employee, test must be observed and signed by a company representative.

37. Attach Weld Procedure Qualification Coupon Test Report to Welding Procedure Qualification Record. Submit as directed in VGS Welding Procedure Qualification Instructions.

Weld Procedure Qualification Coupon Test Report

Vermont Gas	Welding Procedure number:
	Test/Report No:
	Date:
	Welder:
	Social Security Number: XXX-XX-
	Welder Stencil:
Contractor:	**Project:**
Location:	**Weather:**
Welding Process: Manual SMAW	**Pipe Material Description:**
Electrical Characteristics:	**Pipe Diameter:**
Welding Machine:	**Wall Thickness:**
Preheat Temperature:	**Pipe Manufacturer:**
Direction of Travel	**Heat Number:**
Number of Welders: ○ 1 ○ 2	**Joint Design:**
Method of Cleaning: ☐ Hand Tools ☐ Power Tools	**Filler Metal:** Root Subsequent
Position:	**Shielding:**
Time Between Passes: 1-2 Subsequent	**Welder Identification Verified:**
Total Weld Time:	**Interpass Temperature:**
Post Weld Heat Treatment:	**Notes:**

WELD PASS	ELECTRODE	ROD DIAMETER	PREHEAT	VOLTAGE RANGE	AMPERAGE RANGE	TRAVEL SPEED (inches per min.)	Start / Stop
			°F	/	/	IPM	/
			°F	/	/	IPM	/
			°F	/	/	IPM	/
			°F	/	/	IPM	/
			°F	/	/	IPM	/
			°F	/	/	IPM	/
			°F	/	/	IPM	/

Notes:

Weld Procedure Qualification Coupon Test Report

Bend Tests				Nick Break Tests		Additional Nick Break in lieu of Tensile	
Face 1		Root 1		Nick 1		Nick 5	
Face 2		Root 2		Nick 2		Nick 6	
Face 3		Root 3		Nick 3		Nick 7	
Face 4		Root 4		Nick 4		Nick 8	

	Tensile 1	Tensile 2	Tensile 3	Tensile 4
Dimensions				
Area				
Max Load				
Tensile Strength				
Fracture Location				
Disposition				

☐ Destructively Tested ☐ Examined by Radiography (not required); If performed, attach copy of Radiography Report.

☐ **Qualified** ☐ **Qualified with Changes (see notes below)** ☐ **Disqualified**

Note any Changes to Draft WPS:

Qualification Limitations for this Test				
	Diameter:	☐ < 2.375" O.D.	☐ 2.375" - 12.75" O.D.	☐ >12.75" O.D.
	Wall Thickness:	☐ < .188" W.T.	☐ .188" - .750" W.T.	☐ > .750" W.T.

I/We certify that the statements in this record are correct and that the test welds were prepared, welded and tested in accordance with the requirements of API 1104 (latest edition adopted by 49 CFR 192).

Tested by: Date:

Company Representative: Date:
(Required if tested by other than Company personnel)

Issuing a VGS Welder Qualification Test Report

1. Enter Welder's name.
2. Enter Welder's employer.
3. Enter location of test.
4. Enter date of test.
5. Select type of qualification:
    - Single (Butt Weld only)
    - Multiple (Butt and Branch Welds)
    - Requalification (Butt Weld Only)
6. Select Butt Weld Test or Low Hydrogen Sleeve (groove weld) Test
7. Enter Number for WPS being used.
8. Enter pipe information:
    - Pipe specification and grade
    - Pipe diameter
    - Pipe wall thickness
9. Enter following information as observed during the test weld:
    - Rod Diameter
    - Electrode AWS Class
    - Direction of travel
10. Enter following test information as required by API 1104 Section 5.6:
    - Bend Tests
    - Nick Break Tests
    - Tensile Tests
11. Select whether visual inspection is Acceptable or Unacceptable
12. Select Weld Test or Low Hydrogen Sleeve (fillet weld) Test if multiple qualification was selected above. If Single qualification or Requalification was selected proceed to step 18.

13. Enter Number for WPS being used.

14. Enter pipe information:

- Pipe specification and grade
- Pipe diameter
- Pipe wall thickness

15. Enter following information as observed during the test weld:

- Rod Diameter
- Electrode AWS Class
- Direction of travel

16. Enter the Nick Break Test information as required by API 1104 Section 5.8.

17. Select whether visual inspection is Acceptable or Unacceptable

18. Select whether radiographic inspection was used during the test and whether it was acceptable or unacceptable.

19. Person conducting the test shall sign and date form. If person conducting the test is not a VGS employee, test must be observed and signed by a company representative.

20. Forward completed form to the VGS Welding Supervisor or Codes and Compliance Administrator for recordkeeping.

WELDER QUALIFICATION REPORT

In accordance with API 1104

Vermont Gas

Welder Name: Employer

Test Location Date

Qualification Type: ◯ Single (Butt Weld Only) ◯ Multiple (Butt and Branch Welds) ◯ Requalification (Butt Weld Only)

◯ Butt Weld Test ◯ Low Hydrogen Sleeve (groove weld) Test WPS #

Process: SMAW Joint Design: V-Bevel Position: Fixed

Pipe Spec/Grade: Pipe Diameter: Pipe Wall Thickness:

Pass	Rod Diameter	AWS Class	Direction of Travel
Root Pass			
Hot Pass			
Filler Pass(es)			
Cap Pass(es)			

Nick Break Tests

Nick 1

Nick 2

Nick 3

Nick 4

Bend Tests

Face 1 Face 3 Root 1 Root 3

Face 2 Face 4 Root 2 Root 4

Additional Nick Break in lieu of Tensile

Nick 5

Nick 6

Nick 7

Nick 8

Visual:

	Tensile 1	Tensile 2	Tensile 3	Tensile 4
Fracture Location				
Disposition				

◯ Branch Weld test ◯ Low Hydrogen Sleeve ((fillet weld) Test WPS #

Process: SMAW Joint Design: V-Bevel Position: Fixed

Pipe Spec/Grade: Pipe Diameter: Pipe Wall Thickness::

Pass	Rod Diameter	AWS Class	Direction of Travel
Root Pass			
Hot Pass			
Filler Pass(es)			
Cap Pass(es)			

Nick Break Tests

Nick 1

Nick 2

Nick 3

Nick 4

Visual:

Was optional radiographic inspection performed? ◯ No ◯ Yes - Acceptable ◯ Yes - Unacceptable
If yes, attach copy of radiography report.

Test Result: ◯ **Qualified** ◯ **Disqualified**

Tested by: Date:

Rev.1 05/21/15 Company Representative (Required if tested by other than Company

D15

WELDER QUALIFICATION CHECKLIST
(For use conjunction with the Welder Qualification Test Report)

Date: ______________________ Welder: ______________________

WPS #: ______________________ ID Verified Via: ______________________

ELEMENT	WITHIN WPS PARAMETERS	OUTSIDE WPS PARAMETERS
Preheat		
Proper Space and Alignment		
Electrode Classification and Diameter		
Polarity		
Amperage, Voltage and Travel Speed		
Clamp Release at Proper Time*		

*If no clamp is used enter N/A in the Within WPS Parameters column.

ELEMENT	ACCEPTABLE	UNACCEPTABLE
Pipe End Damage and Cleanliness		
Proper Ground Connection		
Visual Inspection of Root Pass for Cracks, Burn-through, etc.		

Each element shall be checked during welder qualification testing. Any mark in the "Outside WPS Parameters" or "Unacceptable" columns will cause a failure of the qualification test.

Tested by: ______________________ Date: ______________________

Vermont Gas

WELDER CONTINUITY REPORT

In accordance with 49 CFR 192.229

Welder Name: ____ Employer ____

Stencil: ____ Last 4 SSN: ____ Qualification/Continuity Due Date: ____

A welder may not weld on pipe unless within the preceding 6 calendar months the welder has had at least one production weld tested and found acceptable under section 6 of API Standard 1104.

Alternatively, a welder may maintain an ongoing qualification status by performing welds tested and found acceptable under section 6 of API Standard 1104, at least twice each calendar year, but at intervals not exceeding 7 1/2 months.

This forms serves to document the compliance to these requirements.

☐ Welder has had a production weld tested and found acceptable within the last 6 calendar months

Date of Acceptable NDE Report: ____ Attach NDE report referencing above stencil number.

☐ Welder has performed a test weld which was found acceptable

Date of Acceptable Test Weld: ____ Attach Welder Qualification Report referencing above stencil number.

New Qualification/Continuity Date: ____

(New date is calculated as 6 months from the date of the Welder Qualification Test Report or the NDE Report.)

Approved By: ____ Date: ____

Company Representative
(Required if approved by other than Company personnel): ____

WELDING PROCEDURE SPECIFICATION

Vermont Gas

TITLE X-65 Butt Weld

WPS # WPS-VGS-X65-2:2014-2

Supporting Procedure Qualification Record: PQR-VGS-X65-2:2014-2

In accordance with API 1104

Welding Process: SMAW Position: Fixed Joint Design: V Bevel (see sketch) Minimum # Passes: 3 Shielding: Flux-Cellulose

Pipe Material Description: ☐ Group A ☐ Group B ☒ Group C : Specify APL 5L X-65

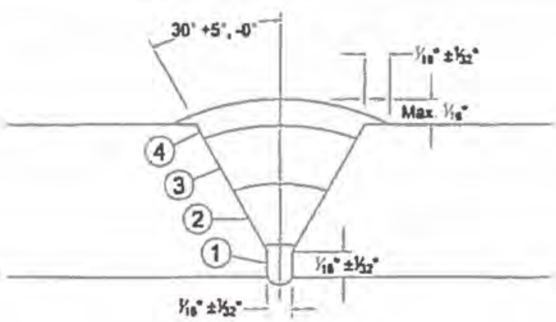
Diameter: ☐ OD < 2.375 Inches ☒ OD 2.375 to 12.750 Inches ☐ OD > 12.750 Inches

Wall Thickness(es): ☐ Nominal WT < 0.188 In ☒ Nominal WT 0.188 to 0.750 In ☐ Nominal WT > 0.750 In

Filler Metal Group(s): ☒ Group 1 A5.1 E6010 ☒ Group 2 A5.5 E8010 ☐ Group 3

Preheat: Flame heat to minimum 250°F (to minimum 300°F if ambient below 40°F), maximum 500°F. Check temperatures with temperature crayons or pyrometer.

Postheat: N/A



NOT TO SCALE

Bead #	Electrode Size	Electrode Designation	Voltage Range	Current Amperage Range	AC/DC	Polarity	Direction of Travel	Travel Speed
1	1/8", 5/32"	A5.1 6010	15-30	75-135, 100-175	DC	Electrode Positive	Downhill	6-16 IPM
2	5/32", 3/16"	A5.5 8010	20-32	100-165,130-210	DC	Electrode Positive	Downhill	6-16 IPM
3+	5/32", 3/16"	A5.5 8010	20-32	100-165,130-210	DC	Electrode Positive	Downhill	6-16 IPM

Time Lapse Bead 1 to Bead 2: 5 minutes Bead 2 to each succeeding bead: 10 minutes

Line Up Clamp: ☐ Internal ☒ External ☒ Not Required Removal (if used): After minimum of 50% of root bead welding

Cleaning and/or Grinding: ☒ Power Tools ☒ Hand Tools

Prepared by: [signature] Date/Time Field: Dec 5, 2014

Approved by: [signature] Date/Time Field: Dec 5, 2014

Rev. 0 04/08/15

Printed as uncontrolled copy. Please verify on VGS server that you have the most up to date revision prior to use.

WELDING PROCEDURE SPECIFICATION

Vermont Gas

TITLE: X-65 BRANCH TEE

WPS #: WPS-VGS-X65-1: 2014-3

Supporting Procedure Qualification Record: PQR-VGS-X65-1: 2014-2

In accordance with API 1104

Welding Process: SMAW Position: Fixed Joint Design: V Bevel (see sketch) Minimum # Passes: 3 Shielding: Flux-Cellulose

Pipe Material Description: ☐ Group A ☐ Group B ☒ Group C : Specify API 5L X-65

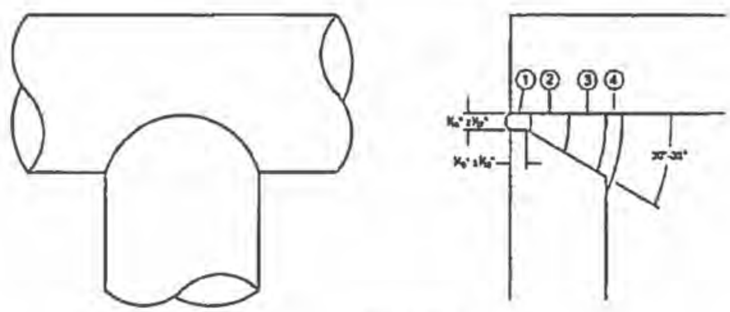
Diameter: ☐ OD < 2.375 Inches ☒ OD 2.375 to 12.750 Inches ☐ OD > 12.750 Inches

Wall Thickness(es): ☐ Nominal WT < 0.188 In ☒ Nominal WT 0.188 to 0.750 In ☐ Nominal WT > 0.750 In

Filler Metal Group(s): ☒ Group 1 A5.1 E6010 ☒ Group 2 A5.5 E8010 ☐ Group 3

Preheat: Flame heat to minimum 250°F (to minimum 300°F if ambient below 40°F), maximum 500°F.
Check temperatures with terperature crayons or pyrometer

Postheat: N/A



NOT TO SCALE

Bead #	Electrode Size	Electrode Designation	Voltage Range	Current Amperage Range	AC/DC	Polarity	Direction of Travel	Travel Speed
1	1/8". 5/32"	A5.1 6010	15-30	75-140, 100-175	DC	Electrode Positive	Downhill	6-16 IPM
2	5/32". 3/16"	A5.5 8010	20-32	100-165 130-210	DC	Electrode Positive	Downhill	6-16 IPM
3+	5/32". 3/16"	A5.5 8010	19-32	100-165 130-210	DC	Electrode Positive	Downhill	6-16 IPM

Time Lapse Bead 1 to Bead 2: 5 Minutes Bead 2 to each succeeding bead: 10 Minutes

Line Up Clamp: ☐ Internal ☒ External ☒ Not Required Removal (if used): After minimum of 50% of root bead welding

Cleaning and/or Grinding: ☒ Power Tools ☒ Hand Tools

Prepared by: [signature] Date/Time Field: Dec 5, 2014

Approved by: [signature] Date/Time Field: Dec 5, 2014

Rev. 0 04/08/15

WELDING PROCEDURE SPECIFICATION

Vermont Gas

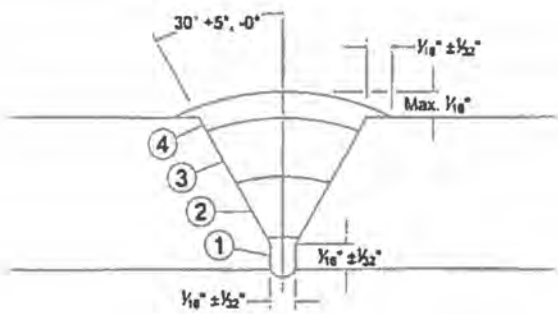
TITLE	Grade "B" Butt Weld (6010, 8010)
WPS #	WPS-VGS-B-2: 2014-2
Supporting Procedure Qualification Record:	PQR-VGS-B-2: 2014-2

In accordance with API 1104

Welding Process: SMAW Position: Fixed Joint Design: V Bevel (see sketch) Minimum # Passes: 3 Shielding: Flux-Cellulose

Pipe Material Description:	☐ Group A	☒ Group B	☐ Group C : Specify
Diameter:	☐ OD < 2.375 Inches	☒ OD 2.375 to 12.750 Inches	☐ OD > 12.750 Inches
Wall Thickness(es):	☐ Nominal WT < 0.188 In	☒ Nominal WT 0.188 to 0.750 In	☐ Nominal WT > 0.750 In
Filler Metal Group(s):	☒ Group 1 A5.1 E6010	☒ Group 2 A5.5 E8010	☐ Group 3

Preheat	250°F (if ambient below 40°F, 300°F)
Postheat	N/A



NOT TO SCALE

Bead #	Electrode Size	Electrode Designation	Voltage Range	Current Amperage Range	Current AC/DC	Polarity	Direction of Travel	Travel Speed
1	1/8", 5/32"	5.1 6010	15-30	75-135, 100-175	DC	Electrode Positive	Downhill	6-16 IPM
2	5/32", 3/16"	5.5 8010G	20-32	100-165 120-210	DC	Electrode Positive	Downhill	6-16 IPM
3+	5/32", 3/16"	5.5 8010G	20-32	100-175 130-210	DC	Electrode Positive	Downhill	6-16 IPM

Time Lapse Bead 1 to Bead 2: 5 minutes Bead 2 to each succeeding bead: 20 minutes

Line Up Clamp: ☐ Internal ☒ External ☒ Not Required Removal (if used): After minimum of 50% of root bead welding

Cleaning and/or Grinding: ☒ Power Tools ☒ Hand Tools

Prepared by:	[signature]	Date/Time Field	Dec 5, 2014
Approved by:	[signature]	Date/Time Field	Dec 5, 2014

Rev 0 04/08/15

Printed as uncontrolled copy. Please verify on VGS server that you have the most up to date revision prior to use.

WELDING PROCEDURE SPECIFICATION

Vermont Gas

TITLE Grade "B" Branch Tee (6010, 8010)

WPS # WPS-VGS-B-1: 2014-2

Supporting Procedure Qualification Record: PQR-VGS-B-1: 2014-2

In accordance with API 1104

Welding Process: SMAW Position: Fixed Joint Design: V Bevel (see sketch) Minimum # Passes: 3 Shielding: Flux-Cellulose

Pipe Material Description: ☒ Group A ☐ Group B ☐ Group C : Specify

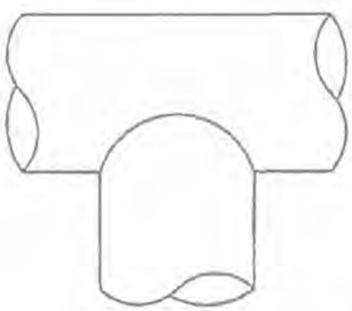
Diameter: ☐ OD < 2.375 Inches ☒ OD 2.375 to 12.750 Inches ☐ OD > 12.750 Inches

Wall Thickness(es): ☐ Nominal WT < 0.188 In ☒ Nominal WT 0.188 to 0.750 In ☐ Nominal WT > 0.750 In

Filler Metal Group(s): ☒ Group 1 A5.1 E6010 ☒ Group 2 A5.5 E8010 ☐ Group 3

Preheat: 250°F (if ambient is below 40°F, 300°F)

Postheat: N/A



NOT TO SCALE

Bead #	Electrode Size	Electrode Designation	Voltage Range	Current Amperage Range	Current AC/DC	Polarity	Direction of Travel	Travel Speed
1	1/8". 5/32"	5.1 6010	15-30	75-135. 100-175	DC	Electrode Positive	Downhill	6-16 IPM
2	5/32". 3/16"	5.5 8010G	20-32	100-165 130-210	DC	Electrode Positive	Downhill	6-16 IPM
3+	5/32". 3/16"	5.5 8010G	20-32	100-165 130-210	DC	Electrode Positive	Downhill	6-16 IPM

Time Lapse Bead 1 to Bead 2: 5 minutes Bead 2 to each succeeding bead: 20 minutes

Line Up Clamp: ☐ Internal ☒ External ☒ Not Required Removal (if used): After minimum of 50% of root bead welding

Cleaning and/or Grinding: ☒ Power Tools ☒ Hand Tools

Prepared by: [signature] Date/Time Field Dec 5, 2014

Approved by: [signature] Date/Time Field Dec 5, 2014

Rev. 0 04/08/15

WELDING PROCEDURE SPECIFICATION

Vermont Gas

TITLE	Grade "B" Branch Tee (6010)
WPS #	WPS-VGS-B-1: 2014-1
Supporting Procedure Qualification Record:	PQR-VGS-B-1: 2014-1

In accordance with API 1104

Welding Process: SMAW Position: Fixed Joint Design: V Bevel (see sketch) Minimum # Passes: 3 Shielding: Flux-Cellulose

Pipe Material Description: ☐ Group A ☒ Group B ☐ Group C : Specify

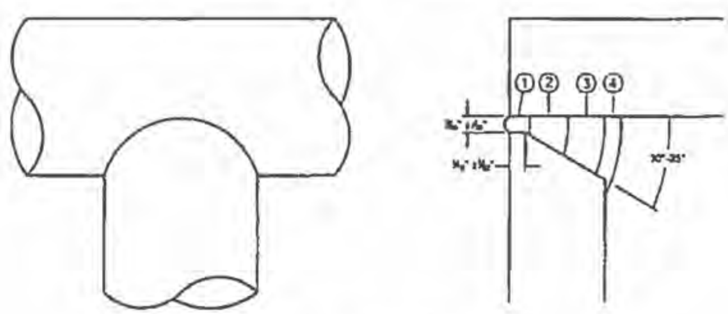
Diameter: ☐ OD < 2.375 Inches ☒ OD 2.375 to 12.750 Inches ☐ OD > 12.750 Inches

Wall Thickness(es): ☐ Nominal WT < 0.188 In ☒ Nominal WT 0.188 to 0.750 In ☐ Nominal WT > 0.750 In

Filler Metal Group(s): ☒ Group 1 A5.1 E6010 ☐ Group 2 ☐ Group 3

Preheat: 250°F (if ambient is below 40°F, 300°F)

Postheat: N/A



NOT TO SCALE

Bead #	Electrode Size	Electrode Designation	Voltage Range	Current Amperage Range	AC/DC	Polarity	Direction of Travel	Travel Speed
1	1/8". 5/32"	A5.1 6010	15-30	75-135. 100-175	DC	Electrode Positive	Downhill	6-16 IPM
2	5/32". 3/16"	A5.1 6010	20-32	100-175 140-225	DC	Electrode Positive	Downhill	6-16 IPM
3+	5/32". 3/16"	A5.1 6010	20-32	100-175 140-225	DC	Electrode Positive	Downhill	6-16 IPM

Time Lapse Bead 1 to Bead 2: 5 minutes Bead 2 to each succeeding bead: 20 minutes

Line Up Clamp: ☐ Internal ☒ External ☒ Not Required Removal (if used): After minimum of 50% of root bead welding

Cleaning and/or Grinding: ☒ Power Tools ☒ Hand Tools

Prepared by:	[signature]	Date/Time Field	Dec 5, 2014
Approved by:	[signature]	Date/Time Field	Dec 5, 2014

Rev 0 04/08/15

Printed as uncontrolled copy. Please verify on VGS server that you have the most up to date revision prior to use.

WELDING PROCEDURE SPECIFICATION

Vermont Gas

TITLE	Grade "B" Butt Weld (6010)
WPS #	WPS-VGS-B-2: 2014-1
Supporting Procedure Qualification Record:	PQR-VGS-B-2: 2014-1

In accordance with API 1104

Welding Process: SMAW Position: Fixed Joint Design: V Bevel (see sketch) Minimum # Passes: 3 Shielding: Flux-Cellulose

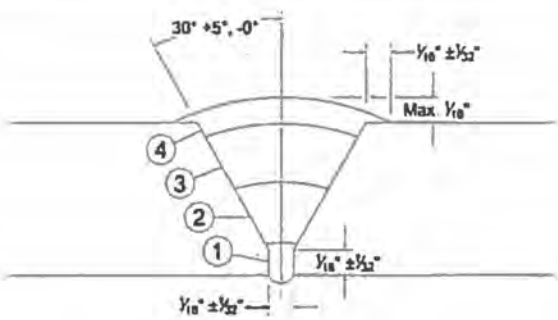
Pipe Material Description: ☐ Group A ☒ Group B ☐ Group C : Specify

Diameter: ☐ OD < 2.375 Inches ☒ OD 2.375 to 12.750 Inches ☐ OD > 12.750 Inches

Wall Thickness(es): ☐ Nominal WT < 0.188 In ☒ Nominal WT 0.188 to 0.750 In ☐ Nominal WT > 0.750 In

Filler Metal Group(s): ☒ Group 1 A5.1 E6010 ☐ Group 2 ☐ Group 3

Preheat	250°F (if ambient below 40°F, 300°F)
Postheat	N/A



NOT TO SCALE

Bead #	Electrode Size	Electrode Designation	Voltage Range	Current Amperage Range	AC/DC	Polarity	Direction of Travel	Travel Speed
1	1/8", 5/32"	A5.1 6010	15-30	75-150, 100-175	DC	Electrode Positive	Downhill	6-16 IPM
2	5/32", 3/16"	A5.1 6010	20-32	100-175 140-225	DC	Electrode Positive	Downhill	6-16 IPM
3+	5/32", 3/16"	A5.1 6010	20-32	100-175 140-225	DC	Electrode Positive	Downhill	6-16 IPM

Time Lapse Bead 1 to Bead 2: 5 minutes Bead 2 to each succeeding bead: 20 minutes

Line Up Clamp: ☐ Internal ☒ External ☒ Not Required Removal (If used): After minimum of 50% of root bead welding

Cleaning and/or Grinding: ☒ Power Tools ☒ Hand Tools

Prepared by:	Lee Brown	Date/Time Field	Dec 5, 2014
Approved by:	[signature]	Date/Time Field	Dec 5, 2014

Rev 0 04/08/15

Q. Welding rod stubs or unused welding rod shall be carefully removed from the site and shall not be discarded in the ditch, right-of-way or elsewhere on the site.

R. No miter joints allowed.

S. During the final tie-in section the pipe shall be supported by side booms until all filler passes are complete.

3.4 WELD INSPECTION & NON-DESTRUCTIVE EXAMINATION

A. All welds shall be 100% radiographically inspected at the OWNER'S expense according to API 1104. If the results of these inspections indicate the welds to be defective, CONTRACTOR shall replace or repair the defective welds at CONTRACTOR'S expense. If the cut-out method of examination of weld is employed by the OWNER, the OWNER may, in the judgment of its OWNER INSPECTOR, cut-out and test any welds designated by him. Should such cut-out welds pass the requirements of API 1104, the cost of cutting out and subsequent tie-in will be borne by the OWNER. The cost of cutting out and replacing any welds that fail the tests shall be borne by the CONTRACTOR.

B. Liquid dye penetrant inspection, magnetic particle inspection or ultrasonic inspection may be utilized by OWNER on a case-by-case basis. Acceptance criteria for these inspections are as stated in API 1104.

3.5 WELD REPAIRS

A. Any defect found in a weld, which is determined to be detrimental to its serviceability, shall be either ground out and re-welded, or removed from the line as a cylinder and replaced by welding in a new section of pipe.

B. If visual or radiographic inspection indicates a weld to be defective, the CONTRACTOR, at no additional cost to the OWNER, shall cut a cylinder of pipe containing such weld from the pipeline and replace it with new pipe or shall have the defective weld repaired in accordance with API 1104. Correction of an individual bead prior to the laying of a succeeding bead is not considered a repair of a defect under these specifications.

C. Preheating shall be used according to the WPS. Such preheating shall be accomplished by a method acceptable to the OWNER and shall cover at least four (4) inches wide on each side of the weld. Heating shall not char the pipe coating. Preheat temperature shall be checked by use of temperature indicating crayons.

D. All repair and replacement welds shall be 100% radiographically inspected and shall meet the acceptance standards of API 1104.

E. Only one repair shall be allowed per girth weld. The necessity of a second weld repair constitutes a mandatory cut-out.

F. The accumulated length of weld repairs shall not exceed 8% of the total length of the girth weld.

G. Under no circumstances should attempts be made to repair cracks in a weld. All cracks shall be cut outs.

TAB 3

Vermont Gas

Page 1 of 2
Corrective/Preventive Action Request (CPAR)

CA ■ PA ☐
(Check appropriate box to indicate corrective or preventive action)

Initiator: K. Oxholm Corrective Action # 2015-004
or
Date: 10/19/15 Preventive Action # ____________

	Date Due	By/Assigned to	Completed Initials & Date
Investigation		Kristy Oxholm	KHO 11/25/2015
Implementation		Lee Brown	
Audit			
CAR/PAR closed		John St. Hilaire	JSH 12/11/15

Description of Issue

Pipe at appx. 398+00 to 406+00 has garage/trash mixed in with backfill. Pipe is reportedly padded with select backfill, has mirify fabric laid and the backfill in question on top of the mirify. Varying reports describe the garbage/trash as mostly broken glass to chunks of metal and other household garbage/trash.

Work Processes need to be modified or ceased during investigation?: Yes ___ No x
If so, specify:

Approved by: [signature] Date: 12/11/15

Investigation Finding

In speaking with a variety of people there is clear cause for concern. At least two test pits will be dug to determine the extent of the problem and to complete this investigation.

During the period of 12/1/15 to 12/8/15 a total of 8 test pits were dug in the area of concern. No trash or garbage was found in close proximity to the installed pipe. A small amount of small items was found in the very top layer of the cover, well above the pipe. No mirify fabric was found at any of the dig sites. (see attached pictures).

Rev. 0 07/24/2015

Vermont Gas

Corrective/Preventive Action Request (CPAR)

Recommendations for Corrective / Preventive Action
As a result of the findings in the test pits, no corrective action is required. VGS will be commissioning the cathodic protection (CP) system at the gas-up of the pipeline. This will provide protection should any coating holidays exist on the pipeline because of the trash/debris. Additionally, a direct assessment type survey will be conducted in the spring of 2016. If any part of the coating is damaged in this area because of trash/debris, the survey will indicate an anomaly and it can properly be inspected and remediated.

Action Taken / Verification
Any future re-evaluation and follow-up required? Yes ___ No x If so, specify:
Verified by: ______________________ Date: ______________ Was action taken effective? ☐ Yes ☐ No If no, new CA/PA number: ________ ____ Comments: ______________________________

Rev. 0 07/24/2015

12/01/15 Dig #1

12/01/15 Dig #2

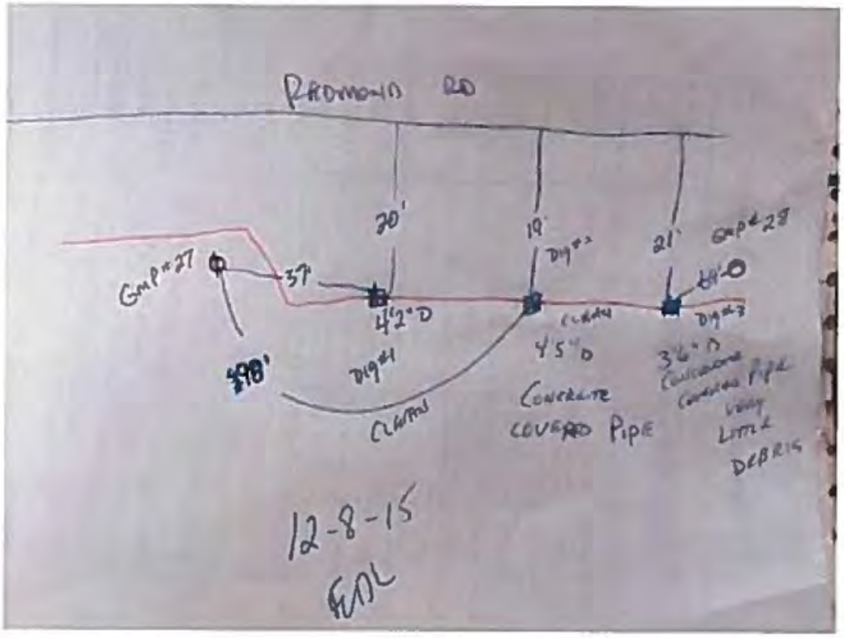
12/7/15 Digs

Dig #1

Dig #2

Dig #3

12/8/15 Digs



Dig #1

Dig #2

Dig #3

Dig #2

VERMONT GAS SYSTEMS, INC.
TRANSMISSION LINE EXPOSURE REPORT

This report is to be completed when excavation work is being done near a transmission pipeline.

Date: 12-7-15	Clock #: 616	Dig safe Ticket Number: 20154800754	Photo's taken (Y) / N
Location: REDMOND RD.		Pipe Diameter: 12"	Wall Thickness:
Municipality: WILLISTON	VGS facilities marked: Y / N	As-Built Station No.	
Pipeline As-Built Sheet: of	High Consequence Area: Y / (N)	HCA segment number:	
CP Pipe to Soil Reading: N/AV	Coating Type:	Pipe Depth:	
Coating Condition: (Bonded) Slight disbondment Disbonded		Coating Replaced: Y / (N)	
Type Replacement Coating:		Replacement Coating Length:	
Exposed bare pipe: Y / (N)	Pitting: Y / (N)	Pitting Location:	UT Gauge testing: N/A
Soil: (Sand) Clay (Loam) Cinders Refuse		Soil Packing: Loose (Medium) Hard	
Soil Sample Taken: Y / (N)		Soil Moisture Content: Dry (Damp) Wet	
Foreign Pipe crossing: Y / (N)	Foreign Pipe crossing clearance:	Foreign pipe crossing ties taken: Y / N	

DIGGING TO INSPECT 12" FOR ANY GARBAGE BURIED OVER & AROUND PIPE INBETWEEN GMP POLE # 26 & 28 PIPE NOT GASED UP

File: T\OPS\ TRANSMISSION LINE EXPOSURE REPORT

VERMONT GAS SYSTEMS, INC.
TRANSMISSION LINE EXPOSURE REPORT

This report is to be completed when excavation work is being done near a transmission pipeline.

Date: 12-8-15	Clock #: 616	Dig safe Ticket Number: 20154800754	Photo's taken (Y) / N
Location: REDMOND RD		Pipe Diameter: 12"	Wall Thickness:
Municipality: WILLISTON	VGS facilities marked: Y / N		As-Built Station No.
Pipeline As-Built Sheet: of	High Consequence Area: Y / (N)		HCA segment number:
CP Pipe to Soil Reading: N/A v	Coating Type:		Pipe Depth:
Coating Condition: (Bonded) Slight disbondment Disbonded			Coating Replaced: Y / (N)
Type Replacement Coating:		Replacement Coating Length: N/A	
Exposed bare pipe: Y / (N)	Pitting: Y / (N)	Pitting Location: N/A	UT Gauge testing: N/A
Soil: (Sand) Clay (Loam) Cinders Refuse		Soil Packing: Loose (Medium) Hard	
Soil Sample Taken: Y / N		Soil Moisture Content: Dry (Damp) Wet	
Foreign Pipe crossing: Y / (N)	Foreign Pipe crossing clearance: N/A	Foreign pipe crossing ties taken: Y / N N/A	

Digging TO INSPECT NON GASED UP 12"
FOR ANY GARBAGE BURIED OVER OR AROUND
PIPE IN BETWEEN GMP # POLE 27 & 28

File: T\OPS\ TRANSMISSION LINE EXPOSURE REPORT

TAB 4

Vermont Gas

Corrective/Preventive Action Request (CPAR)

CA ■ PA ☐

(Check appropriate box to indicate corrective or preventive action)

Initiator: K. Oxholm

Corrective Action # 2015-005

or

Date: 10/19/15

Preventive Action #

	Date Due	By/Assigned to	Completed Initials & Date
Investigation	11/30/2015	Christopher LeForce	CAL 12/11/2015
Implementation	12/1/2015	Christopher LeForce	CAL 12/11/2015
Audit			
CAR/PAR closed			

Description of Issue

Pipe installed by 2014 Contractor (Over & Under) with insufficient cover in numerous locations.

Work Processes need to be modified or ceased during investigation?: Yes ___ No x
If so, specify:

Approved by: [signature]

Date: 12/11/15

Investigation Finding

After reviewing as-built data collected by CHA, it was found that the ANGP pipeline that was installed by Over and Under in 2014 had multiple areas with insufficient cover. The majority of the areas with insufficient cover pertained to the minimum depth of cover in the VTrans permit and other permits/agreements with various agencies. The final list identified 77 areas along the pipeline where depth of cover needed to be investigated and then remediated.

Rev. 0 07/24/2015

Vermont Gas

Corrective/Preventive Action Request (CPAR)

Recommendations for Corrective / Preventive Action
The first step was to survey the areas identified to ensure that the proper finished grade was surveyed and that the GPS data was correct and accurate. There were multiple areas where the depth of cover was only lacking by 1-3 inches. All the areas were surveyed and the pipe was probed with a probe bar to confirm the depth. The results can be separated into three general categories; areas where the data was off and the pipe was actually installed to the proper depth, areas where the grade was not restored to pre-construction conditions, and areas where the pipe was not installed to proper depth. Going forward, the as-built depth of cover data will be looked at more closely and in a more timely manner at the time of construction so that it can be remediated quickly, efficiently, and effectively.

Action Taken / Verification
See attached
Any future re-evaluation and follow-up required? Yes x No ___ If so, specify:
Final as-builts for approximately the first 10.5 miles of the ANGP pipeline will be reviewed once complete to ensure proper depth of cover as related to the specific permits, specifications, and agreements.
Verified by: ______________________ Date: ______________
Was action taken effective? ☐ Yes ☐ No If no, new CA/PA number: ________
Comments: ______________________________

Rev. 0 07/24/2015

Attachment to CAR 2015-005
Action Taken / Verification

The areas where probing verified that the pipe was installed to the proper depth of cover were removed from the list. This included a total of 24 areas. There were a total of 41 areas where regrading was performed to achieve the proper depth of cover. The Survey Team set stakes in these areas which indicated the additional depth of cover that was needed. There were 6 areas where the pipe was completely removed, the trench was dug to ensure proper depth, and the pipe reinstalled to the proper depth. At this time there is still one area that needs regrading to achieve proper depth of cover, which will be completed after the construction mats are removed from this area.

There were 5 areas where the pipe was not installed to the proper depth that was included in the VTrans permit related to the proposed Circumferential Highway or "Circ." Since this project has been planned for over 20 years and there is no currently schedule to build it, VGS received a permit amendment/waiver to leave it at the current installed location. VGS asked for this amendment/waiver because the design of the highway could easily change in the future and per the agreement VGS has with VTrans for the pipeline in the Circ corridor, VGS is responsible to move it if there are any conflicts between the highway infrastructure and the pipeline.

A final summary table is attached denoting all 77 areas.

Addison Natural Gas Project (ANGP) – Segment 1
Depth of Cover Remediation Table/List

Area #	Approx. Begin STA.	Approx End STA.	Min. Cover Needed (ft)	Reason for Lack of Cover (other then 3 ft)	Approx. Additional Cover Needed (ft)	VGS to Fix?	Remediation Plan	Additional Notes
1	126+50	128+00	4	VTrans	0.7-0.8	YES	Completed.	
2	130+00	131+00	4	VTrans	0.3-0.4	YES	Completed.	
3	132+00	132+00	4	VTrans	0.1	YES	Completed.	
4	133+00	135+50	4	VTrans	0.2-0.7	YES	Completed.	
5	140+00	140+00	4	VTrans	0.6	YES	Completed.	
6	142+50	143+50	4	VTrans	0.5-1.2	YES	Completed.	
7	144+50	148+00	4	VTrans	0.1-0.6	YES	Completed.	
8	188+75	190+00	4	VTrans	0.1-0.9	YES	Completed.	
9	192+75	192+75	4	VTrans	0.5	YES	Completed.	
10	193+75	193+75	4	VTrans	0.3	YES	Completed.	
11	197+00	207+00	4	VTrans	0.1-1.2	YES	Completed.	
12	208+00	208+00	4	VTrans	0.6	YES	Completed.	
13	229+75	229+75	4	VTrans	0.1	YES	Completed.	
14	230+50	230+50	4	VTrans	0.2	YES	Completed	
15	322+75	324+50	4	VTrans	0.3-1.4	YES	Completed.	
16	326+50	326+50	4	VTrans	0.5	YES	Completed.	
17	331+00	332+00	4	VTrans	0.3-0.6	YES	Completed.	
18	333+75	333+75	4	VTrans	0.2	YES	Completed.	
19	338+50	339+50	4	VTrans	0.2-0.4	YES	Completed.	
20	340+50	340+50	4	VTrans	0.4	YES	Completed.	
21	344+00	346+00	4	VTrans	0.2-1.9	YES	Completed.	
22	346+75	346+75	4	VTrans	0.1	YES	Completed.	
23	348+50	348+50	4	VTrans	0.5	YES	Completed.	
23A	349+25	351+25	5	Stream Crossing	0.6-2.2	YES	Completed.	Cut out pipe sectio proper depth. Wor
24	352+00	352+00	4	Agriculture	0.6	YES	Completed.	
25	353+50	354+00	4	Agriculture	0.1-0.8	YES	Completed.	
26	355+00	355+00	4	Agriculture	0.1	YES	Completed.	
27	366+75	366+75	4	Agriculture	0.9	YES	Completed.	
28	367+25	367+25	4	Agriculture	0.8	YES	Completed.	
29	369+25	369+25	4	Agriculture	0.7	No	None.	Probed, measured
30	370+75	370+75	5	Stream Crossing	1.3	No	None.	No stream or ditch.
31	375+50	379+75	3	Typical	0.1-0.4	No	None.	Probed, measured
32	381+75	384+50	3	VTrans	0-0.7	YES	None.	Verified with VTran acceptable is this a
32A	386+50	387+50	3	Typical	0.2-0.6	YES		Mats were in the w Need to fix still.
33	401+00	404+00	3			No	None.	Probed, measured
34	405+25	408+50	3			No	None.	Probed, measured
35	409+50	410+50	3			No	None.	Probed, measured
36	414+25	415+00	3			No	None.	Probed, measured
37	415+50	418+50	3	Typical	0.1-0.3	No	None.	Probed, measured
38	418+75	420+00	4	Typical	0.3-1.7	YES	Completed.	Cut out pipe sectio proper depth. Wor
39	423+25	423+25	3	Typical	0.2	YES	Completed.	
40	425+50	426+75				No	None.	Probed, measured
41	430+00	430+00	3	Typical	1.2	No	None.	Probed, measured
42	433+00	435+00	4	VELCO	0.5-0.7	YES	Completed.	Probe to verify. VE
43	435+75	435+75	4	VELCO	0.4	Yes	Completed.	Probe to verify. VE
44	437+75	437+75	3	Typical	0.2	No	None.	Probed, measured
45	440+25	440+75	5	Stream Crossing	0.8-1.0	Yes	Completed.	Cut out pipe sectio proper depth. Wor
46	443+75	443+75	3	Typical		No	None.	Probed, measured
47	445+25	445+25	3	Typical	0.2	Yes	Completed.	
48	447+75	447+75	3	Typical	0.1	No	None.	Probed, measured
49	453+50	455+00	3	Typical		No	None.	Probed, measured
50	456+25	456+25	4	VELCO		No	None.	Probed, measured
51	457+50	465+50	4	Agriculture	0.1-0.4	Yes	Completed.	Waiver from VTran
52	465+75	478+50	Varies	VTrans/VTrans Cut	0.1-13.0	No	None.	Waiver from VTran
52A	474+00	474+75	3	Typical	0.3-0.8	Yes	Completed.	
53	478+50	481+00	4	VTrans		No	None.	Probed, measured
53A	480+80	480+80	3	Typical	0.1	No	None.	Probed, measured
54	482+50	488+00	3	Typical		No	None.	Probed, measured
55	488+50	489+50	4	VTrans	0.5-0.9	Yes	Completed.	
56	492+60	492+60	4	VTrans	0.6	Yes	Completed.	
57	493+50	496+00	4 to 10	VTrans	0.1-6.0	No	None.	Waiver from VTran
57A	494+00	495+75	4	VTrans	0.1-0.3	Yes	Completed.	
58	499+00	500+50	4	VTrans		No	None.	Probed, measured
59	515+25	516+25	4 to 9	VTrans Cut	0.1 to 5	No	None.	Waiver from VTran
60	516+75	520+50	4, 4 to 8	VTrans Cut	0.1 to 4.0	No	None.	Waiver from VTran
60A	518+50	519+00	4	VTrans	0.2-0.5	Yes	Completed.	
61	524+50	524+50	4	VTrans	0.1	Yes	Completed.	
62	529+00	532+00	4 to 9	VTrans Cut	0.2-4.0	No		Probed, measured
63	532+00	534+50	4 to 8	VTrans	0.2-4.0	No		Probed, measured
64	535+00	535+00	4	VTrans Cut	0.4	No		Probed, measured
65	538+50	540+50	4 to 13	VTrans Cut	0.1-9.0	No		Probed, measured
65A	539+00	540+25	4	VTrans	0.1	Yes	Completed.	
66	538+25	538+25	4	VTrans	0.4	Yes	Completed.	

TAB 5

Vermont Gas

Corrective/Preventive Action Request (CPAR)

CA ■ PA ☐

(Check appropriate box to indicate corrective or preventive action)

Initiator: K. Oxholm

Corrective Action # 2015-006

or

Date: 11/18/2015

Preventive Action #

	Date Due	By/Assigned to	Completed Initials & Date
Investigation	12/9/2015	Christopher LeForce	CAL 12/11/2015
Implementation	12/11/2015	Christopher LeForce	CAL 12/11/2015
Audit			
CAR/PAR closed			

Description of Issue

In areas where pipe was installed by the 2014 Contractor (Over & Under) on ANGP, trench breakers were not installed as designed in numerous locations. A table attached, titled "ANGP Trench Breaker As-built 2014 (Segment 1)", shows the general design locations by station number and the corresponding as-built location if installed. There were both sand trench breakers and bentonite trench breakers on this list. Also there were some trench breakers installed where there was not a designed location.

Work Processes need to be modified or ceased during investigation?: Yes ___ No x

If so, specify:

Approved by: [signature]

Date: 12/11/15

Investigation Finding

The list titled "ANGP Trench Breaker As-built 2014 (Segment 1)" was reviewed and the locations plotted on a set of design drawings. After talking to field personnel (inspectors), it was determined that some of the locations where trench breakers were designed on paper were omitted because the field conditions warranted them not to be installed. On the other hand there were locations where there was no designed trench breaker, but field conditions warranted one to be installed. There was no documentation of this process.

Rev. 0 07/24/2015

Vermont Gas

Corrective/Preventive Action Request (CPAR)

Recommendations for Corrective / Preventive Action
VGS will investigate the areas where a designed trench breaker was not installed. If field conditions show that one is not needed, then it will be documented as to the reason why not. If one is needed, then one will be scheduled to be installed. While this investigation takes place, VGS Operations will patrol the transmission corridor on a monthly basis, not to exceed 45 days, or after any significant rain event to ensure no erosion occurs due to the lack of a trench breaker. If VGS Operations finds erosion occurring, it will be remediated to ensure the safety of the pipeline.

Action Taken / Verification
Any future re-evaluation and follow-up required? Yes ___ No ___ If so, specify:
As required by code, the transmission corridor is continually patrolled multiple times each year by VGS Operations and one of the items that is looked for is erosion areas or potential erosion areas. Anything that is deemed a threat to the pipe will be remediated by VGS Operations.
Verified by: ______________________ Date: ______________ Was action taken effective? ☐ Yes ☐ No If no, new CA/PA number: ________ Comments: ______________________________

Rev. 0 07/24/2015

ANGP Trench Breaker Locations As-Built 2014 (Segment 1)

NOTE: The following approximate stations are the minimum locations for both sand and bentonite trench breakers for Segment 1 (As Built 2014) of the Addison Natural Gas Project. This list was created using information from details #2 and #5 on drawing ANGP-T-G-015 Rev. 1 from the Plan Set titled "Addison Natural Gas Project Transmission Mainline" dated 04-02-15. The Construction Management Team/Inspectors should review actual field conditions and direct the Contractor to install additional trench breakers as necessary to supplement the listed areas.

LEGEND:

(grey)	Sand Trench Breaker
(yellow)	Bentonite Trench Breaker

"Theoretical Station"	Type	As-Built Station	As-Built Type	Comments
NONE	N/A	129+15	SAND	
NONE	N/A	132+62	SAND	
NONE	N/A	144+15	SAND	
NONE	N/A	147+22	SAND	
NONE	N/A	150+10	SAND	
187+75	BENTONITE	NONE	N/A	
188+50	BENTONITE	188+78	BENTONITE	
NONE	N/A	189+14	SAND	
NONE	N/A	190+10	SAND	
190+55	BENTONITE	190+53	BENTONITE	
193+15	BENTONITE	193+56	BENTONITE	
194+55	SAND	NONE	N/A	
195+80	SAND	NONE	N/A	
197+00	SAND	NONE	N/A	
202+17	SAND	NONE	N/A	

ANGP Trench Breaker Locations As-Built 2014 (Segment 1)

NOTE: The following approximate stations are the minimum locations for both sand and bentonite trench breakers for Segment 1 (As Built 2014) of the Addison Natural Gas Project. This list was created using information from details #2 and #5 on drawing ANGP-T-G-015 Rev. 1 from the Plan Set titled "Addison Natural Gas Project Transmission Mainline" dated 04-02-15. The Construction Management Team/Inspectors should review actual field conditions and direct the Contractor to install additional trench breakers as necessary to supplement the listed areas.

LEGEND:

(grey)	Sand Trench Breaker
(yellow)	Bentonite Trench Breaker

"Theoretical Station"	Type	As-Built Station	As-Built Type	Comments
202+95	SAND	NONE	N/A	
211+90	SAND	NONE	N/A	
NONE	N/A	238+79	SAND	
328+10	SAND	327+77	SAND	
328+92	SAND	328+64	SAND	
330+65	SAND	331+22	SAND	
331+40	SAND	331+66	SAND	
343+62	SAND	NONE	N/A	
344+35	SAND	344+50	SAND	
345+08	SAND	345+02	SAND	
347+42	SAND	NONE	N/A	
348+00	SAND	347+80	SAND	
348+60	SAND	NONE	SAND	
348+80	BENTONITE	348+45	BENTONITE	
349+25	BENTONITE	349+52	BENTONITE	

ANGP Trench Breaker Locations As-Built 2014 (Segment 1)

NOTE: The following approximate stations are the minimum locations for both sand and bentonite trench breakers for Segment 1 (As Built 2014) of the Addison Natural Gas Project. This list was created using information from details #2 and #5 on drawing ANGP-T-G-015 Rev. 1 from the Plan Set titled "Addison Natural Gas Project Transmission Mainline" dated 04-02-15. The Construction Management Team/Inspectors should review actual field conditions and direct the Contractor to install additional trench breakers as necessary to supplement the listed areas.

LEGEND:

(grey)	Sand Trench Breaker
(yellow)	Bentonite Trench Breaker

"Theoretical Station"	Type	As-Built Station	As-Built Type	Comments
350+72	BENTONITE	350+72	BENTONITE	
351+06	BENTONITE	351+06	BENTONITE	
367+30	BENTONITE	367+40	BENTONITE	
369+12	BENTONITE	368+72	BENTONITE	
369+47	SAND	NONE	N/A	
370+45	BENTONITE	NONE	N/A	
371+10	BENTONITE	NONE	N/A	
374+22	SAND	NONE	N/A	
375+05	SAND	NONE	N/A	
380+45	SAND	NONE	N/A	
381+40	SAND	NONE	N/A	
380+75	BENTONITE	380+80	BENTONITE	
382+10	BENTONITE	NONE	N/A	
382+60	BENTONITE	NONE	N/A	
384+00	BENTONITE	NONE	N/A	

ANGP Trench Breaker Locations As-Built 2014 (Segment 1)

NOTE: The following approximate stations are the minimum locations for both sand and bentonite trench breakers for Segment 1 (As Built 2014) of the Addison Natural Gas Project. This list was created using information from details #2 and #5 on drawing ANGP-T-G-015 Rev. 1 from the Plan Set titled "Addison Natural Gas Project Transmission Mainline" dated 04-02-15. The Construction Management Team/Inspectors should review actual field conditions and direct the Contractor to install additional trench breakers as necessary to supplement the listed areas.

LEGEND:

(grey)	Sand Trench Breaker
(yellow)	Bentonite Trench Breaker

"Theoretical Station"	Type	As-Built Station	As-Built Type	Comments
384+60	BENTONITE	NONE	N/A	
385+00	BENTONITE	386+12	BENTONITE	
401+49	SAND	NONE	N/A	
403+00	SAND	NONE	N/A	
404+93	SAND	NONE	N/A	
406+42	SAND	NONE	N/A	
407+96	SAND	NONE	N/A	
409+48	SAND	NONE	N/A	
411+00	SAND	NONE	N/A	
429+35	BENTONITE	429+30	BENTONITE	
429+05	BENTONITE	429+43	BENTONITE	
429+50	SAND	NONE	N/A	
430+30	SAND	NONE	N/A	
433+50	SAND	433+53	SAND	
435+00	SAND	NONE	N/A	

ANGP Trench Breaker Locations As-Built 2014 (Segment 1)

NOTE: The following approximate stations are the minimum locations for both sand and bentonite trench breakers for Segment 1 (As Built 2014) of the Addison Natural Gas Project. This list was created using information from details #2 and #5 on drawing ANGP-T-G-015 Rev. 1 from the Plan Set titled "Addison Natural Gas Project Transmission Mainline" dated 04-02-15. The Construction Management Team/Inspectors should review actual field conditions and direct the Contractor to install additional trench breakers as necessary to supplement the listed areas.

LEGEND:

(grey)	Sand Trench Breaker
(yellow)	Bentonite Trench Breaker

"Theoretical Station"	Type	As-Built Station	As-Built Type	Comments
436+90	BENTONITE	436+70	BENTONITE	
NONE	N/A	437+00	BENTONITE	
437+20	BENTONITE	437+19	BENTONITE	
440+50	BENTONITE	440+22	BENTONITE	
440+70	BENTONITE	441+10	BENTONITE	
448+40	BENTONITE	447+75	BENTONITE	
449+30	BENTONITE	449+09	BENTONITE	
459+50	BENTONITE	NONE	N/A	
460+15	BENTONITE	460+09	BENTONITE	
466+05	BENTONITE	466+00	BENTONITE	
466+55	BENTONITE	466+50	BENTONITE	
468+70	BENTONITE	468+62	BENTONITE	
469+30	BENTONITE	469+35	BENTONITE	
506+45	BENTONITE	NONE	N/A	
507+30	BENTONITE	NONE	N/A	

ANGP Trench Breaker Locations As-Built 2014 (Segment 1)

NOTE: The following approximate stations are the minimum locations for both sand and bentonite trench breakers for Segment 1 (As Built 2014) of the Addison Natural Gas Project. This list was created using information from details #2 and #5 on drawing ANGP-T-G-015 Rev. 1 from the Plan Set titled "Addison Natural Gas Project Transmission Mainline" dated 04-02-15. The Construction Management Team/Inspectors should review actual field conditions and direct the Contractor to install additional trench breakers as necessary to supplement the listed areas.

LEGEND:

	Sand Trench Breaker
	Bentonite Trench Breaker

"Theoretical Station"	Type	As-Built Station	As-Built Type	Comments
510+25	BENTONITE	509+90	BENTONITE	
511+80	BENTONITE	NONE	N/A	
514+70	BENTONITE	514+89	BENTONITE	
515+50	BENTONITE	515+45	BENTONITE	
540+35	BENTONITE	540+43	BENTONITE	
540+65	BENTONITE	537+60 (STA EQN.)	BENTONITE	
546+30	BENTONITE	546+09	BENTONITE	
547+35	BENTONITE	547+62	BENTONITE	
548+00	BENTONITE	NONE	N/A	
NONE	N/A	549+68	Unk.*	need to confirm with survey TRBKR type
551+00	BENTONITE	NONE	N/A	
552+60	BENTONITE	553+30	Unk.*	need to confirm with survey TRBKR type

TAB 6

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 8/28/2015

Subject: Welding Line Up Clamp Usage Clarification

Directive Number: 2015-004

The Butt Weld procedures used on this project (WPS-VGS-B-2 2014-2; WPS-VGS-X-65-2 2014-2) indicate that the use of an external line up clamp is allowed, but not required. This directive serves as a notification that the use of an external line up clamp is required on all main line girth welds on this project except when it is not feasible due to situations where the contour of a fitting does not allow use. In such cases the weld will be fitted up in a manner that does not place undue stress on the weldment. This is also stated in the Technical Specification Section 137000 – Welding in Part 3, Subsection 3.3(B).

If another situation arises where use of a clamp is not feasible, then it must be reviewed and approved by the Construction Inspection Team and VGS Operations.

The clamp shall not be removed until a minimum of 50% of the root bead has been placed, according to the instructions in the WPS and Section 137000 – Welding.

This Project Directive replaces 2015-002.

Issued by (print): Christopher LeForce

Signature: 8/28/2015

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

TAB 7

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 9/29/2015

Subject: Pipe surface preparation for shrink sleeves weld coating

Directive Number: 2015 – 010

Pipe surface preparation for Shrink Sleeves will be sandblasting using the SSPC-SP10 or NACE 2- Near-White Blast Cleaning Specificiation.

Method of surface preparation shall continue to be recorded for each weld.

Issued by (print): Christopher LeForce

Signature: ____________

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

Vermont Gas

Corrective/Preventive Action Request (CPAR)

CA ■ PA ☐

(Check appropriate box to indicate corrective or preventive action)

Initiator: K. Oxholm Corrective Action # 2015-003

or

Date: 9/11/15 Preventive Action #

	Date Due	By/Assigned to	Completed Initials & Date
Investigation		Eric Curtis	
Implementation		Eric Curtis	
Audit			
CAR/PAR closed			

Description of Issue

Pritec patches were discovered to not be adhering appropriately to the Pritec pipe.

Work Processes need to be modified or ceased during investigation?: Yes x No ___
If so, specify:

Patches were one of two acceptable repair methods. Patch use was discontinued during investigation. Canusa sleeves were the only remaining acceptable method during this time.

Approved by: [signature] Date: 12/4/15

Investigation Finding

Discussion with Liberty Coatings representative Wally Armstrong determined that the patch kits used during 2014 were CRP-65 kits. Prior to the 2015 construction season the CRP-65 kits were discontinued by the manufacturer. The replacement for the discontinued kit is the CRP-Ultra kit. The kits used in 2015 were CRP-Ultra kits. The adherence problem appears to affect the CRP-Ultra kits.

A variety of kits were used at the coating mill and several patches that were installed at the mill were tested and found to be adhering properly. There were patches that did not appear to be adhering properly upon receipt of the pipe at the laydown yard. Those that were not adhering were repaired in the laydown yard.

Rev. 0 07/24/2015

Vermont Gas

Corrective/Preventive Action Request (CPAR)

Recommendations for Corrective / Preventive Action
Recommend switching to use of the Canusa sleeve as the sole method of repair in this situation. Additional methods of repair may be reviewed and approved in the future.

Action Taken / Verification
The use of CRP-Ultra kits was discontinued in favor of using Canusa sleeves until such time as an alternative repair method is approved. Direct assessment to be conducted in 2016 will address concerns about any potential holidays. In addition, VGS will be commissioning the cathodic protection (CP) system at the gas-up of the pipeline. This will provide additional protections should any coating holidays exist on the pipeline.
Any future re-evaluation and follow-up required? Yes x No ___ If so, specify:
The planned direct assessment will be used to verify whether any coating holidays exist.
Verified by: ____________________ Date: ____________ Was action taken effective? ☐ Yes ☐ No If no, new CA/PA number: ________ ______________________________ Comments: ______________________________

Rev. 0 07/24/2015

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 9/14/2015

Subject: Sacrificial Weld Coating on HDD Installations

Directive Number: 2015 – 009

For added abrasion resistance on horizontal direction drill (HDD) installations, Canusa's Wrapid Shield™ XL shall be installed over the Powercrete® R-95 coated weld. Please follow all manufacturer's instructions regarding the installation of both coatings and ensure the coatings are installed by qualified contractor personnel. All installations shall be observed by an inspector from the VGS Construction Inspection Team. Also ensure that at least one adhesion test is completed on the Powercrete® R-95 coating before the Wrapid Shield™ XL is installed.

At least one weld coating shall be visually inspected and jeeped after the pullback operation.

Attached for added reference is a memo explaining the use of additional abrasion resistance coating, along with the installation guide and product data sheet for the Wrapid Shield™ XL.

Issued by (print): Christopher LeForce

Signature: [signature] 9/14/2015

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

MEMORANDUM

TO: Addison Rutland Natural Gas Project (ARNGP) File

FROM: Christopher LeForce

DATE: September 4, 2015

RE: Use of sacrificial coating over primary weld coatings on horizontal directional drilling (HDD) installations

Vermont Gas Systems, Inc. (VGS) is proposing to use a sacrificial coating over the primary weld coating on (HDD) installations. VGS is using Powercrete® R-95 liquid epoxy for the primary corrosion protection at the welds. The R-95 is a single coat, 100% solids, high build epoxy novolac that coats pipelines. As an abrasion resistant overlay (ARO) it is compatible with fusion bond epoxy (FBE) and CTE mainline coatings. The purpose of the sacrificial coating is to add additional protection to the weld coating during pullback of the pipe during the HDD process.

In HDD installations, a typical corrosion coating, like FBE, cannot be used because of the potential for the coating to be damaged down to bare metal. For that reason either an ARO coating is used over the FBE or a harder, more durable coating is used. The line pipe is coated with a two-layer system, a FBE coating under an ARO coating, which is the sacrificial coating. In a similar manner, VGS is proposing to add a sacrificial coating over the R-95 coating to provide additional protection.

VGS is proposing to use Wrapid Shield™ XL manufactured by Canusa-CPS, a Shawcor Company. Wrapid Shield™ XL is a fiberglass cloth, pre-impregnated with a resin that can be activated by salt or freshwater to coat and protect any diameter of pipe within minutes. The product is formulated to resist shear, impact and abrasion on pipe coating systems above and below ground such as fittings and joints on all mill-coated pipe and as an outer wrap over heat-shrinkable sleeves for added mechanical protection.

The purpose of the pipeline coating is to provide a barrier between the steel pipe and the elements that can cause it to corrode or rust. The coating is the primary corrosion control method of protection the pipe. If there is a coating break or holiday, then the pipe is protected by the secondary measure of cathodic protection (CP).

The question that has been brought up is does applying this type of coating cause cathodic shielding. Shielding is caused by an external material that prevents the cathodic protection (CP) current from getting to the steel pipe. Technically, properly applied coating fits into the definition of cathodic shielding because it does not allow any connection with a foreign material. In order for CP to work you need a full circuit for the current to flow from the pipe to the soil and back. Other foreign materials can cause shielding which include plastic sheets with no adhesion, tree roots, rocks, soil, improper backfill/compaction, casings, and any other high resistance materials.

As supported by a letter from Steve Anderson (NACE CIP2 # 25805) of Shawcor, dated August 12, 2015, a properly applied coating will not cause cathodic shielding. In this case when both coatings are applied correctly and appropriately tested to ensure no holidays, this will not cause a cathodic shielding condition. The sacrificial coating of the Wrapid Shield™ XL will help protect the primary coating of the R-95 from damage during the HDD pullback.

The primary coating of R95 will be applied per manufacturer's procedures, inspected by the construction inspection team, and properly checked for any coating holidays before the wrap is applied to ensure the integrity of the coating. After the installation of the pipe is complete, at least one coated weld will be inspected per the VGS inspection criteria.

In conclusion, the Wrapid Shield™ XL will help ensure the primary coating is protected and can function as designed in protecting the steel pipe. If the sacrificial coating is not used, there is a higher potential of having coating holidays in the primary coating and it would not be able to function properly. In this case the secondary corrosion control method of CP would be used to protect the pipe. In 49 CFR Part §192.461 External corrosion control: Protective coating, it states "if coated pipe is installed by boring, driving, or other similar method, precautions must be taken to minimize damage to the coating during installation." Using the Wrapid Shield™ XL is the best method of minimizing the damage to the primary coating during installation.

August 12, 2015

To:
Mr. Wally Armstrong
Liberty Sales and Distribution
2880 Bergey Rd. Ste. F
Hatfield, PA. 19440

RE:
WrapidShield-XL Compatibility with Powercrete R95 and Nap-Gard FBE's / ARO's, and Cathodic Shielding Concerns on VGS's Addison County Expansion Project.

Dear Mr. Armstrong,

Canusa's WrapidShield-XL product is fully compatible with all 2 part liquid epoxies, all Fusion Bonded Epoxies, and all ARO epoxies (powder or liquid). The XL product consists of a woven glass and a moisture cured Polyurethane. Polyurethanes and epoxies are chemically compatible, and the 2 will adhere to one another given that proper surface preparation is completed (surface abrasion of the FBE/2PLE/ARO).

As far as the Cathodic Shielding concerns, all coatings have the potential to shield if not installed properly. All coatings have electrically resistive properties. Proper application training and following the manufacturers recommended installation procedure will assure that coatings will not shield.

Please let me know if I can be of further assistance.

Sincerely,

Steve Anderson

Steve Anderson
Technical Sales Representative

SHAWCOR

NACE CIP2 # 25805
steve.anderson@shawcor.com
M. 832-314-7110

CANUSA-CPS
A ShawCor Company

Wrapid Shield XL

Fiberglass Mechanical Protection for Field Joints on Directionally Drilled Pipelines

Product Description

Wrapid Shield XL is supplied within the kit and is contained in a heat-sealed foil pouch.

Installer Kit
An Installer Kit is supplied separately and includes Compression Film and Nitrile gloves.

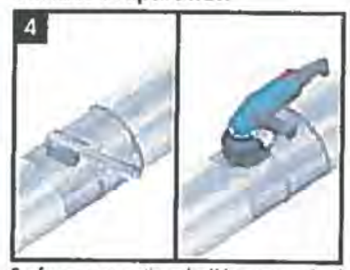
Equipment List

Appropriate tools for surface abrasion and preparation (wire brush/power wire brush or grit blaster, abrasive paper (40-80 grit), Knife, lint free rags, approved solvent and water spray bottle. Standard safety equipment, gloves, safety glasses, hard hat, etc.

Surface Preparation

Clean exposed steel and adjacent pipe coating with an approved solvent (Acetone, MEK, Alcohol >96%) to remove the presence of oil, grease, and other contaminants if present. Ensure that the pipe is dry prior to mechanical cleaning.

Surface Preparation

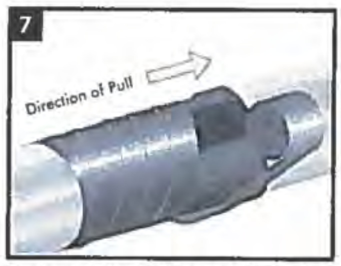


Surface preparation shall be as required for the specific corrosion coating used in conjunction with Wrapid Shield XL.

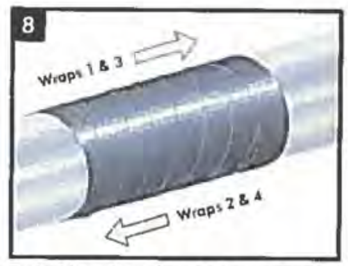
For heat-shrinkable sleeve corrosion coatings use the Canusa product specific installation guide.

Outer Wrap
Application Wrapid Shield XL

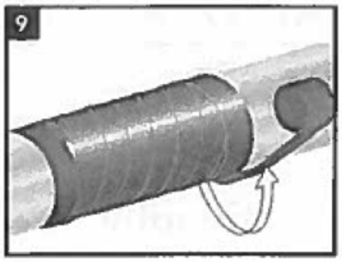
Water is needed to activate Wrapid Shield XL. Open the foil pouch, remove the roll. Once opened, the product cannot be repackaged. Wrapid Shield XL is activated using a water sprayer to mist and wet each layer as it is wrapped.



Starting at the trailing end of the field joint, begin the application at a distance of 50mm (2") past the inner corrosion coating and extend the wrap 150 mm (6") beyond the corrosion coating on the leading edge. Apply the first wrap circumferentially around the pipe at a 90° angle then begin spiral wrapping with a 50% overlap following the wrapping guideline that is printed on the roll. Apply pressure during application by pulling firmly on the roll as it is applied. Squeeze and mold firmly in the direction of the wrap until tight.

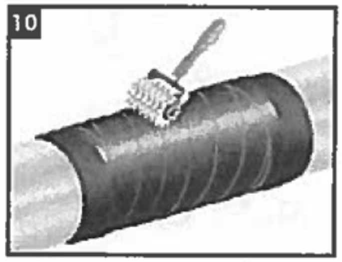


End with a circumferential wrap applied at 90° to the pipe. For high shear or impact requirements, additional layers may be required. To create thinned edges for directional drilling, reduce the overlap in the last 100mm - 150mm of the edges to 10-20% rather than 50%.



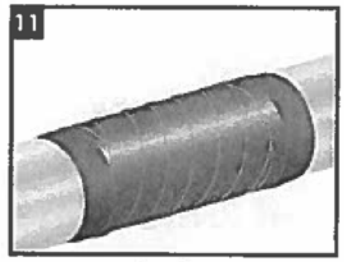
Apply compression film in the same direction as the previous layers with a 50% overlap. Start min. 50mm (2") beyond the outer edge of the Wrapid Shield XL, pulling firmly during application.

NOTE: Compression film should be applied before excess foaming is observed from the Wrapid Shield XL. A second installer should begin this step and follow the Wrapid Shield XL installer(s) as they progress with the wrapping of the pipe. The resin should be compressed and the film perforated as quickly as possible.



Perforate the compression film using a wire brush (or other perforating device) by tapping firmly on the tape with the metal bristles. Perforation allows the CO^2 gas generated by the curing process to escape. Compression film may be removed after material hardens and either discarded or left in place.

Prior to Pulling



Allow the Wrapid Shield XL to reach a Shore D Hardness of 70 prior to pulling. Wrapid Shield XL is fully cured at a Shore D Hardness of 83 @ 72°F.

Note: If holiday inspection is required it must be done after installation of the corrosion coating product is installed because the holiday detector with jeep on residual moisture in the Wrapid Shield XL installed product.

Storage & Safety Guidelines

To ensure maximum performance, store Canusa products in a dry, ventilated area. Keep products sealed in original cartons and avoid exposure to direct sunlight, rain, snow, dust or other adverse environmental elements. Avoid prolonged storage at temperatures above 35°C (95°F) or below -20°C (-4°F). Product installation should be done in accordance with local health and safety regulations.

These installation instructions are intended as a guide for standard products. Consult your Canusa representative for specific projects or unique applications.

Canusa-CPS
A division of ShawCor Ltd.

Head Office
25 Bethridge Rd.
Toronto, ON M9W 1M7 Canada
Tel: +1 416 743 7111
Fax: +1 416 743 5927

Canada
Suite 3200, 450 - 1st Street S.W.
Calgary, AB T2P 5H1 Canada
Tel: +1 403 218 8207
Fax: +1 403 264 3649

Americas
2408 Timberloch Place, Building C-8
The Woodlands, TX 77380 USA
Tel: +1 281 367 8866
Fax: +1 281 367 4304

Europe, Middle East, Africa & Russia
Unit 3, Sterling Park,
Gatwick Road, Crawley, West Sussex
RH10 9QT United Kingdom
Tel: +44 1293 541254
Fax: +44 1293 541777

Asia-Pacific
101 Thomson Road,
#11-03 United Square
307591 Singapore
Tel: +65 6749 8918
Fax: +65 6749 8919

Canusa-CPS is registered to ISO 9001:2008

Part No. 99060-228
IG_Wrapid Shield XL_rev010

LIBERTY SALES & DISTRIBUTION

2880 Bergey Road, Suite F · Hatfield, PA 19440 · Ph: 877-373-0118 · Fx: 888-850-3787

PRINCIPAL MANUFACTURERS

A.Y. MCDONALD MFG. COMPANY is the leading manufacturer of Plug and Ball style Gas Meter Shutoff Valves utilized in both residential and commercial applications up to 175 PSIG. A.Y. McDonald offers a variety of Integral Valve and Standard Configuration Meter Bars including single and multiple residential By-Pass Meter Bars and the newly developed Industrial By-Pass Bar. A full line of straight and off-set Meter Swivels, Meter Nuts, and Meter Plugs are also available in black malleable iron or a galvanized finish. 3 Part Unions in ¾" thru 2" diameters are also manufactured in a BMI finish.

BÖHMER is a worldwide leader in the manufacturing of forged, fully welded, trunnion mounted style ball valves for a variety of high pressure field applications. Nearly 60 years of German engineering and design have resulted in a state of the art production facility and one of the highest quality, flange/welded end valves available on the market. Böhmer Valves are available in diameter sizes ranging from 2" thru 56" with ANSI Class 150 to 1500 nominal pressure ratings, and made in accordance with API 6D standards.

CANUSA-CPS is the global leader in field applied corrosion protection systems. CANUSA Heat-Shrinkable Sleeves include Wraparound and Tubular Sleeve Systems and Tapes. CANUSA also offers HBE-95 Liquid Epoxy Coating for all your field joint coating needs. CANUSA products are also specified for a variety of specialty applications including Directional Drillings, Casings, Bridge Crossings, Water/Wastewater fittings, and elbows. CANUSA also recently developed Wrapid Shield™ PE, a high impact resistant rockshield to protect your corrosion coatings.

CCI PIPELINE SYSTEMS specializes in providing a complete line of Casing related products for the Gas, Oil, Water and Wastewater Industries offering Wrap-It Link Seals, High-Density Polyethylene, Carbon or Stainless Steel Casing Spacers, and Neoprene Rubber End Seals for Casing Pipe and Wall Penetration applications.

CHASE CORPORATION is a leading manufacturer of field applied coatings and tapes for the natural gas, oil, water and wastewater industries. Chase's pipeline coatings division sells the highest quality and well respected brand name products including the Tapecoat ® and Royston ® suite of corrosion protection products. Their extensive product lines include a variety of Cold and Hot Applied Tapes, Sealants, Protective Outerwraps, Liquid Epoxies, Mastics, Petrolatum Wax Tapes and Casing Fill products and services.

CITADEL TECHNOLOGIES is the leading developer and only manufacturer of the Diamond Wrap suite of products on the market. The Diamond Wrap HP, Diamond Wrap and Black Diamond systems consist of a 100% Solid Epoxy coupled with a Bi-Directional Carbon Fiber Wrap. Our Carbon Fiber Composite Repair Systems are extremely low profile and unmatched in structural integrity used to completely restore corroded/eroded piping systems to their original MAOP without service interruption.

LIBERTY SALES & DISTRIBUTION

2880 Bergey Road, Suite F · Hatfield, PA 19440 · Ph: 877-373-0118 · Fx: 888-850-3787

PRINCIPAL MANUFACTURERS

Denso

DENSO is an internationally recognized leader in corrosion prevention and sealing systems for new and rehabilitation applications. DENSO developed the original Petrolatum Wax Tape and they have completed successful applications for over 75 years. DENSO's suite of corrosion products include: Petrolatum Wax Tapes for above/below grade applications, fast curing Protal Liquid Epoxies for standard and LOW TEMP applications, Bitumen and Butyl Tape systems, and Sealing/Molding products including their Profiling Mastic for irregular shaped valves and flanged connections.

ERICO

ERICO is the worldwide CP connections leader. ERICO was the first to develop the exothermic welded electrical connections that will never loosen, corrode or increase in resistance. The remotely detonated, CADWELD® PLUS system is the latest advancement in welded connections providing your crews with simple and quick installations from outside the ditch.

glas mesh co.

GLAS MESH CO. manufacturers and supplies a complete line of Fiberglass Reinforced Plastic (FRP) Corrosion/Abrasion control products for a variety of pipeline applications such as Bridge/Aerial Crossings, Compressor/Pumping Stations, and Meter Set/Station piping applications. Glas Mesh products include the FRP Shields, Spacers, Saddles, Flatties, Casing Insulators, Coated U-Bolts and EPI Seam-Sealer.

LB&A manufacturers a variety of Non-Conductive Pipe Rollers, Pipe Hangers, and related support hardware for pipeline Bridge Crossing applications. LB&A's Hangers and related support hardware are available in a variety of corrosion prevention finishes including stainless steel and a proprietary BLUECOAT system. LB&A products have been proven to provide long-term durability, weatherability and performance.

LIBERTY COATING COMPANY

A Liberty Group Company

LIBERTY COATING COMPANY, LLC is the Northeast leader in the application of anti-corrosion coatings for the gas, oil, electric, water and wastewater industries. In addition to our PRITEC® coating system, Liberty applies ID/OD Specialty Paint and Lining Systems and provides Pipe-Type Cable Flaring and Coatings. Liberty Coating is located on 35 acres with Rail and Truck access. Pipe Handling, Cutting, Storage, and Logistical Freight Services are also available.

LIBERTY SALES & DISTRIBUTION

Directional Drilling Coatings

LIBERTY SALES & DISTRIBUTION, LLC offers products from the pipeline industries leading manufacturers of HDD coating systems. These include the liquid epoxy coatings Powercrete J, Powercrete R-95, Denso ARO, Warrior 100, as well as the Canusa DDX heat shrink sleeve system. Liberty Sales readily stocks these coating systems, ensuring quick response and timely delivery.

LIBERTY SALES & DISTRIBUTION

2880 Bergey Road, Suite F · Hatfield, PA 19440 · Ph: 877-373-0118 · Fx: 888-850-3787

PRINCIPAL MANUFACTURERS

LIBERTY SALES & DISTRIBUTION

Pipeline Markers

LIBERTY SALES & DISTRIBUTION, LLC can provide you with all your marking needs for both underground and above ground infrastructure. The Liberty Dome Post, Test Station, Vent Casing Post, and Flat Marker Post are all made from impact resistant, UV stable plastics and resins that will provide long term marking protection. They are available in standard lengths and colors.

LIBERTY SALES & DISTRIBUTION

Pipeline Pigging Products

LIBERTY SALES & DISTRIBUTION, LLC serves the pipeline industry by distributing a wide selection of pipeline pigging products and accessories. Our pipeline pigging products are available in most sizes for cleaning, swabbing and batching solutions for your pipeline. Whatever the job requires, Liberty Sales can provide the proper pig, pig launcher or pig tracker, each customized to the customers specifications.

LIBERTY SALES & DISTRIBUTION

Liberty HD Rockshield®

LIBERTY HD ROCKSHIELD® provides high impact and abrasion resistance to protect all of your underground pipeline infrastructure needs. Made from a random looped, lead free, PVC material, this high-density rockshield will save you money by eliminating the need for select back fill, and provide long term abrasion resistance for the life of the pipeline. We will custom cut most orders to help reduce waste on your project. Liberty Sales and Distribution also provides a variety of lighter weight rockshields to meet all your underground pipeline protection needs.

LIBERTY SALES & DISTRIBUTION

Tracer Wire & Cathodic Protection

LIBERTY SALES & DISTRIBUTION, LLC supplies a variety of solid/stranded copper Tracer Wire and CP Wire for your damage prevention and corrosion protection needs. Our HMWPE Tracer Wire is insulated with a rugged, moisture resistant High Molecular Weight Polyethylene (HMWPE) ideal for direct burial applications in the Gas, Fiber Optic, Water and Wastewater Industries. Our CP wire is available in #2 - #8 sizes along with a variety of color options. Custom markings and packaging is available upon request.

MONTI

MONTI TOOLS INC. produces high quality surface preparation tools that provide consistent profile depth for field joints and countless other applications. The Monti Bristle Blaster Kit is available in both electric and pneumatic models with a wide selection of attachments. They are widely used in both shop and field applications and can provide SSPC-SP10 surface cleanliness and anchor profile up to 4.7 mils depending upon the substrate.

SPY Pipeline Inspection Company, Ltd

PIPELINE INSPECTION COMPANY produces a host of pipe inspection products including the well known SPY Holiday Detector. Each of the SPY Portable Holiday Detectors offer an indefinite adjustable voltage settings range including the Model 780 (1kV-5kV), Model 785 (1kV-15 kV) and the Model 790 (5 kV-35 kV). The positive ground light and audible alarm features are designed with safety in mind and the rugged ergonomic design and easy installation batteries makes for the most efficient and reliable Jeep on the market.

LIBERTY SALES & DISTRIBUTION

2880 Bergey Road, Suite F • Hatfield, PA 19440 • Ph: 877-373-0118 • Fx: 888-850-3787

PRINCIPAL MANUFACTURERS

TECO AMERICAS

TECO AMERICAS - The FireBag® Thermal-activated Gas Shut-off Device automatically turns off the gas supply in the event of a fire, preventing explosions and the spreading of fire. In the unfortunate event of a fire, when the external ambient temperature of The Firebag® reaches 203-212°F (95-100°C) the metal alloy that keeps the plug & cartridge together melts. Then the spring pressure pushes the plug against the gas opening closing it completely. No fire or heat detectors are required to automatically intercept gas flow. Meets AGA/CGI ANSI Z21.15, DIN 3586 and UIE EN 1775 standards for indoor gas installations.

Western Technology

WESTERN TECHNOLOGY INC. is the premier manufacturer and supplier of Explosion Proof and Low Voltage Lighting products, serving a variety of industries. The NEW UL Approved, CLASS I DIV I BRICK Light offers brilliant white LED lighting with safety and "kick it tough" durability. The BRICK Light provides superior lighting with minimal heat generation even after hours of operation. Western Technology also provides a complete line of Explosion Proof Products for a variety of applications in hazardous locations.

WOODARD & CURRAN

WOODARD & CURRAN has successfully served the energy market for over 20 years providing a broad scope of regulatory, environmental, and construction support services with clients specializing in the generation, transmission, distribution, and the storage of energy. Woodard & Curran's experience includes electricity, natural gas, petroleum, nuclear energy, heat/power, and the renewable energy sectors. Typical services include: design engineering, linear project routing and permitting, site evaluations, feasibility studies, regulatory compliance, wetland use and resource permitting, mapping and GIS services.

CONTACT INFORMATION

Corporate Office:

Liberty Sales and Distribution, LLC
2880 Bergey Road, Suite F
Hatfield, PA 19440
Phone: (877) 373-0118
Fax: (888) 850-3787

www.libertysales.net
www.libertyhd.net
www.libertymarkers.net

Tracey Rocchino
Office Manager
Email: trocchino@libertysales.net

Tracy Nixon
Inside Sales Representative
Email: tnixon@libertysales.net

Jenna Rorer
Inside Sales Representative
Email: jrorer@libertysales.net

Regional Offices:

New England Territory
Wally Armstrong
Cell: (978) 815-8336
Email: warmstrong@libertysales.net

Mid Atlantic Territory
George Rocchino
Cell: (267) 767-9423
Email: grocchino@libertysales.net

Southern Territory
Lou Taylor
Cell: (267) 664-8177
Email: ltaylor@libertysales.net

Northern Territory
Shane Quackenbush
Cell: (518) 441-5532
Email: squackenbush@libertysales.net

Outside Sales Consultants:

Mid Atlantic Territory
Chuck Lang IV
Cell: (215) 350-9990
Email: clang4@libertysales.net

New England Territory
John Maher
Cell: (207) 650-5740
Email: jmaher@libertysales.net

CANUSA-CPS
A SHAWCOR COMPANY

Wrapid Shield™ XL/XL-FC

Fiberglass Mechanical Protection for Field Joints on Directionally Drilled Pipelines

Wrapid Shield™ XL/XL-FC is a fiberglass cloth, preimpregnated with a resin that can be activated by salt or freshwater to coat and protect any diameter of pipe within minutes. The product is formulated to resist shear, impact and abrasion on pipe coating systems above and below ground such as fittings and joints on all mill-coated pipe and as an outer wrap over heat-shrinkable sleeves for added mechanical protection.

Superior Mechanical Protection

- Provides unparalleled protection against impact, indentation, abrasion, punctures and tears that may result from directional drilling, rough handling, native backfills or severe in-service conditions.
- Designed to protect the underlying field joint coating from the effect of forces associated with directional drilling.

Chemical Resistance

- Resistant to corrosive salt water, soil acids, alkalies and salts, common chemicals, chemical vapors, and exposure to outdoor weathering and sunlight.

Long Term Corrosion Protection

- In combination with a heat-shrinkable sleeve the composition of the products is such that they provide an effective barrier to water and oxygen which provides effective corrosion protection and soil stress resistance.

Different Cure Speeds Available

- Wrapid Shield™ XL is available in 2 configurations depending on project or environmental conditions.
- Wrapid Shield™ XL is the standard version and has an application time of 20 minutes at 23°C.
- Wrapid Shield™ XL-FC is a Fast Cure version and has an application time of 5 minutes at 23°C.

Applications

- Oil & Gas
- Onshore Pipelines
- Offshore Pipelines
- Girth-Weld Joints
- Directional Drilling

Wrapid Shield™ XL/XL-FC

Fiberglass Mechanical Protection for Field Joints on Directionally Drilled Pipelines

The product information shown here is intended as a guide for standard products.

Consult your Canusa representative for specific projects or unique applications.

Typical Wrapid Shield™ XL Properties*	Test Method	Typical Values
Cure Time at 23°C**		20 min.
Lap Shear Strength	ASTM D3163	12 Mpa
Density	ASTM D792	1.15 g/cm³
Glass Transition Temperature (DSC)	ASTM D3418	Tg = 175 - 189°C
Tensile Strength	ASTM D638	248 MPa
Hardness	Shore D	80
Dielectric strength	ASTM D149	16 kV/mm
Flexural Strength	ASTM D790	405 MPa
Compressive Strength	ASTM D695	165 MPa
Impact Resistance	ASTM G14/G62 (MOD)	167 J

Typical Wrapid Shield™ XL-FC Properties*	Test Method	Typical Values
Cure Time at 23°C**		5 min.
Density	ASTM D792	1.14 g/cm³
Tensile Strength	ASTM D638	206 MPa
Hardness	Shore D	> 70
Flexural Strength	ASTM D790	372 MPa
Impact Resistance	ASTM G14/G62 (MOD)	167 J

*With an 8 layer system

**Cure times will vary depending on substrate temperature. Please contact your local Canusa office for help in determining which configuration would work best for your project's conditions.

Canusa-CPS
A division of ShawCor Ltd.

Head Office
25 Bethridge Rd.
Toronto, ON M9W 1M7 Canada
Tel: +1 416 743 7111
Fax: +1 416 743 5927

Canada
Suite 3200, 450 - 1st Street S.W.
Calgary, AB T2P 5H1 Canada
Tel: +1 403 218 8207
Fax: +1 403 264 3649

Americas
2408 Timberloch Place, Building C-8
The Woodlands, TX 77380 USA
Tel: +1 281 367 8866
Fax: +1 281 367 4304

Europe, Middle East, Africa & Russia
Unit 3, Sterling Park,
Gatwick Road, Crawley, West Sussex
RH10 9QT United Kingdom
Tel: +44 1293 541254
Fax: +44 1293 541777

Asia-Pacific
101 Thomson Road,
#11-03 United Square
307591 Singapore
Tel: +65 6749 8918
Fax: +65 6749 8919

Canusa-CPS is registered to ISO 9001:2008

PDS_Wrapid Shield™ XL/XL-FC_rev010

Since 1967, Canusa-CPS has been a leading developer and manufacturer of specialty pipeline coatings for the sealing and corrosion protection of pipeline joints and other substrates. Canusa-CPS high performance products are manufactured to the highest quality standards and are available in a number of configurations to accommodate many specific project applications.

CANUSA-CPS
A ShawCor Company

Pipeline corrosion Protection

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 9/30/2015

Subject: Adhesion Testing – Field Coating

Directive Number: 2015 - 011

An adhesion test shall be performed on an average of 2% of epoxy coated welds from April 1st through September 30th and 5% of epoxy coated welds from October 1st through March 31st, as well as on a minimum of one coated weld in the string for each HDD installation.

The instructions for completing these tests, "**QA/QC Adhesion Test for Field Applied Coatings (Revision 0),**" is attached to this directive.

Any questions on adhesion should be directed to Christopher LeForce or Eric Curtis.

This directive supercedes directive 2015- 008.

Issued by (print): Christopher LeForce

Signature: [signature]

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

TAB 8

Vermont Gas

Corrective/Preventive Action Request (CPAR)

CA ■ PA ☐

(Check appropriate box to indicate corrective or preventive action)

Initiator: K. Oxholm

Corrective Action # 2015-002

or

Date: 9/1/15

Preventive Action #

	Date Due	By/Assigned to	Completed Initials & Date
Investigation		Kristy Oxholm	KHO 12/17/2015
Implementation		Chris LeForce	CAL 12/18/2015
Audit			
CAR/PAR closed			

Description of Issue

Concern was expressed about the use of sand berms/pillows instead of sand bags for pipe support since it was not specifically called out in the technical specifications as an approved method of support and padding.

Work Processes need to be modified or ceased during investigation?: Yes x No ___
If so, specify:

Use of sand berms/pillows was ceased during the investigation.

Approved by: [signature]

Date: 12/18/2015

Investigation Finding

During investigation, Michels agreed to cease use of the berms/pillows in favor of sand bags.

Regardless of the support material/type, the pipe supports in the length of the trench are only temporary support (to achieve separation of the pipe from rocks or hard bottom in the trench bottom) until the padding/backfill material is placed around and under the area between the supports.

The sand berms/pillows react to the weighted pipe in a similar manner as the padding/backfilled soil that is subsequently installed between these supports, thereby achieving a consistent, continuous, and uniform surface for the pipeline.

The dirt berm/pillow supports are created/installed by the padding/sifting hoes, are much wider than sandbags supports (larger load bearing area), and are free of deleterious materials, rocks, etc. This method is an accepted practice in the pipeline industry.

Rev. 0 07/24/2015

Vermont Gas

Corrective/Preventive Action Request (CPAR)

Recommendations for Corrective / Preventive Action
Recommend the discontinuance of the use of sand berms/pillows, unless it is added to the technical specifications as an approved method of support and padding of the pipe.

Action Taken / Verification
Sand berms/pillows were not approved as an alternative to sand bags for further use. Based on information (attached) that the use of sand berms/pillows is a common industry practice the berms/pillows that are already in place will be left in use.
Any future re-evaluation and follow-up required? Yes ___ No x___ If so, specify:
Verified by: ______________________ Date: ______________ Was action taken effective? ☐ Yes ☐ No If no, new CA/PA number: ________ ______________________________________ Comments: ______________________________

Rev. 0 07/24/2015

Kristy Oxholm

From: Shawn Pomerleau <spomerle@michels.us>
Sent: Thursday, December 17, 2015 5:10 PM
To: Kristy Oxholm
Subject: RE: Sand/Earth Berms

Kristy – The sand berm method of temporary pipe support (prior to adding padding material) is a common practice within the pipeline industry. Generally these are installed with the use of a padding bucket which screens/filters the material. As these sand berms are built using native backfill material the pipe is able to settle consistently. I have never heard of, or seen, this method cause adverse conditions to the pipeline. Let me know if you need anything else. I will be glad to help. Thank you.

Shawn Pomerleau | Project Manager

Michels Pipeline Construction
A Division of **MICHELS Corporation**
office: 724.249.2065 | cell: 920.737.4701
spomerle@michels.us | www.michels.us
2155 Park Avenue, Suite 105
Washington, PA 15301

From: Kristy Oxholm [mailto:KOxholm@vermontgas.com]
Sent: Thursday, December 17, 2015 5:00 PM
To: Shawn Pomerleau <spomerle@michels.us>
Subject: Sand/Earth Berms

Good Afternoon,

Have you seen the sand/earth berm (pillow) method of temporary pipe support when installing pipe (prior to backfilling) prior to the VGS installations?

If so, have you ever seen them cause any Conditions Adverse to Quality?

Is this a common practice in the pipeline industry?

Thanks,
Kristy

Building Interstate Natural Gas Transmission Pipelines: A Primer

INGAA FOUNDATION REPORT 2013.01

January 2013

The INGAA Foundation, Inc.

The INGAA Foundation Inc.
20 F Street NW Suite 450
Washington, DC 20001

INGAA Foundation Ad-Hoc Construction Committee

Steering Committee/Working Group:

INGAA Foundation	Rich Hoffmann
Alliance Pipeline	Harold Kraft
Bi-Con Services	Denny Patterson
CenterPoint Energy	Erik Dilts
El Paso	Daniel Martin
El Paso	Mike Morgan
Integrated Pipeline Services	Tom Alexander
Integrated Pipeline Services	John Allcorn
Mears	John Fluharty
TransCanada	Mark Domke
Williams	Mario DiCocco

Significant Contributions:

CenterPoint Energy	Debbie Ristig
Energy Transfer	Eric Amundsen
Energy Transfer	Kirk Peterman
Energy Transfer	Dan Pribble
INGAA Foundation	Kevin Voelkel
Kinder Morgan	Dwayne Burton
Sheehan Pipeline	David Sheehan
Spectra Energy	Joseph Ramsey
Spectra Energy	Andy Drake
Sunland	Craig Meier
Process Performance Improvement Consultants, LLC	John Zurcher
TransCanada	Tracy Schultz

Process Performance Improvement Consultants, LLC	Mark Hereth, Technical Lead and Facilitation

Cover photo courtesy of Alliance Pipeline.

Table of Contents

[1] See foreword for a description of the process used to determine space requirements.

Foreword

This primer was written to explain how interstate natural gas pipelines are constructed, from the planning stages to completion. The primer is designed to help the reader understand what is done during each step of construction, how it is done, the types of equipment used, and the types of special practices employed in commonly found construction situations.

It also describes practices and methods used to protect workers, ensure safe operation of equipment, respect landowner property, protect the environment and ensure safe installation of the pipeline and appurtenances.

This report is meant to be used by all those interested in pipelines and their construction, including federal agencies, landowners, the public, state and local governments, emergency responders and new employees of pipeline and construction companies.

This primer, which was reviewed by INGAA Foundation member companies, updates previous works produced by the INGAA Foundation.

In particular, the steering committee working group determined nominal technical space requirements discussed in Appendix A. This group also designed the drawings in Appendix B. Project specific circumstances will have a bearing on the workspace proposed by individual pipeline project applicants. When determining nominal workspace requirements, the pipeline company must consider the space needed for the safest construction possible, including personnel safety, staging of pipe and pipeline appurtenances, efficient movement of materials and equipment, as well as diligent management of environmental impacts.

Concrete coating may be used under streams and in wetlands. Weighting is applied to manage buoyancy in special circumstances, such as river and wetland crossings.

Valves and appurtenances are coated with either FBE or coal tar.

The March 2009 QA/QC Workshop mentioned above also identified an opportunity to improve coating practices on the portion of the pipe where girth welds have been made. A group of INGAA Foundation members worked together in 2010 and 2011 to develop guidance for coating applicators and coating inspectors. The group produced a report entitled, Training Guidance for Construction Workers and Inspectors for Welding and Coating, which is available on the INGAA Foundation Web Site. A separate working group of INGAA Foundation members evaluated challenges with applying coatings during construction. The group developed a report entitled, Best Practices in Field Applied Coatings, also available on the INGAA Foundation Web Site.

3.9 Lowering the Pipe into the Trench

Prior to lowering the pipeline, the trench is cleaned of debris and foreign material, and dewatered as necessary. Trench dewatering entails pumping accumulated groundwater or rainwater from the trench to stable upland areas. The work is performed in accordance with applicable local, state and federal permitting requirements, as well as the operator's procedures. In rocky areas, the bottom of the trench is padded with sand, gravel, screened soils, sandbags or support pillows to protect the pipe coating. Topsoil is not used as padding material.

As described above, an inspection of the coating via jeeping is performed to ensure the integrity prior to lowering. Any coating anomalies detected are repaired.

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 9/1/2015

Subject: Construction in Sand Area

Directive Number: 2015 - 005

In 3.5(B) – Bedding and Backfilling of Section 312333 – Trenching, Pipe Laying, and Backfilling of the Technical Specifications: pipe supports shall be installed in all locations prior to backfilling, unless otherwise directed by the Construction Management Team.

This document serves to direct the construction without pipe supports in the sand area from station 240+26 to station 279+75, as the uniform sand in the trench meets requirements for select backfill.

Issued by (print): John Stamatov

Signature: [signature]

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 8/31/2015

Subject: Backfill Compaction in Typical Cross-Country Areas

Directive Number: 2015 – 006

In 3.5(D)(1) – Bedding and Backfilling of Section 312333 – Trenching, Pipe Laying, and Backfilling of the Technical Specifications, it states that the pipe trench in typical cross-country areas shall be thoroughly compacted by mechanical means to avoid any future trench settlement. In these cross-country areas, the trench can be compacted by mechanical means using an excavator bucket.

Compaction shall occur when there is at least 12" of sand padding and 12" of general backfill above the pipe and at a maximum of 24" lifts thereafter. Final compaction at grade can be completed using either an excavator bucket or the tracks of a piece of excavating equipment.

The use of an excavator for mechanical means of compaction in cross-country areas is typical in transmission line construction.

Issued by (print): Kristy Oxholm (for Christopher LeForce)

Signature: [signature]

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 8/31/2015

Subject: General Backfill Materials

Directive Number: 2015 – 007

In 2.1(B) – Materials of Section 312333 – Trenching, Pipe Laying, and Backfilling of the Technical Specifications, it states native materials containing no stones or clods larger than 3" in the longest dimension are acceptable for general backfill. This directive will serve as notice that native materials containing no stones or clods larger than 6" in the longest dimension are acceptable for general backfill.

The VGS Operations and Maintenance Manual in the Trenching and Backfilling Procedure allows for this change to the specification and now the two documents will be consistent.

Issued by (print): Kristy Oxholm (for Christopher LeForce)

Signature: KWOxholm

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

TAB 9

Vermont Gas

Corrective/Preventive Action Request (CPAR)

CA ■ PA ☐

(Check appropriate box to indicate corrective or preventive action)

Initiator: Christopher LeForce | Corrective Action # 2015-008

or

Date: 7/1/2015 | Preventive Action # ______

	Date Due	By/Assigned to	Completed Initials & Date
Investigation	6/18/2015	Christopher LeForce	CAL 12/11/2015
Implementation	9/1/2015	Christopher LeForce	CAL 12/11/2015
Audit			
CAR/PAR closed			

Description of Issue

The horizontal direction drilling (HDD) installation of the 12" transmission line, as part of Phase I of ANGP, under route 2A and the railroad in Essex did not meet the current acceptance criteria, at that time, for installation. The pipe was installed by ECI.

Work Processes need to be modified or ceased during investigation?: Yes ___ No x

If so, specify:

Approved by: [signature] Date: 12/11/15

Investigation Finding

When the pipe was first pulled out of the bore hole and inspected, there was coating damage both on a weld and to the pipe. The welds were coated with Powercrete R-95 liquid epoxy and there was damage down to metal on the weld inspected. The coating damage on the pipe went through the abrasion resistant overlay (ARO) and through the fusion bonded epoxy (FBE) to bare metal. Additional pipe was pulled through the hole for inspection, which is allowed by the VGS Operations and Maintenance Manual. An additional 15 feet of pipe was inspected and an additional weld. No coating damage was found on the pipe but there was one small area of coating damage found on the weld, which was down to bare metal.

Vermont Gas

Corrective/Preventive Action Request (CPAR)

Recommendations for Corrective / Preventive Action
With only one small area having coating damage and the fact that pulling more pipe through the hole could cause more damage because it had been idle for multiple days, VGS decided to look for another method of inspection. It was decided that an above ground indirect corrosion survey would be completed on the pipe.

Action Taken / Verification
See attached
Any future re-evaluation and follow-up required? Yes x No ___ If so, specify:
EN's recommendation is to perform a Close-Interval Survey (CIS) within six months of commissioning the system and verify if the pipeline is meeting NACE criteria for cathodic protection. This will be completed in the spring of 2016.
Verified by: ______________________ Date: ______________ Was action taken effective? ☐ Yes ☐ No If no, new CA/PA number: ________ ____ Comments: ______________________________________

Rev. 0 07/24/2015

Attachment to CAR 2015-008
Action Taken / Verification

VGS hired EN Engineering to conduct the indirect inspection of the pipe. EN Engineering provides "comprehensive and dependable engineering, consulting, and automation services to pipeline companies, utilities, and industrial customers." EN Engineering reviewed and revised VGS' Direct Assessment procedure and was hired in 2015 to conduct a direct assessment on multiple sections of pipe in VGS' transmission system. Their credentials are attached.

EN performed a close-interval survey (CIS), a alternating current voltage gradient (ACVG) survey, and a direct current voltage gradient (DCVG) survey on the section of pipe installed by HDD. The ACVG survey found one minor coating defect on the upstream side of the pipe, but the DCVG survey found no indications. EN concluded that its appears "that this segment of pipe could be adequately cathodically protected as long as coating damage does not exist anywhere else along the pipe that would raise the necessary cathodic protection levels" and that "based on the testing, it appears this section of pipe is acceptable." They do indicate that the survey is most effective at depths of less than 20 feet. Although a majority of this section of pipe is greater than 20 feet deep, there is an approximately a 100-foot portion of pipe that was pulled through the entire hole on the lead end at a depth of 20 feet or less. The survey did not find any coating defects on this portion of pipe. A copy of report is attached.

In addition, VGS will be commissioning the cathodic protection (CP) system at the gas-up of the pipeline. This will provide additional protection should any other coating holidays exist on the pipeline.

ENEngineering

Date: 8/19/15

To: Chris LeForce
Vermont Gas Systems
Engineering Manager
CLeForce@vermontgas.com

From: Kristi Sparbanie
T: (630)353-4024
F: (630)353-7777
ksparbanie@engineering.com

Subject: Project # F56637.00: Route 2A/Rail Crossing HDD Coating Investigation Findings

Vermont Gas Systems retained the services of EN Engineering (ENE) to conduct a coating integrity analysis along the Route 2A/Rail Crossing HDD Bore. The testing and analysis was performed to identify any possible coating faults along the 760 foot length of 12" pipe. The pipeline station is approximately 108+00 to 116+00. This is one HDD segment and is part of an approximately 41 mile "Addison Rutland Natural Gas" project. The HDD is located in Essex, Vermont.

The testing was performed and completed on July 16, 2015 by ENE. The testing that was performed included the following:

- Close-Interval Survey (CIS Native) – This survey was performed to acquire the native potential values of the survey section.
- Close-Interval Survey (CIS DC Applied) – This survey was performed by installing a temporary rectifier and ground bed to determine how much current would be needed to protect this section of pipe. Once the temporary system was installed an "On" and "Instant Off" survey was performed.
- Alternating Current Voltage Gradient (ACVG) – This survey was performed to locate any coating holidays along the pipe.
- Direct Current Voltage Gradient (DCVG) – This survey was performed to locate any coating holidays along the pipe. If a coating holiday is located, side-drain readings are taken to calculate the %IR reading to determine the severity of the coating holiday.

All testing that was performed is found to be the most reliable when pipe depths are less than 20 feet deep. For the majority of the 760 foot section of pipe that was tested, the depth of cover was greater than 20 feet with a maximum depth of 55 feet.

Test Results

A native CIS survey of the pipe was performed.

- The survey did not show any moderate or severe anodic or cathodic peaks.
- Most of the native pipe-to-soil potentials ranged from -400mV to -500mV.

An "On" and "Instant Off" CIS survey was performed when a temporary interrupted current source of 10mA was applied to the 760 foot section of pipe to simulate a cathodic protection system.

- The data collected does not indicate the potential for any moderate corrosion activity (Moderate dips: "On" readings more negative than -850mV and "Instant Off" readings more positive than -850mV).
- The data does not indicate the potential for any severe corrosion activity (Severe dips: "On" and "Instant Off" readings more positive than -850mV).
- The data indicated two (2) minor dips in the survey at neat station 3+50 and 5+75.
- The pipeline exhibited rapid polarization from the applied CP current.
- VGS indicated the original design parameters for this pipeline was a $1mA/ft^2$ density value and a 95% or better design coating. Based on the design, ENE calculated a current density value of 126mA would need to be applied to represent the origin design parameters.

The ACVG survey performed found one minor coating defect at station 5+95, two feet from the east side of Colchester Rd.

- One (1) minor coating defect was discovered along the 760 foot section of pipe. The coating defect was 42 dBµV.

The DCVG survey performed did not indicate any coating faults.

Analysis
Analysis of the CIS survey data, ACVG, and DCVG indicate that only one (1) minor coating defect was identified along the entire 760 foot HDD bore and there were no moderate or severe anodic or cathodic peaks in the survey data.

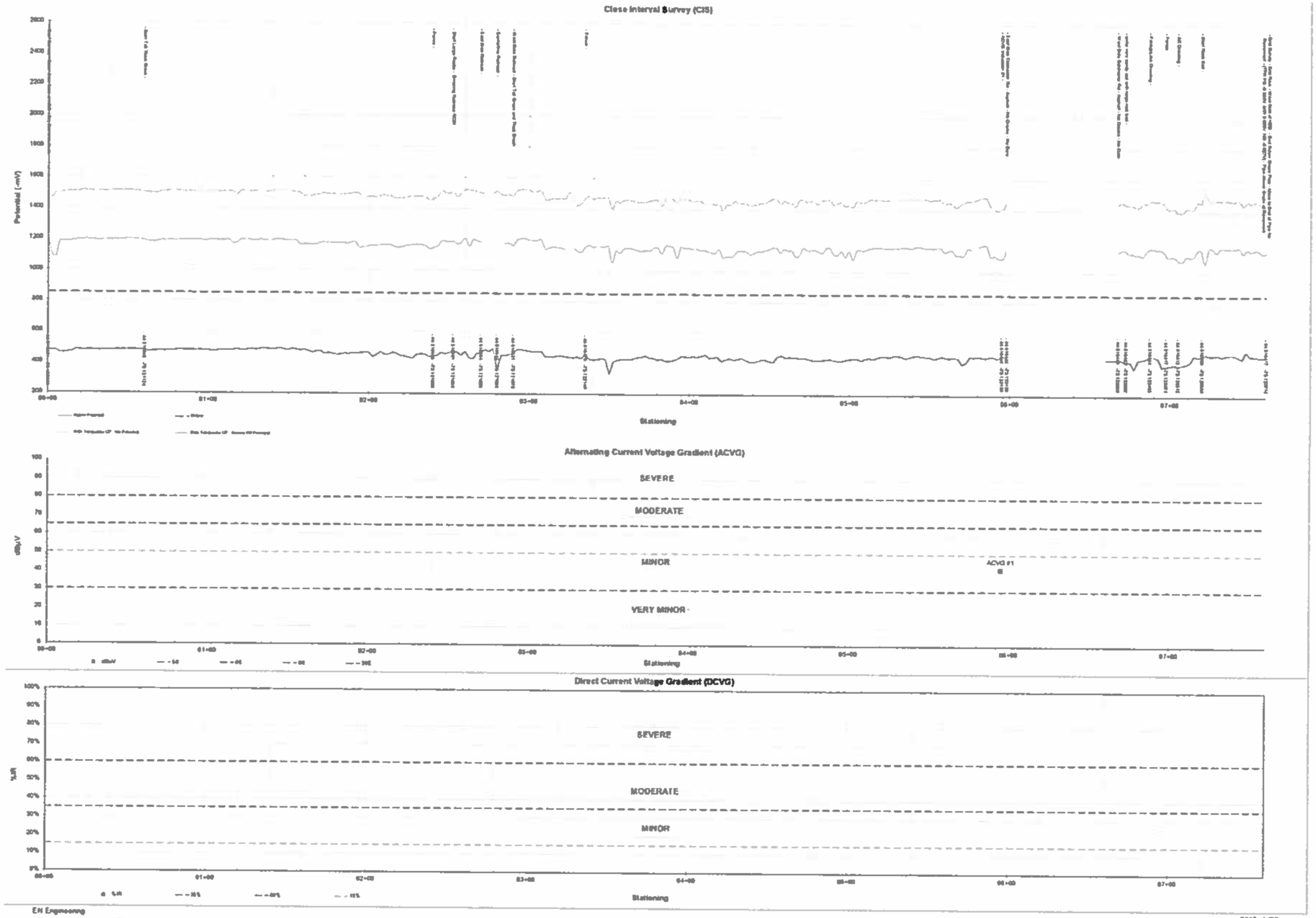
The values used for the proposed cathodic protection system were 1 mA/ft2 and a 95% effective coating design basis. Based on this, it would appear that this segment of pipe could be adequately cathodically protected as long as coating damage does not exist anywhere else along the pipe that would raise the necessary cathodic protection levels.

Based on the testing, it appears this section of pipe is acceptable. However, the pipe depth was greater than 20 feet deep and at that depth the surveys performed are not as reliable. It is possible that additional indications exist on this section of pipe, but because of the depth they are not being picked up with the limitations of the equipment. In addition, the surveys performed do not determine if physical damage or wall loss is present in the pipeline steel wall.

Recommendations
Perform a Close-Interval Survey (CIS) within six months of commissioning the system and verify if the pipeline is meeting NACE criteria for cathodic protection.

Vermont Gas Systems - HDD Assessment

0+00 to 7+60



ENEngineering.

2 November 2015

Vermont Gas Systems, Inc.
85 Swift Street
South Burlington, Vermont 05043

Attention: Kate (Rich) Marcotte
Operations Engineer
kmarcotte@vermontgas.com
802.951.0388 (office)
802.922.3254 (mobile)

Reference: References/Resumes for VGS HDD coating survey

Dear Kate:

I am providing the following information based on your October 14, 2015 request as e-mailed to Alfredo (Fred) Ulanday, Sr. Project Manager (ENE).

To date for Vermont Gas, EN Engineering has only completed the corrosion engineering assessment of two (2) HDD locations on the 41 mile "Addision Rutland Natural Gas" project.

EN Engineering is currently providing a large Midwest natural gas transmission company with HDD corrosion engineering assessments over the past two (2) years. This is being performed on over 40 HDD locations on two (2) active pipeline construction projects. HDD corrosion engineering assessment is the result of an earlier HDD installation where the pipeline was believed damaged during the installation. The process of assessment is now part of contract specifications and consists of the following:

- Perform the following testing at all HDD locations:
  - Close-Interval Survey (Native Readings) – Used to identify any anodic or cathodic peaks
  - Close-Interval Survey ("On" and "Instant Off" survey when current is temporary applied to the pipeline) – Used to identify any anodic or cathodic peaks and if the HDD pipeline segment can be protected with the current design parameters
  - Current Demand Testing – Used to determine if the HDD pipeline segment can protected with the current design parameters
  - ACVG Survey – Used to determine if any coating holidays exist
  - DCVG Survey – Only performing DCVG if the pipeline was too deep and the ACVG equipment could not be used
- The HDD testing is more accurate when the pipe is less than 20 feet deep. The survey can still be performed at depths greater than 20 feet deep, but some of the equipment and/or testing methods might not be as reliable.
- The HDD testing ENE performs does not determine if physical damage or wall loss is present.
- The HDD testing can determine if the pipeline segment can be protected with the proposed design parameters.
- The HDD testing is best performed when the pipeline ends are exposed and not connected to the remainder of the pipeline. The ends should have temporary test leads installed and no drill equipment should remain on the pipe.

A criterion for the confirmation of HDD acceptability from a corrosion engineering perspective is used to clearly define the acceptability of an HDD installation and includes the following:

- Testing results may not be in excess of the following:
    - Any single coating indication greater than 80 dBµ V.
    - More than four (4) coating indications greater than 65 dBµ V but less than or equal to 80 dBµ V per 160-ft of individual HDD installation.
    - Cathodic protection current demand in excess of 2 ma/ft^2 for an assumed 98% effective coating (2% bare); with Close interval survey (CIS)
    - Any single location that cannot be polarized (pipe-to-soil instant off measurement) equal to or more negative than -0.950 Vdc using a protective cathodic protection current as established above.

EN Engineering employees working on this project have included: Adam Gervasio, Ryan McCarthy, Corey Mitchell, Dominic Ciarlette and Kristi Sparbanie.

EN Engineering has been performing this type of testing on various projects over the last thirteen (13) or more years – most significantly with the following companies:

- Valero, Illinois– 60-foot depth HDD installation associated with liquids line from terminal to dock facility

- Enbridge Energy: Line 14 – New Pipeline construction from Construction from Illinois/Wisconsin border to Griffith, Indiana. Corrosion engineering field inspection of all HDD or bore type crossings on Line 14 construction[1]

- Nicor Gas: Multi-year Contract (2001 to 2010) – Various HDD or bore type crossings inspected as part of corrosion control engineering and cathodic assessment projects.

---

[1] Line 14 is routed from Superior, Wisconsin to Griffith, Indiana. Corrosion engineering inspection was only performed on the Illinois/Indiana section of the pipeline construction project. No post construction issues were found on this section of pipe; however, many post and significant construction issues, related to corrosion control and cathodic protection, were found on the section of pipeline from Superior, Wisconsin to the Illinois/Wisconsin border.

I wish to thank-you for the opportunity to provide you with this information. Please let Fred or I know if you have any other questions or additional need for information. I can be reached at 630.353.4039.

Sincerely,

David A. Schramm
Vice President
Corrosion Control Engineering
630 353 4039 (Office)
630 353 7777 (Fax)
630 303 1213 (Mobile)
dschramm@enengineering.com

Attachment: Resumes

- A. Gervasio, R. McCarthy, C. Mitchell, D. Ciarlette, K. Sparbanie, D. Schramm

Management-of-Change and Approval Record (MOCAR)			
Date	Version	Description	Name
11/02/2015	0.1	FINAL	Ulanday
10/31/2015	0.1	DRAFT	Schramm

Key Relevance
MAOP Verification
External/Internal Corrosion Direct Assessment
Corrosion Control Field Assessments

Job Title:
Design Engineer
Integrity

Years with EN Engineering: 1

Total Years of Experience: 1

Primary Office Location:
Warrenville, IL

Education:

- BS, Chemical Engineering, University of Illinois at Chicago

Overview: Mr. Ciarlette is a graduate of University of Illinois at Chicago. Since joining EN Engineering, he has served as a team member for MAOP verification projects, as well as working on other integrity based projects and tasks.

Relevant Projects:

Genesis - MAOP Verification
Alabama Participated in MAOP verification including quality assurance activities to confirm accuracy and completeness. Reviewed and assessed pipeline engineering documents used to validate the pipeline MAOP. Assembled spreadsheets to track pipeline features and examined pipeline specifications and tests to determine safe operating conditions.

Pacific Gas and Electric - MAOP Verification
California Participated in MAOP verification including quality assurance activities to confirm accuracy and completeness. Reviewed and assessed pipeline engineering documents used to validate the pipeline MAOP. Assembled spreadsheets to track pipeline features and examined pipeline specifications and tests to determine safe operating conditions.

DTE - ECDA/ICDA Surveys
Michigan Performed Close Interval Survey (CIS), Alternating Current Voltage Gradient (ACVG), Current Attenuation, Elevation and Depth of Cover Surveys.

MidAmerica Energy - Direct Assessment Surveys
Iowa Performed Close Interval Survey (CIS), Alternating Current Voltage Gradient (ACVG), Current Attenuation, Elevation and Depth of Cover Surveys.

Enbridge – Elevation Surveys
Illinois Performed Elevation and Depth of Cover Surveys for crude oil transmission line.

NIPSCO - MAOP Verification
Indiana Participated in MAOP verification including quality assurance activities to confirm accuracy and completeness. Reviewed and assessed pipeline engineering documents used to validate the pipeline MAOP. Assembled spreadsheets to track pipeline features and examined pipeline specifications and tests to determine safe operating conditions.

Key Relevance
Corrosion Control Field Assessments
Cathodic Protection Trouble Shooting
Atmospheric Corrosion Inspection
Corrosion Control Field Assessments

Job Title:
Design Engineer
Corrosion

Years with EN Engineering: 2

Total Years of Experience: 3

Primary Office Location:
Warrenville, IL, USA

Education:

- B.S., Civil Engineering, University of Illinois, Chicago, IL.

Professional Certifications:

- Professional Engineer Intern
- OSHA 30 Hour Construction Course
- Cathodic Protection Test (CP1), NACE

Overview: Adam Gervasio has two years experience of project experience in cathodic protection, corrosion control survey. Prior to joining EN Engineering, he worked for Weeks Marine doing heavy marine construction and environmental remediation in addition to interning at TY Lin and Cook County Highway department. He is a Cathodic Protection Tester and has passed the FE Exam.

Relevant Projects:

Cook County Highway Department

Assisted in reviewing permits on behalf of the Transportation and Planning division. Processed and prepared new permit requests on behalf of Permits division. Aided in the development of proposals for RTA/CMAP grants. Evaluated possible solutions for specific problem intersections/traffic related issues. Location: IL

T.Y. Lin International

Worked in a team, met various project deadlines, where I assisted in civil design and drafting work on the proposed Cermak Green Line elevated CTA (rail) station from 30% to bid-set submittals. Including: Removal Plan, Maintenance of Traffic, Proposed Work, Track Design, Grading Plan, Pavement Markings, Existing Conditions, and documentation control. Location: IL.

Weeks Marine

Collected, processed and analyzed hydrographic and beach survey data using electronic data collection instruments (DGPS, digital echo sounder, RTK etc.) and custom software packages. Analyzed daily collected dredge data for projects managers and superintendents to optimize operations efficiency at individual job sites. Responsible for constructing dig patterns using custom software to maximize dig productivity. Led a survey crew in gradation for beach nourishment and disposal areas. Responsible for troubleshooting, functionality and accuracy of all land and water survey equipment. Assisted in the mobilization and demobilization of all projects assigned to. Location: NY, NC, FL, LA

MidAmerican Energy - Cathodic Interval Survey

Operator in a closed interval survey for a 100 mile pipeline along with gathering soil resistivity data along the length of the pipeline. Location: IA

NIPSCO

Performed field inspections in order to determine if pipelines were bare steel along with final analysis and report writing. Testing included PCM attenuation Locations: IN

Zoetis INC.

Performed a leak detection survey in addition to report writing and analysis. Locations: IL

Alliant Energy

Performed cathodic protection testing of the protective coating on all completed horizontal directional drilled (HDD) locations. Field procedures included the following testing to be performed: Alternating Current Voltage Gradient Survey (ACVG), Close-Interval Survey (CIS), and Electrical Conductance Testing at all completed HDD locations. Locations: WI, IA

Relevant Projects (Cont'd)

National Fuel Gas – AC Mitigation Design

Gathered soil resistivity and assessed existing power line systems in the field for proposed 96 mile pipeline. Locations: PA, NY

Key Relevance
Corrosion Control Field Assessments
Cathodic Protection Trouble Shooting
Internal Corrosion

Job Title:
Corrosion Technician
Corrosion

Years with EN Engineering: 2

Total Years of Experience: 2

Primary Office Location:
Warrenville, IL, USA

Education:

- Harper College
- Illinois State University

Professional Certifications:

- Cathodic Protection Tester (CP1), NACE
- NCCER – Pipeline Core 2013

Overview: Mr. McCarthy has over two (2) years of experience in the corrosion industry, focusing primarily on coating, external corrosion and integrity. I became a Cathodic Protection Tester in February 2014.

Relevant Projects:

EN Engineering – Corrosion Technician
Survey and analysis of cathodic protection annual and troubleshooting surveys including CIS, DCVG, ACVG and ICDA. Thermite welding of valve connections. Confined space supervisor and maximum allowed operating pressure (MAOP). Location: IL

Exxon Mobile
Annual cathodic protection survey. Observe and performed pipe to soil readings in gas storage tank in refinery. Troubleshooting shorted wiring to gas tanks. Locations: IL

Nicor - Aux Sable AC Mitigation Design
Field assessed and modeled a proposed 30 mile pipeline in a highly congested ROW corridor. Provided mitigation design and construction support for multiple phases of installation. Location: IL

Genesis
Completed maximum operation pressure forms for Genesis Martinville-Gwinville Junction and Freestate pipeline. Locations: MS

Integrity Solutions - AC Assessment and Design
Provided AC assessment procedures and field guidelines for third party contractors. Evaluated the collected data and modeled 485 miles of a proposed pipeline. Provided AC mitigation design for various locations along the ROW. Locations: WY, MT

Illinois American Water
Confined Space Supervisor. Thermite welding connections at valves. Location: IL

Enbridge – Spearhead line 55
Annual Cathodic protection survey. Pipe to soil readings at test stations, bonds, foreign crossings and valves. Measurements and inspection of rectifiers. Mainline valve inspections. Location: OK, KS, MO, IL

MidAmerican Energy (MEC)
Cathodic protection survey including: AVCG and CIS of Illinois – Iowa gas transmission pipelines. Locations: IL, IA

DTE Energy
Cathodic Protection survey including: ACVG, CIS, IDCA and stationing of Frankfort, Powers-Gladstone, Powers – Iron River, Mackinaw, and Petoskey gas transmissions pipelines. Location: MI

Alliant
HDD survey including: ACVG, DCVG, and CIS of Oakdale and Clarinda gas transmission pipelines. Cathodic protection survey including: CIS of Story County gas transmission pipeline. Location: IA, WI

NIPSCO
Pipe to soil readings at test stations, bonds, foreign crossings, and valves. Measurements and inspection of NIPSCO rectifiers. Soil resistivity of NIPSCO gas transmission pipeline. Bare steel inspection of NIPSCO gas distribution pipeline. Location: IN

Explorer
AC Mitigation survey: Soil resistivity for Explorer gas transmission pipeline. Location: IL

Key Relevance
Cathodic Protection Design
Corrosion Control Field Assessments
Cathodic Protection Trouble Shooting
AC Mitigation Design and Analysis
Atmospheric Corrosion Inspection
Internal Corrosion

Job Title:
Sr. Design Engineer
Corrosion

Years with EN Engineering: 3

Total Years of Experience: 3

Primary Office Location:
Warrenville, IL, USA

Education:

- B.S., Civil Engineering, Southern Illinois University, Carbondale, IL

Professional Certifications:

- Cathodic Protection Test (CP1), NACE
- Cathodic Protection Technician (CP2), NACE

Overview: Mr. Mitchell is an engineer with three (3) years of project experience in cathodic protection, corrosion control survey and inspection. Work on a vast array of different and unique projects provides Mr. Mitchell with an excellent background in pipeline corrosion control and integrity field services within the: oil, gas, and water transmission and distribution arena. Mr. Mitchell is proficient in the entire external corrosion direct assessment (ECDA) and internal corrosion direct assessment (ICDA) process including the performance of:

- Close-interval survey (CIS),
- Direct current voltage gradient (DCVG),
- Alternating current voltage gradient (ACVG),
- Current attenuation (PCM), and
- Pipeline profile surveys.
- ICDA Dig Assessment
- ECDA Dig Assessment

Relevant Projects:

Pacific Gas and Electric (PG&E)
MAOP Verification: Reviewed and evaluated historical pipeline engineering documents to determine the current pipeline MAOP as determined by PHMSA requirement 49 CFR Part 192 – Subparts J & L. Assembled spreadsheets to track pipeline characteristics and examined pipeline specifications and tests to determine operating safety of existing pipeline. Performed Quality Control of team of 7 engineers to ensure an accurate and uniform deliverable. Location: CA

Enbridge
Foreign Operations: Performed a review of foreign operations for Enbridge's proposed pipeline and contacted each foreign operator to schedule and compile encroachment agreements between companies. CP Construction: Contributed as part of a team in the design of a cathodic protection system of a new 600 mile pipeline. Collected field data at key locations along proposed route required for CP design and coordinated any/all foreign operations that took place along ROW. Responsible for providing construction oversight for 150+ miles during installation of cathodic protection test stations, ground-beds, and rectifiers. Affectively communicated with a multitude of construction crews throughout the installation process to ensure a quality product be delivered to the client. Annual / Exceptions Report: Organized and reviewed data collected during annual surveys along several Enbridge pipelines throughout the Midwest. Compiled and prepared annual reports for both D.O.T. and Enbridge field personnel detailing any non-compliance issues found during the survey. Locations: IL, MO, KS, OK

Relevant Projects: (Cont'd)

Blue Racer
Impressed Current Cathodic Protection Design: Collected soil resistivity along ROW and designed a cathodic protection system for twenty-eight (28) miles of parallel 10" and 8" pipelines located within the state of Ohio. Provided a review of existing CP test stations with recommendations, Impressed Current Protection Design, CP typicals for construction, BOM for CP design, and a CP design report to the client. Galvanic Cathodic Protection Design: Collected soil resistivity along ROW and designed a cathodic protection system for 2.77 miles of 12" pipe located within the state of Ohio. Provided an AC threat assessment, Galvanic Cathodic Protection Design, CP typicals for construction, BOM for CP design, and a CP design report to the client. Location: OH

DTE
ECDA / ICDA Survey: Performed Close Interval Survey (CIS), Alternating Current Voltage Gradient (ACVG), Current Attenuation, Elevation and Depth of Cover Surveys as well as collected soil resistivity data. Prepared indirect examination, direct examination, and post-assessment reports. Locations: MI

MidAmerican Energy (MEC)
CIS Survey: Performed Close Interval Survey (CIS) along 100+ miles of pipeline throughout the state of Iowa. Lead and trained a crew to perform the necessary duties to collect the necessary data to complete the project affectively. Collected soil resistivity readings at half mile intervals along all surveyed pipelines. Lead data and equipment management throughout the project to ensure a quality product would be delivered to the client. Locations: IA

CF Industries
Responsible for providing construction oversight for of cathodic protection facilities: such as anodes, test stations, insulating flanges, and Dairyland devices. Performed data collection and baseline readings at new cathodic protection test stations. Affectively communicated with a multitude of construction crews throughout the installation process to ensure a quality product be delivered to the client. Locations: IA

Alliant
Performed cathodic protection testing of the protective coating on all completed horizontal directional drilled (HDD) locations. Field procedures included the following testing to be performed: Alternating Current Voltage Gradient Survey (ACVG), Close-Interval Survey (CIS), and Electrical Conductance Testing at all completed HDD locations. Locations: WI

Enbridge Tank Farm
Contributed as part of a team in the design of a cathodic protection system for a 1000 feet of new 30" pipe and the cabling to oil storage tank bottom. Assisted with the following throughout the project: Validate the design adequacy of the distributed anode system to the protect the pipeline and tank bottom, design proper isolation of the pipeline from other entities, prepare construction level drawings for the anodes, cabling, coupons, reference cells, and bond boxes for the project, and provide construction level oversight to ensure the design is followed during the installation. Locations: IL

Relevant Projects: (Cont'd)

NIPSCO AC Design
Performed an evaluation of AC levels on a 6" and 4" pipeline collocated with overhead high voltage AC distribution and transmission towers: Data review and field data collection, AC threat assessment, and AC mitigation modeling and design. Locations: IL

WE Energies
ECDA Survey: Performed Close Interval Survey (CIS), Alternating Current Voltage Gradient (ACVG), Direct Current Voltage Gradient (DCVG), and Current Attenuation Surveys as well as collected soil resistivity data. Prepared indirect examination, direct examination, and post-assessment reports. Locations: WI

Vermont Gas
ECDA / ICDA Survey along High Consequential Areas (HCA): Performed Close Interval Survey (CIS), Alternating Current Voltage Gradient (ACVG), Current Attenuation, Elevation and Depth of Cover Surveys as well as collected soil resistivity data. Performed data analysis and recommended dig locations. Performed direct examinations for all ICDA and ECDA digs along the HCA's. Prepared indirect examination, direct examination, and post-assessment reports. Performed cathodic protection testing of the protective coating on all completed horizontal directional drilled (HDD) locations. Field procedures included the following testing to be performed: Alternating Current Voltage Gradient Survey (ACVG), Close-Interval Survey (CIS), and Electrical Conductance Testing at all completed HDD locations Locations: VT

Key Relevance
SME - Cathodic Protection Design
SME – HVDC and Pipeline Conflicts (Stray Current)
SME - Corrosion Control Field Assessments
SME - Cathodic Protection Trouble Shooting
SME - AC Mitigation Design and Analysis
SME -Atmospheric Corrosion Inspection
SME -Internal Corrosion
SME – Wall Loss Assessment (Corrosion)
SME – Coating Selection and Condition Assessment
Operator Qualification Program Management and Assessment
Corrosion Education and Training

Job Title:
Vice-President/Senior Project Manager – Corrosion Engineering

Years with EN Engineering:
13+

Total Years of Experience:
35

Primary Office Location:
Warrenville, IL, USA

Education:

B.S., Forestry: Resource Management, Iowa State University, Ames, Iowa

B.S., Integrated Pest Management (Entomology, Pathology and Dendrology), Iowa State University, Ames, Iowa

Overview: Mr. Schramm has over thirty-five (35) years of extensive experience in the direct and practical application of corrosion control methods, cathodic protection assessment and design, and system integrity management and field services.

Direct experience with external, internal, and atmospheric corrosion control on natural gas and liquid transmission and distribution pipeline systems, under-ground natural gas storage, under-ground storage tanks, above-grade storage tanks, power plant structures, condenser/chiller/heat exchange equipment, production and injection/withdrawal wells, lead sheath cable, underground electric cable, water transmission systems, and fresh-water marine structures

Responsible for the technical performance, quality, and operation service offerings that provide:

- Corrosion engineering analysis and design
- Cathodic protection monitoring and assessment
- Process control and measurement
- Correlation of internal "smart" tool to indirection inspection survey data
- Cathodic protection design, installation and maintenance
- AC safety and AC corrosion assessment, modeling, and mitigative design
- Computerized close interval potential survey
- Direct current and alternating current voltage gradient survey
- Stray DC interference and telluric current monitoring, measurement, and mitigation
- Coating selection and inspection
- Material selection, specification and procurement
- Technical specification and procedure
- OQ qualification and training
- Corrosion related field failure, wall loss assessment, and remaining strength evaluation
- Indirect and direct inspection program support
- Field installation oversight and inspection
- Project management and commission services
- Operational support including:
  - Leak detection
  - Purge operations
  - Watch and protect and rights-of-way inspection
  - Locating
  - High Consequence Assessment and Class Survey

Professional Certifications:

- NACE Institute No. 3178 Certified Cathodic Protection Specialist
- NACE Institute No. 3178 Certified Corrosion Technologist

Professional Organizations & Affiliations:

NACE International Institute (NII)

- Board of Directors – (2012-2016)
- Chairman, Certification Committee (2012-2016)
- Audit Committee (Board) 2015-2016)

NACE International (NACE)

- Professional Activities Director (PDAC) (Board) (2011 to 2014)
- Audit Committee (Board) (2011 to 2014)
- Professional Activities (PDAC) Chair (2011 to 2014)
- Professional Activities (PDAC) Vice-Chair (2008 to 2011)
- Certification Committee Chair (2003 to 2006)
- Certification Committee Vice-Chair (2000 to 2002)
- T-10A-11: Gas Distribution Industry Corrosion Problems Chair (1997 to 2001)
- T-10A-11: Gas Distribution Industry Corrosion Problems Vice-Chair (1995 to 1997)
- SME Department of Defense (DoD) Panel on Training and Certification
- CP Interference Course Development Task Group: Cathodic Protection Interference (2006)
- Cathodic Protection Sub-Committee: Cathodic Protection Technologist (2004)
- Cathodic Protection Training and Certification Program Task Group: Cathodic Protection Level 1 (2000) and Cathodic Protection Level 2 (2000)
- Chicago Section Membership Chairman (1986-1987)

Corporate program support:

- ENE Health, Safety, and Environmental Committee – member
- OSHA Safety Training Programs
  - Development and documentation of program safety documents.
  - Initial creation and training of Level 0 OSHA training presentations (PowerPoint)
- Vision Accounting and Project Documentation:
  - Part of management team charged with the development of project management and project set-up (2014/2015) Vision EWMS project.
  - Developed IN proposal documentation and procedures under Opportunity section of Vision
  - Automation of reports and training of Vision to departmental Project Mangers
  - EMWS Super User
- Operator Qualification and Safety Records
  - Administrator for ISNETWORLD software and NCCER program audit and oversight.
  - Initial development and submittal of safety programs for RAV review
  - Initial support for Client response and safety program update.
  - Set-up and established support for Veriforce OQ programs.
- ISO 9001: 2000 Certification
  - Part of team tasked with the initial development and completion of ISO 9001 policy and procedures within EN Engineering; leading to, ISO9001: 2000 certification for the corporate office.

Relevant Projects:

Tallgrass Development
Provide subject matter expertise (SME) related to conflict between proposed HVDC system and large diameter, high pressure natural gas pipeline in the State of Illinois.

Whiting Petroleum Corporation
Provide professional subject matter expertise (SME) of a test installation of nine (9) deep anode cathodic protection systems installed to provide protection to directionally drilled production wellhead systems in the State of North Dakota. Data review and professional opinion of deep anode design, cement log, and cathodic protection profile (CPP) tool run data. Project deliverables included a professional opinion report and a technical presentation on results.

Professional Organizations & Affiliations:

- Cathodic Protection Task Group: Cathodic Protection Training Program (1999 – 2000)
- Chicago Section – Special Events Chairman (1985-1986)
- Chicago Section – Membership
- Chicago Regional Committee on Underground Corrosion (CRCUC) Chair and Vice-Chair
- Michigan Electrolysis Committee Chair and Vice-Chair

National Center for Construction Education and Research (NCCER)

- Certified Master Trainer (2010)
- Certified Administrator (2010)
- Certified Craft Trainer/Evaluator: Core Curricula, Gas Pipeline Operations, Liquid Pipeline Control Center Operations, Liquid Pipeline Field Operations, Pipeline Core, Pipeline Corrosion Control, Pipeline Electrical and Instrumentation (E&I), Pipeline Maintenance, Pipeline Mechanical, Specialty Craft

Veriforce

- Authorized Evaluator

Midwest Energy Association (MEA)

- Administrator

The Society for Protective Coatings (SSPC)

- Member

Industry Participation:

- API 1161 – Task Group on Operator Qualification, Pipeline Segment – Resolution of Appreciation for contributions to the Task Group
- OSHA 510 Certified "Occupational Safety & Health Standards for the Construction Industry"
- Quality Awareness Training (Nicor Gas- 1993)
- Basic Corrosion Course (NACE-1983)

Tallgrass Development
SME project direction related to excavation analysis of coating and pipeline wall assessment and conductance, evaluation, and assessment if in-situ pipeline coating assessment to TMO102-2002 Standards. Direct analysis of data obtained from field and laboratory testing, written report and recommendations.

Valero Energy Corporation
SME project direction for AC Threat Assessment on 150-mile pipeline as an "active" high level management approach to evaluate both present "threat area" and future AC "threat" risk. Project included the gathering of AC voltages on the pipeline and soil resistivity at intervals not exceeding 1000-ft. AC Threat calculation, research and inclusion of historic data obtained from other sources (DFOS), generation of plots and graphs, scenario or sensitivity analysis, report, observations and recommendations.

Southern Star Gas Central
SME project support for 20-inch diameter natural gas pipeline damaged by 12kV AC power line arc near Joplin, Missouri including: assessment of condition, documentation of event, wall loss discovery, assessment and written report, and Client support with regulatory oversight and questions

Exxon Mobil Refinery
SME technical project support assessment of condition (cathodic protection systems), annual survey, remediation, and recommendation.

United States Gypsum
Develop, perform training, assessment and evaluation for operator qualification of Client employee resources, assess natural gas pipeline system and plant facilities, and develop initial pipeline normal operation system drawing format.

United States Gypsum
SME level support for isolation flange failure in Washington, PA including: assessment of condition, purge out of product, oversight of repairs, purge in of product, and restoration of service.

Industry Participation:

- TWIC (Transportation Workers Identification Credential)
- Clockspring Trainer/Installer Certified (2002)
- Administration Training: Assessor Training (Nicor Gas-1994)
- Goodall Rectifier School: Goodall Electric, Inc. (1982 –
- Managing Cultural Diversity (Coleman Management Consultants (1994)
- Control, West Virginia, University (1985)
- Corrosion Prevention by Cathodic Protection (NACE– 1983)
- Effective Business Communication (IWCC – 1990)
- Appalachian Underground Course: Advanced Corrosion

Expert Witness Testimony:

- South Dakota Public Utility Commission - Testimony
  - Keystone Pipeline, October 2007- Corrosion and Protective Coating Sections and Related Code
  - Keystone XL, September 2009 – Corrosion and Protective Coating Sections and Related Code
  - Keystone XL, March-July-September, 2015 – Corrosion Protective Coating Sections and Related Code
- State of Iowa Utilities Board
  - 2002, Testimony related to AC Interference, assessment, and mitigation as it relates to: proposed pipeline construction beneath overhead AC transmission systems, Iowa.
- Illinois Commerce Commission
  - 2015, Expert Witness Testimony related to impact of proposed HVDC system on large diameter, high pressure natural gas pipeline system in Illinois

Corrosion Control Operations

Managed and directed the Corrosion Control Service Group for Nicor Technologies and Nicor Gas providing corrosion control consulting services to distribution and transmission pipelines, municipal and utility organizations, and commercial and industrial customers. Responsible for the performance of all operating corrosion control programs (internal, external and atmospheric) on the Nicor Gas pipeline system including specification, performance and day-to-day operation. As a member of the Nicor Gas welding and joining, system integrity, and code committee operating task groups provided technical expertise in pipeline integrity, research and testing, corrosion control and cathodic protection issues. Having responsibility for the due diligence corrosion control and cathodic protection evaluations on acquisition projects in Argentina and Tennessee. Developed risk, quality, and integrity management programs related to corrosion control and cathodic protection operations. Location: IL

Corrosion Control Services

Directed and coordinated the Nicor Gas corrosion control programs for distribution, transmission, and storage facilities. Directly supervision responsibility for the completion of annual corrosion control and corrosion control activities which include: annual reading programs, close interval survey, stray current interference, and impressed current rectifier system replacement.

Research Services

Managed and directed the research lab for Nicor Gas and was responsible for day-to-day operation, quality performance, testing, recommendation and approval, including the performance and analysis ASTM and ANSI test standards and methods. Directly responsible for the purge routine process for all large-diameter high- pressure pipelines. Conducted, analyzed and developed corrosion control action and recommendation for all wall loss and field failure events. Locations: IL

Lakehead Pipeline Company

Directed the completion of all annual cathodic protection reading programs, close interval survey, stray current interference, impressed current rectifier system replacement, and field failure investigations for the Lakehead Pipe Line Company over a six (6) year period on facilities that include pipeline, compression, substation, and storage facilities. Locations: ND, MN, WI, IL, MI, NY.

Technical Presentations:

- Whiting Petroleum Corporation September 2015 presentation on Cathodic Protection of Wellhead Structures
- NACE International – Rocky Mountain Section Meeting, September 2015 presentation on AC Interference and Mitigation.
- Columbia Gas, Virginia – Technical presentation on AC Interference and Mitigation and CIS/ACVG/DCVG Data Interpretation, September, 2015
- Baltimore Gas and Electric (BGE), September, 2015 – Technical Presentation on
- Baltimore-Washington Corrosion Committee (BWCC) – Technical Presentation on AC Interference and Mitigation- May, 2015
- PG&E – February, 2015 Technical Presentation on AC Interference and Mitigation
- NACE International, January-2015 Northern Plains Corrosion Control Short Course, Omaha, Nebraska – Speaker and presentation on AC interference and Mitigation and case examples
- USG – January, 2015 – Technical Presentation on Plant Audit Inspections
- NACE San Antonio Section Meeting, May-2014 – Speaker and presentation on AC interference and mitigation and case examples
- NACE International, January-2014 Plains Short Course (Omaha), Nebraska – Speaker and presentation on AC interference and Mitigation and case example
- NACE Wisconsin Short Course, September, 2013 – Cathodic Protection Design and Practical
- NACE Wisconsin Short Course, September, 2013 – Casings: Design and Regulations
- NACE International, August – 2013 Central Area Conference, Little Rock – Speaker and presentation on AC interference and Mitigation and case example.

Portal Pipeline Company

Supervised and completed the annual cathodic protection reading program for the Portal Pipe Line Company including pipeline, gathering and wellhead systems. Location: ND

Alyeska Pipeline Service Company

In-state direction, supervision and related to the process of conducting, analyzing and performing telluric based close interval surveys for the Trans-Alaska Pipeline System (TAPS) over a four (4) year period. Direct responsible for the performance, provision, data quality, data analysis and report recommendations. Location: AK

Desert Generation and Transmission Company

Supervised, conducted and performed the design and testing services for the Deseret Generation and Transmission Company. Planned and performed a wide variety of duties involving the evaluation, design, and installation of cathodic protection systems to inhibit corrosion on pipelines, tanks, and similar underground and submerged structures including electrical continuity and protection of concrete steel cylinder pipe. Locations: UT

Mobil Oil

Conducted and analyzed all underground facilities for the potential application of cathodic protection for the Mobil-Joliet Refinery. Operational and performance responsibilities related to installation of new and existing cathodic protection systems: design, redesign, and installation of impressed current systems for tank bottoms. Location: IL

Montana Power

Conducted, analyzed and performed close interval and leak detection surveys on large diameter - high pressure – natural gas transmission pipelines owned and operated by Montana Power near Helena, Montana. Location: MT

Northern Natural Gas

Conducted, analyzed and performed close interval surveys on large diameter - high pressure – natural gas transmission pipelines owned and operated by Northern Natural Gas (NNG) in the Upper Peninsula of Michigan. Location: MI

Mountain Bell Telephone

Supervised, conducted, analyzed and performed the corrosion control and cathodic protection analysis of the Mountain Bell Telephone lead sheath cable running between Evanston and Cheyenne. Locations: WY

Technical Presentations:

- Northern Natural Gas (NNG) Spring Corrosion Round Table – 2013: AC Interference and Mitigation Training (Minneapolis, Des Moines, El Paso)
- Northern Natural Gas (NNG) Spring Corrosion Round Table – 2013: CIS/ECDA Defect and Interpretation
- AGA/SPE, March 2012 – Identification and Prevention of Corrosion in Gas Storage Gathering Facilities
- NACE Wisconsin Section – Annual Short Course – 2013: Speaker and presentation on Cathodic Protection Design and Practical's and Casings: Design and Regulations
- NACE Wisconsin Section – 2012: Speaker and presentation on AC interference and Mitigation and a case example related to a 12-inch and 20-inch pipeline system.
- 51st. Annual Underground Corrosion Short Course: Speaker and presentation on AC issues on Pipelines presented under the System Integrity section, Purdue University, 2012
- 51st. Annual Underground Corrosion Short Course: Pipeline Casing Presentation, 2012
- 51st. Annual Underground Corrosion Short Course: Station Assessment Procedures, 2012
- EPRI/Southwest Research: June 2010, Copper Grounding Presentation
- China International Oil and Gas Pipeline Conference, Langfang, Hebel, China, November-2009: Safety and Operability Assessment Report and HAZOP Study Report (PetroChina),
- China International Oil and Gas Pipeline Conference, Langfang, Hebel, China, November-2009: ECDA Implementation Case Study – Pipeline Integrity and Corrosion Control Technology
- NACE International, March, 1991 – The Development and Conversion to an "On-line" Corrosion Control Records System on a Mainframe Computer, Corrosion 91, Paper Number 346, NACE International.

Coffeen Power Plant

Supervised, conducted, analyzed, designed and installed cathodic protection systems for the Coffeen Power Plant Facilities operated by the Central Illinois Light Company (CILCO). Location: IL

LaGrange Hospital

Designed, analyzed and supervised the installation of galvanic anode systems designed to protect the interior water box of condenser/chiller units operated by the LaGrange Hospital. Location: IL

Union 76

Supervised, conducted and analyzed the cathodic protection systems installed on over 250 underground gasoline and waste oil storage tanks systems owned and operated by Union 76. Locations: IL, KY, IN

O'Hare Airport

Designed and supervised the installation of galvanic anode protection systems for aviation fuel pipelines related to jet-way expansions. Responsible for the cathodic protection assessment, design, and mitigation on jet-way expansions of the G & H terminals as well as field supervision on the United Airlines terminal 1 construction project. Locations: IL

City of Viburnum

Designed and supervised the installation of down-hole impressed current systems for the City of Viburnum including the protection of water well casing, column and bowls. Location: MO

Key Relevance
Cathodic Protection Design
Corrosion Control Field Assessments
Cathodic Protection Trouble Shooting
AC Mitigation Design and Analysis
Atmospheric Corrosion Inspection
Internal Corrosion

Job Title:
Sr. Project Engineer
Corrosion

Years with EN Engineering: 12

Total Years of Experience: 12

Primary Office Location:
Warrenville, IL, USA

Education:

B.S., Mechanical Engineering, Northern Illinois University, DeKalb, IL.

Professional Certifications:

- Cathodic Protection Tester (CP1), NACE
- Cathodic Protection Technician (CP2), NACE
- National Center for Construction Education and Research (NCCER)
- Fundamentals of Engineering Exam (FE), State of Illinois

Overview: Ms. Sparbanie is an engineer with experience in cathodic protection, corrosion control surveys, design, and maintenance of natural gas and water distribution and transmission mains. She has experience in performing close-interval (CIS) and DCVG surveys, cathodic protection annual surveys, stray current interference, analyzing and reporting data, performing External Corrosion Direct Assessments (ECDA), and cathodic protection design of pipelines and stations; such as, galvanic or impressed current systems, calculating anode design life, procurement of materials, and installing CP facilities for monitoring.
Additional designs have been performed for distribution and transmission pipelines and stations which include utilization of sizing programs for regulators, designing heaters and odorizers for customer operating stations, cost estimation and analysis, preparation of bid documents, analysis of public improvement project designs for conflict with gas piping, conflict resolution and reduction, new product testing to determine applicability for field application and standard criteria with reliability testing, cost analysis, and development of customer specifications.

Relevant Projects:

Pacific gas and Electric (PG&E)
Reviewed and assessed historical pipeline engineering documents used to validate the pipeline MAOP as determined by PHMSA requirement 49 CFR Part 192 – Subparts J & L. Assembled spreadsheets to track pipeline characteristics and examined pipeline specifications and tests to determine safe pipeline operations. Verified spreadsheets as part of the quality control team to ensure accuracy and completeness of the final product being delivered. Location: IL

DuPage Water
Performed testing and analysis of structure-to-electrolyte readings, AC readings, bond readings, isolation flanges, pipeline continuity, panhandle eastern (casing) testing, close-interval surveys (CIS), DCVG and ACVG Surveys, and static and dynamic stray current interference which included system wide testing. Analyzed cathodic protection pipeline systems and back-up generation stations, prepared construction drawings for galvanic and impressed current designs and monitoring facilities, and procurement of materials. Location: IL

Kern River
Performed an interference assessment and design on a 30" and 36" pipeline in Wyoming. Reviewed historical data and assessed data to provide a stray current mitigation design that involved installing DC coupon test stations and two galvanic anode systems. Location: IL

Illinois American Water
Performed testing, analysis, and design for steel, PCCP, and ductile iron pipelines which included baseline and annual surveys, AC study, test stations and CP monitoring facilities, air release locations, stray current interference, zinc grounding mats, and CP design. Field testing included structure-to-electrolyte readings, AC potentials, isolation and continuity testing, stray current interference testing, recording data from line current test stations to determine the calibration factor, and installing temporary data loggers to monitor the AC and DC readings over time. Location: IL

United States Gypsum

Performed an External Corrosion Direct Assessment (ECDA) on various pipeline segments which included pre-assessment and indirect inspection phases. Field work performed consisted of close-interval surveys (CIS), DCVG surveys, interference testing, isolation testing, and depth of cover surveys. Locations: TN and AL

Northwestern Suburban Municipal Joint Action Water Agency (NSMJAWA)
Annual testing of different line segments to determine structure-to-electrolyte readings, AC readings, and isolation at each test station. Performed close-interval surveys (CIS), stray current interference testing, and analyzed and provided recommendations based on the data obtained. Location: IL

Louisville Gas and Electric (LG&E)
Designed a cathodic protection system for an 8.1 mile 20" diameter pipeline in Kentucky which included two stations and a section of pipeline installed in rock. Utilized design calculations to determine rectifier size, anode type and amount, and cable lengths and sizes. Monitoring facilities including foreign pipeline test stations, AC coupon test stations, anode test stations for galvanic anodes protecting piping inside stations, isolation test stations, and permanent gradient control mats for AC safety. Assisted in the AC assessment and AC design for the HVAC. Location: IL

Alliant Energy
Designed a cathodic protection system for a 13.31 mile 20" diameter pipeline in Iowa which included an Interconnect and a Gas Yard Station and a 12.76 mile 12" diameter pipeline in Iowa which included an Interconnect and a Regulator Station. Utilized design calculations to determine rectifier size, anode type and amount, and cable lengths and sizes. Location: IL

DTE Energy
Assisted in training and performing the close-interval (CIS) and DCVG surveys for the External Corrosion Direct Assessment (ECDA) on several sections of main. Location: MI

Nicor Gas
Designed cathodic protection systems on distribution and transmission work orders and performed close-interval (CIS) and DCVG surveys on Nicor Gas pipelines. Designed stations which included odorant and storage tanks, meter sets, sizing regulators, procurement of material, and estimation of cost. Analyzed and determine extents of main to be replaced for public improvements involving the replacement of cast iron, steel, or P.E. main. Location: IL

Enbridge Pipeline
Performed annual potential reads on various line segments, performed close-interval survey (CIS), and designed impressed current systems for several locations in Minnesota. Locations: IL, WI, and MI

Valero
Performed close-interval surveys (CIS), stray current interference testing, and analyzed and provided recommendations based on the data obtained. Location: IL

Vectren

Modified Gas and Liquid IMP procedures and forms. Assisted in the study and design of an AC system. Location: IL

Citgo Refinery

Designed 2,275' of 8" main to run along New Avenue and 135th Street for the new hydrogen plant for CITGO. Analysis was performed to determine the minimum radius of curvature and the operational stresses on the 8" main crossing the railroad at an approximate depth of 20'. In addition, a new meter station was proposed that included a 6" meter set and 4" Mooney regulators. Location: IL

Adkin's Energy

Designed a station for the new plant for Adkin's Energy that included a 500,000 Btu/hr heater, a meter set with a 4" turbine meter, and a dual regulator run with 3" Mooney regulators and 6" ball valves. In addition, an 8" fuel line was run for about 1,140' up to the Adkin's energy building where another dual regulator run was designed to cut the pressure down. Location: IL

TAB 10

Vermont Gas

2015 ANGP Project Directive Log

Number	Date	Subject	Issued By	Disposition*
2015-001	8/24/15	Reporting Potential Vandalism	John Stamatov	
2015-002	8/24/15	Welding Line Up Clamp Usage Clarification	Chris LeForce	Superseded by 2015-004
2015-003	8/24/15	CP Test Stations for the first 11 miles	Chris LeForce	
2015-004	8/28/15	Welding Line Up Clamp Usage Clarification	Chris LeForce	Replaces 2015-002
2015-005	9/1/15	Construction in Sand Area	John Stamatov	
2015-006	8/31/15	Backfill Compaction	Kristy Oxholm on behalf of Chris LeForce	
2015-007	8/31/15	General Backfill Materials	Kristy Oxholm on behalf of Chris LeForce	
2015-008	8/31/15	Adhesion Testing – Field Coating	Kristy Oxholm on behalf of Chris LeForce	Superseded by 2015-011
2015-009	9/14/15	HDD Sacrificial Weld Coating	Chris LeForce	
2015-010	9/30/15	Pipe Surface Preparation for Shrink Sleeve Weld Coating	Chris LeForce	
2015-011	9/30/15	Adhesion Testing – Field Coating	Chris LeForce	Replaces 2015-008

*Dispositions: Expired, Superseded, Cancelled

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 8/24/2015

Subject: Reporting Potential Vandalism

Directive Number: 2015 - 001

Upon discovery of any damage to pipeline components, construction equipment or anything else associated with this project which appears to be a result of vandalism (or the cause of such damage is unknown and not attributable to normal wear and tear, damage inflicted during routine construction activities, etc.), the Construction Management Team shall be notified as soon as possible.

The notification should be first to the on-site inspector and through the chain of command to the Chief Inspector and Construction Manager. The Construction Manager will in turn notify the Project Manager.

This early reporting will allow for prompt notification of law enforcement authorities, if deemed appropriate. This reporting will also allow for realization of trends (i.e., scratched pipe in multiple different locations) which may influence the Construction Management Team's decisions in determining a course of action to follow.

Issued by (print): John Stamatov

Signature: ______________________

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 8/24/2015

Subject: Cathodic Protection (CP) Test Stations for the first 11 miles

Directive Number: 2015 – 003 (Revision 0)

Please use the attached documents when installing the CP Test Stations on the first 11 miles of ARNGP Phase I. The documents included are:

- Proposed CP Test Station Locations
- Corrosion Control – Cathodic Protection (2015 VGS Operations and Maintenance Manual)
- Two Wire Test Station Detail*
- Four Wire IR Drop Test Station Detail

* The detail included does not indicate the color of the wires for the two wire test station. Use white wire as stated in the Corrosion Control – Cathodic Protection Procedure in the 2015 VGS Operations and Maintenance Manual.

Also please notify the VGS Corrosion Technician, Jeremy Bachand, when any installation is scheduled. He will either inspect the test station during installation or afterwards if he is unavailable at the time of installation.

Jeremy Bachand
Corrosion Technician

Vermont Gas Systems, Inc.
P.O. Box 467, Burlington, VT 05402-0467
85 Swift Street, So. Burlington, VT 05403
Tel: 802-951-0333
Cell: 802-309-9279
Fax: 802-863-8871
jbachand@vermontgas.com

Vermont Gas
CLEAN ENERGY CLEAN AIR

Issued by (print): Christopher LeForce

Signature:

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

Vermont Gas Addison Rutland Natural Gas Project (ARNGP) – Phase I

Proposed CP Test Station Locations (First 11 Miles) August 14, 2015

Test Station #	Approx. Station	Approx. Mile Post	Distance Between Boxes	Station Type	Location Description	Town	Land Parcel	
							LL #	Landowner
0	0+00	0.00	0.00	Two Wire	Colchester Launcher	Colchester	1.03	Cade
1	26+00	0.49	0.49	Four Wire IR Drop	Mill Pond Road Crossing	Colchester	2.02	Town of Colchester
2	67+00	1.26	0.77	Two Wire	Access Road "C"	Colchester	3	State of Vermont
3	109+00	2.06	0.80	Two Wire	Rt 2A Crossing	Essex	5	State of Vermont
4	158+00	2.99	0.93	Two Wire	VELCO 289 Crossing	Essex	6	State of Vermont
5	214+00	4.05	1.06	Two Wire	Rt. 15 Crossing	Essex	9	State of Vermont
6	240+50	4.55	0.50	Two Wire	Essex Way Crossing	Essex	9	State of Vermont
7	302+00	5.71	1.16	Four Wire IR Drop	I-89 "Jughandle"	Essex	9	State of Vermont
8	356+00	6.74	1.03	Two Wire	Winooski River HDD Begin	Essex	14	Steiner
9	374+00	7.08	0.34	Two Wire	RR Crossing	Williston	21	CSWD
10	399+50	7.57	0.49	Two Wire	Redmond Road	Williston	23	CSWD
11	443+50	8.40	0.83	Two Wire	Redmond Road	Williston	30	CSWD
12	481+00	9.10	0.70	Two Wire	Mountain View Rd Crossing	Williston	36	Town of Williston
13	518+50	9.82	0.72	Two Wire	West of Catamount CC, Bike Path	Williston	38	State of Vermont
14	551+00	10.43	0.61	Four Wire IR Drop	Williston Station	Williston	41	Town of Williston

8/24/15 11:40 AM

Referring Sections:

192.453 – Requirements for Corrosion Control – General

192.455 – External corrosion control: Buried or submerged pipelines installed after July 31, 1971

192.457 – External corrosion control: Buried or submerged pipelines installed before July 31, 1971

192.463 – External corrosion control: Cathodic Protection

192.467 – External corrosion control: Electrical isolation

192.469 – External corrosion control: Test stations

192.471 – External corrosion control: Test leads

192.473 – External corrosion control: Interference currents

49 CFR 192 - Appendix D

See also following procedure:
Inspection

Corrosion Control procedures, including those for the design, installation, operation and maintenance of cathodic protection systems, must be carried out by, or under the direction of, a person qualified by experience and training in pipeline corrosion control methods.

Cathodic Protection Design Procedure:

All new steel transmission, distribution and service installations will be reviewed by the Corrosion Technician, and/or the Manager of Engineering, for inclusion of the proper cathodic protection devices, anodes, insulators, test stations, etc. Changes or modifications to new or existing systems shall not be permitted unless the Manager of Engineering approves such changes.

All new steel pipe installations will have a cathodic protection system designed to protect the pipeline in its entirety within one year of installation. If any deficiencies should be discovered, they will be reviewed by the Corrosion Technician and corrective measures will be recommended.

When practical, the following corrosion control data should be recorded on the initial survey of a new steel pipeline installation:

1. Location of All Test Stations
2. Pipe Coating Resistance - when practical
3. Protective Current Applied to New Pipe - when practical
4. Pipe to Soil Potentials of New Pipe

Electrical isolation shall be designed and maintained with the use of insulating devices such as insulating unions, flanges, insulating joints, fiberglass shields, casing seals and link seals. Typical locations where insulating devices should be installed include:

1. Metallic structures, such as bridges, pipe support stanchions, pilings, and reinforced concrete structures.
2. Casings and sleeves
3. River weights and pipe anchors
4. Gate stations
5. Service risers
6. Information gathering systems such as SCADA devices

Coated steel carrier pipe must be electrically isolated from metallic casings with the use of insulating devices such as casing seals and link seals. Care shall be used when inserting the coated carrier into the casing to reduce the possibility of damaging the coating and creating electrical shorts. Electrical isolation shall be confirmed at all installations.

Electrical insulators are not to be installed in an area where a combustible atmosphere is anticipated (such as in a vault), unless precautions are taken to prevent arcing.

In areas where fault currents or unusual risk of lightning may be anticipated, such as in close proximity to electrical transmission tower footings, the pipeline must be provided with protection from such currents as recommended by the Corrosion Technician and Manager of Engineering. These protective measures must also be taken at insulating devices, such as those at gate stations.

The protection from these fault currents shall typically be provided with the installation of a grounding cell (such as a Kirk Cell) or an isolator/surge protector. These devices act as an insulator (or isolator) at low DC voltages but conduct AC and high DC fault currents to ground to prevent potentially hazardous voltages from being developed on the pipeline.

<u>The following wire types will be used unless otherwise specified:</u>

Galvanic Anodes shall be supplied with a Minimum #12 AWG solid copper wire with 600 Volt T.W. Type Insulation.

Test Wire: This will be #8-12 AWG solid copper wire with 600 Volt T.W. Type Insulation.

Test Stations

Previous installation may not have followed the current wire color conventions.

The number and location of test points throughout a cathodic protection system shall be such that they provide sufficient data to determine the adequacy of cathodic protection. These test points are to be determined by, or under the direction of, a person qualified by experience and training in pipeline corrosion control methods. Test stations should allow sufficient access to the pipeline for all necessary tests including pipe-to-soil potentials, current flows and interference test.

VGS will install and maintain CP test stations to ensure all pipelines are adequately protected.

Spacing of test stations along the pipeline system will vary widely depending upon the type of soil, moisture, quality of pipe coating, size of pipe, type of cathodic protection system, level of cathodic protection, etc. With so many variables involved, the distance between test stations must be based on the judgment of a person qualified by experience and training in pipeline corrosion control methods for the specific installation and conditions.

As a rule of thumb VGS test stations should be located, on average, every one mile along the transmission system. Test stations will generally be located at road crossings so that they are accessible and can be maintained. Items that may prohibit test stations from the one mile average may include large farm fields, swamps, rivers and streams.

Test Station Location Requirements:

When designing new installations, test station leads must always be installed at the following locations:

a. Pipe Casings
b. Insulating Joints
c. Galvanic Anode Installations
d. Rectifier/impressed Current Anode Installations
e. As directed after review by the Corrosion Technician

Casing Test Stations:

Any installation where steel carrier pipe is inserted into a steel casing requires a test station with leads from both the carrier pipe and casing. Casing test leads will be blue

#8-12 AWG wires and pipe test leads will be black #8–12 AWG wires.

Specific locations and use of stations shall be specified by the Corrosion Technician.

Two-Wire Test Station:

Two-wire test stations will contain 2 white #8-12 AWG wires.

The Corrosion Technician shall specify locations and use of stations.

Four-Wire Test Stations:

Four-wire test stations are generally used to test the pipe on either side of an insulated coupling or other insulator. Black #8–10 AWG wires will be used on one side of the insulator; white #8–10 AWG wires will be used on the other.

The Corrosion Technician shall specify locations and use of stations.

Current Measuring Test Stations (IR Drop):

The Corrosion technician shall specify locations and use of

stations. Special Test Stations:

On occasion, specific situations may dictate the use of special test stations not outlined in the procedure. The arrangement and location will be specified by the Corrosion Technician for each special installation.

Test lead wires are required for various corrosion control testing and monitoring operations after pipe installation. Test wires must be securely attached to the pipe or structure and must be installed in the configuration recommended.

Connection to steel pipe or structures:

Connection of test wires to pipe or structures must be of such a nature as to maintain mechanical strength and electrical continuity.

The only acceptable method is the thermite connection.

Thermite Connection (Cadweld) - The thermite connection for STEEL should use ONLY

15 gram F-33 alloy charges. For #8-12 AWG wire, use cartridge 15P. The powder is copper oxide and aluminum.

Thermite Welding of Wires:

USE CAUTION WHEN MAKING THERMITE CONNECTIONS NOT TO BREATHE ANY FUMES GENERATED DURING THE PROCESS.

Manufacturer's instructions should be consulted. The wire shall encircle the pipe at least once and then be knotted at the top pipe surface to provide a strain relief for the connection. The end of the wire to be attached shall be prepared as follows:

a. For #10 AWG solid anode wire, approximately 3" of the end shall be stripped and the conductor doubled over to provide a 1 ½" connection end.

b. For #8 AWG or #6 AWG copper test wire, approximately 1 ½" of the end shall be stripped and twisted tight and inserted into a copper sleeve supplied with the kit. Compress the sleeve so that it remains firmly on the wire. The thermite welder mold shall have a metal disk and a weld charge placed in the chamber. The mold shall be seated on the cleaned pipe surface, and the wire shall be inserted into the mold slot to its full depth. While the mold is held firmly in place, the charge is ignited and then allowed to cool approximately 15 seconds so the molten metal may solidify. After removal of the mold, the connection shall be tested for strength by striking it sharply with a hammer. After cooling, all thermite connections shall be coated with primer and wax tape or other approved coating methods.

Recoating of Pipe and Wire at Thermite Connection:

For steel pipe, after the thermite weld has cooled sufficiently, prime and tape the weld and adjacent area to provide a coating of similar integrity and strength of mill-applied coating.

Minimizing Stress Concentration:

The test wires shall be securely tied around the pipe so that the connection point will not be affected by any undue stress on the wires and to minimize possible stress concentration on the pipe. Sufficient slack shall be allowed in the installation of all test wires.

Mechanical Connections:

In areas involving leak repairs where residual gas is present, a mechanical clamp may be substituted for a thermite connection. This clamp will be designed specifically for the installation of a sacrificial anode.

Mechanical Splicing Connections:

Mechanical connectors shall be utilized to make wire-to- wire connections either in-line or branch. In-line connections shall be made with a water proof wire connector, while branch connections shall be made with a split-bolt connector. Split-bolt connectors allow branch connections from a header cable without cutting of the header cable itself, requiring only removal of insulation.

Impressed Current Systems:

Impressed current systems shall be utilized to protect large underground structures or distribution systems where stray currents on adjacent foreign structures would not be a serious problem. Ground bed design and rectifier selection are the responsibility of the VGS Corrosion Technician or corrosion consultant. Owners of adjacent underground metallic structures shall be notified before such systems are energized.

Galvanic Systems:

Design and layout of galvanic anode systems shall be the responsibility of the Corrosion Technician or corrosion consultants. Such systems are preferred for smaller sections of pipeline and in areas where stray currents generated by an impressed current system may cause serious damage to other underground metallic structures and where soil conditions permit with respect to resistivity of soil.

Installation of Anodes includes but is not limited to extra depth excavation, cadwelding, connecting, coating and wrapping, wetting, conduit, drip box, and terminal box. Do not connect anodes directly to the pipe under any circumstances, unless approved by the Corrosion Technician.

Efforts shall be made to install anodes parallel to the pipeline at least two (2) feet from the center of the pipeline, and at a distance of ten (10) foot centers when possible.

Anodes will be buried to an elevation of at least one (1) foot from the bottom of the pipeline to the top of the Anode.

Each anode wire lead will be connected to a collector cable (A.W.G. #8-10AWG solid copper with thin type insulation) which shall be installed parallel to the pipeline and over the anodes. Connection to the cable to be made with split bolt copper connectors for #8-12AWG. Connectors shall be wrapped.

Two #8-12AWG main leads shall be attached to the pipeline by the cadweld method. The wires will be two (2) feet apart on the pipeline. The two main leads and collector cable will be terminated together in either a test box or a post mounted terminal box.

When possible, wet the anodes before backfilling. Particular care must be taken in backfilling to ensure the wires are not severed, or damaged.

Insulated Fittings and Couplings

If the corrosion process is to be stopped, it is necessary to break the electrical path or continuity between the gas pipe and all metals cathodic to it. This is done by installing an insulation fitting between the metals. Insulating couplings, tees, flanges, and other insulating fittings are used to break the electrical path. The insulation fitting and the pipe adjacent to it must be well coated to eliminate exposure and a reverse coupling effect.

A. Coated steel pipe shall be insulated from the following structures:

1. Unprotected pipe
2. Bare steel pipe
3. Cast and ductile iron pipe
4. Copper pipe
5. District regulator vaults
6. Casings
7. House piping
8. All other pipelines or structures

B. The insulating end of insulating fitting shall go on the side towards the unprotected pipe.
C. A reasonable effort should be made to test insulating fittings after installation.
D. When non-insulting compression fittings are used, the pipe ends shall be thoroughly cleaned to bare metal to insure metallic contact with the fittings.
E. Steel main inserted into a casing shall have "insulators" installed.

Approved insulated fittings and couplings shall be used to electrically isolate new piping from old piping. Where new coated steel piping will be connected to either old bare steel or cast iron piping, an insulated fitting or coupling must be used. The Corrosion Technician shall have the responsibility of determining the need for an insulated fitting or coupling in all other applications. Insulated fittings and couplings shall be installed by closely following the manufacturer's directions.

Wire and Cable:

Wire and cable shall be suitable for the particular applications. Galvanic systems may utilize standard #8-12AWG wire with THW grade insulation for all underground and above-grade wiring. Impressed current systems may utilize #8-12 AWG wire with THW grade insulation for test wires. 8AWG may be utilized for the negative rectifier cable. However, cable attached to the positive rectifier terminal and used for direct burial in a ground bed shall be cathodic protection cable with High Molecular Weight Polyethylene (HMWPE) insulation. Actual cable size shall be determined by the Corrosion Technician for each installation.

Where underground wiring is to be direct-buried, the surrounding backfill shall be hand-shoveled, rock-free material. Minimum cover for underground wiring in a trench shall be 18". All wiring shall be inspected for damage to the insulation. Galvanic systems may have insulation repaired by taping with electrical tape. Impressed current systems shall not use any cable which, in the opinion of the Corrosion Technician, has excessive insulation damage. Where impressed current cable is deemed to be repairable, only resin type splice kits or cable sleeves that can be heat-shrunk shall be used to repair the defect.

Connections and Splices:

Thermite Weld Connections:

Thermite weld connections shall be the preferred method of attaching cable or wire to underground steel pipes or structures. Refer to specific instructions regarding thermite welding procedures above. The thermite weld is a fusion weld of the conductor to the surface, using a special alloy with a minimum heat effect on the structure.

Mechanical Connections:

In areas involving leak repairs where residual gas is present, a mechanical clamp may be substituted for a thermite weld connection. This clamp will be designed specifically for the installation of a sacrificial anode.

Splice Coating - Impressed Current Systems:

Connections in impressed current ground beds are susceptible to consumption if they are not insulated from the underground electrolyte, so specially manufactured splice kits are used on these connections. Two types of kits are available:

1. Resin Splice Kits. A pre-formed mold is snapped over the connection, and an

epoxy resin is mixed and poured into the mold and allowed to harden and encapsulate the connection.

2. Fold-Over Splice Kits. A symmetrical sheet of elastomeric compound with a depression on each side. The connection is primed and depressed into the encapsulating gel on one side, while the other half is folded over to seal the connection.

Splice Coating - Galvanic Systems:

All splices shall be coated by one of two methods:

1. Immersed in mastic and allowed to dry.
2. Immersed in primer and allowed to dry; wrapped in electrical or cold-applied tape to cover.

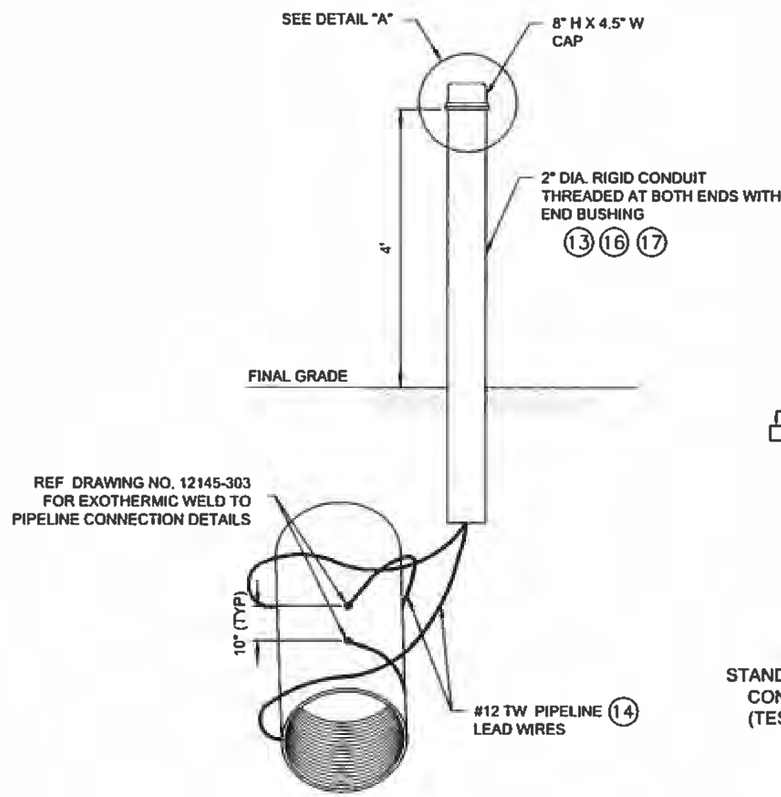
Temporary installations:

Temporary installations are defined as those installations not to be in service for greater than five years beyond installation, need not be cathodically protected if corrosion on that pipeline during that five year period will not be detrimental to public safety.

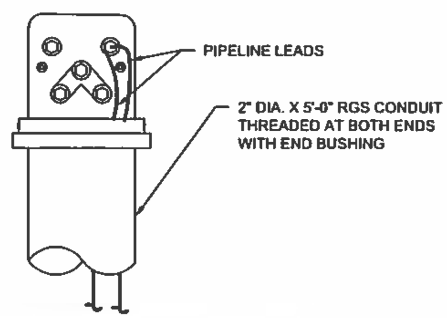
Cathodic Protection Criteria

The criteria for cathodic protection and determination of measurements used by VGS are as described in 49 CFR 192 - Appendix D.

REV	DESCRIPTION	DATE	APPROVED
A	ISSUED FOR CONSTRUCTION - ECO 2014-025	6/27/14	JM



TEST STATION



DETAIL A
STANDARD TEST STATION CONNECTION DETAIL (TESTOX MODEL 715)

NOTES:

1. REMOVE PIPELINE COATING AND CLEAN TO BARE METAL.
2. LOOP & HITCH WIRE AROUND PIPE WITHOUT DAMAGING PIPE COATING, BEFORE THERMITE WELDING.
3. USE 15 GRAM CHARGE FOR EACH EXOTHERMIC WELD AND FOLLOW PROCEDURE RECOMMENDED BY THERMITE WELD MANUFACTURER.
4. USE THERMOWELD ADAPTER SLEEVE P/N 38-0200-00 OR EQUAL FOR EXOTHERMIC WELD CONNECTIONS OF #12 TW LEADS TO PIPELINE.

CLIENT: CHA

SITE: VERMONT GAS SYSTEMS, INC. ADDISON NATURAL GAS PROJECT CATHODIC PROTECTION SYSTEM DESIGN

PROJECT NO. 12-E-145-CP

ARK ENGINEERING & TECH. SERVICES, INC. 639 GRANITE STREET SUITE 200 BRAINTREE, MA 02184 U.S.A.

ARK. Engineering & Technical Services, Inc.

TITLE: TEST STATION INSTALLATION

DRAWN BY	DATE	SIZE	DWG. NO.	REV
JRW	6/18/13	B	12145-302	A
APPROVED BY	DATE	SCALE	CAD FILE NAME	SHEET
JM	9/30/13	NTS	12145-302-1-RA	1 OF 1

4-WIRE IR DROP TEST STATION

NOTES

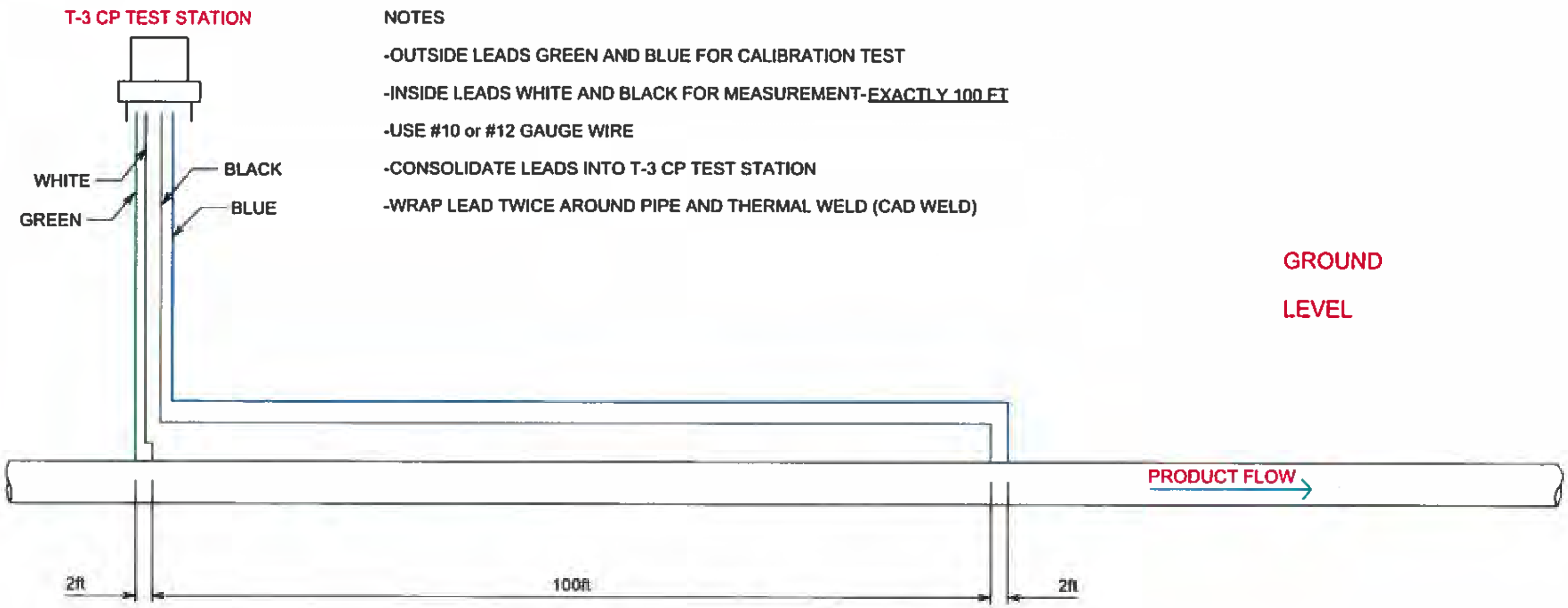
-OUTSIDE LEADS GREEN AND BLUE FOR CALIBRATION TEST

-INSIDE LEADS WHITE AND BLACK FOR MEASUREMENT-<u>EXACTLY 100 FT</u>

-USE #10 or #12 GAUGE WIRE

-CONSOLIDATE LEADS INTO T-3 CP TEST STATION

-WRAP LEAD TWICE AROUND PIPE AND THERMAL WELD (CAD WELD)



Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 8/28/2015

Subject: Welding Line Up Clamp Usage Clarification

Directive Number: 2015-004

The Butt Weld procedures used on this project (WPS-VGS-B-2 2014-2; WPS-VGS-X-65-2 2014-2) indicate that the use of an external line up clamp is allowed, but not required. This directive serves as a notification that the use of an external line up clamp is required on all main line girth welds on this project except when it is not feasible due to situations where the contour of a fitting does not allow use. In such cases the weld will be fitted up in a manner that does not place undue stress on the weldment. This is also stated in the Technical Specification Section 137000 – Welding in Part 3, Subsection 3.3(B).

If another situation arises where use of a clamp is not feasible, then it must be reviewed and approved by the Construction Inspection Team and VGS Operations.

The clamp shall not be removed until a minimum of 50% of the root bead has been placed, according to the instructions in the WPS and Section 137000 – Welding.

This Project Directive replaces 2015-002.

Issued by (print): Christopher LeForce

Signature: [signature] 8/28/2015

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 9/1/2015

Subject: Construction in Sand Area

Directive Number: 2015 - 005

In 3.5(B) – Bedding and Backfilling of Section 312333 – Trenching, Pipe Laying, and Backfilling of the Technical Specifications: pipe supports shall be installed in all locations prior to backfilling, unless otherwise directed by the Construction Management Team.

This document serves to direct the construction without pipe supports in the sand area from station 240+26 to station 279+75, as the uniform sand in the trench meets requirements for select backfill.

Issued by (print): John Stamatov

Signature: [signature] JR. Stt, Prj. Mgr

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 8/31/2015

Subject: Backfill Compaction in Typical Cross-Country Areas

Directive Number: 2015 – 006

In 3.5(D)(1) – Bedding and Backfilling of Section 312333 – Trenching, Pipe Laying, and Backfilling of the Technical Specifications, it states that the pipe trench in typical cross-country areas shall be thoroughly compacted by mechanical means to avoid any future trench settlement. In these cross-country areas, the trench can be compacted by mechanical means using an excavator bucket.

Compaction shall occur when there is at least 12" of sand padding and 12" of general backfill above the pipe and at a maximum of 24" lifts thereafter. Final compaction at grade can be completed using either an excavator bucket or the tracks of a piece of excavating equipment.

The use of an excavator for mechanical means of compaction in cross-country areas is typical in transmission line construction.

Issued by (print): Kristy Oxholm (for Christopher LeForce)

Signature: KMOxholm

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 8/31/2015

Subject: General Backfill Materials

Directive Number: 2015 – 007

In 2.1(B) – Materials of Section 312333 – Trenching, Pipe Laying, and Backfilling of the Technical Specifications, it states native materials containing no stones or clods larger than 3" in the longest dimension are acceptable for general backfill. This directive will serve as notice that native materials containing no stones or clods larger than 6" in the longest dimension are acceptable for general backfill.

The VGS Operations and Maintenance Manual in the Trenching and Backfilling Procedure allows for this change to the specification and now the two documents will be consistent.

Issued by (print): Kristy Oxholm (for Christopher LeForce)

Signature: KWOxholm

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 9/14/2015

Subject: Sacrificial Weld Coating on HDD Installations

Directive Number: 2015 – 009

For added abrasion resistance on horizontal direction drill (HDD) installations, Canusa's Wrapid Shield™ XL shall be installed over the Powercrete® R-95 coated weld. Please follow all manufacturer's instructions regarding the installation of both coatings and ensure the coatings are installed by qualified contractor personnel. All installations shall be observed by an inspector from the VGS Construction Inspection Team. Also ensure that at least one adhesion test is completed on the Powercrete® R-95 coating before the Wrapid Shield™ XL is installed.

At least one weld coating shall be visually inspected and jeeped after the pullback operation.

Attached for added reference is a memo explaining the use of additional abrasion resistance coating, along with the installation guide and product data sheet for the Wrapid Shield™ XL.

Issued by (print): Christopher LeForce

Signature: [signature] 9/14/2015

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

MEMORANDUM

TO: Addison Rutland Natural Gas Project (ARNGP) File

FROM: Christopher LeForce

DATE: September 4, 2015

RE: Use of sacrificial coating over primary weld coatings on horizontal directional drilling (HDD) installations

Vermont Gas Systems, Inc. (VGS) is proposing to use a sacrificial coating over the primary weld coating on (HDD) installations. VGS is using Powercrete® R-95 liquid epoxy for the primary corrosion protection at the welds. The R-95 is a single coat, 100% solids, high build epoxy novolac that coats pipelines. As an abrasion resistant overlay (ARO) it is compatible with fusion bond epoxy (FBE) and CTE mainline coatings. The purpose of the sacrificial coating is to add additional protection to the weld coating during pullback of the pipe during the HDD process.

In HDD installations, a typical corrosion coating, like FBE, cannot be used because of the potential for the coating to be damaged down to bare metal. For that reason either an ARO coating is used over the FBE or a harder, more durable coating is used. The line pipe is coated with a two-layer system, a FBE coating under an ARO coating, which is the sacrificial coating. In a similar manner, VGS is proposing to add a sacrificial coating over the R-95 coating to provide additional protection.

VGS is proposing to use Wrapid Shield™ XL manufactured by Canusa-CPS, a Shawcor Company. Wrapid Shield™ XL is a fiberglass cloth, pre-impregnated with a resin that can be activated by salt or freshwater to coat and protect any diameter of pipe within minutes. The product is formulated to resist shear, impact and abrasion on pipe coating systems above and below ground such as fittings and joints on all mill-coated pipe and as an outer wrap over heat-shrinkable sleeves for added mechanical protection.

The purpose of the pipeline coating is to provide a barrier between the steel pipe and the elements that can cause it to corrode or rust. The coating is the primary corrosion control method of protection the pipe. If there is a coating break or holiday, then the pipe is protected by the secondary measure of cathodic protection (CP).

The question that has been brought up is does applying this type of coating cause cathodic shielding. Shielding is caused by an external material that prevents the cathodic protection (CP) current from getting to the steel pipe. Technically, properly applied coating fits into the definition of cathodic shielding because it does not allow any connection with a foreign material. In order for CP to work you need a full circuit for the current to flow from the pipe to the soil and back. Other foreign materials can cause shielding which include plastic sheets with no adhesion, tree roots, rocks, soil, improper backfill/compaction, casings, and any other high resistance materials.

As supported by a letter from Steve Anderson (NACE CIP2 # 25805) of Shawcor, dated August 12, 2015, a properly applied coating will not cause cathodic shielding. In this case when both coatings are applied correctly and appropriately tested to ensure no holidays, this will not cause a cathodic shielding condition. The sacrificial coating of the Wrapid Shield™ XL will help protect the primary coating of the R-95 from damage during the HDD pullback.

The primary coating of R95 will be applied per manufacturer's procedures, inspected by the construction inspection team, and properly checked for any coating holidays before the wrap is applied to ensure the integrity of the coating. After the installation of the pipe is complete, at least one coated weld will be inspected per the VGS inspection criteria.

In conclusion, the Wrapid Shield™ XL will help ensure the primary coating is protected and can function as designed in protecting the steel pipe. If the sacrificial coating is not used, there is a higher potential of having coating holidays in the primary coating and it would not be able to function properly. In this case the secondary corrosion control method of CP would be used to protect the pipe. In 49 CFR Part §192.461 External corrosion control: Protective coating, it states "if coated pipe is installed by boring, driving, or other similar method, precautions must be taken to minimize damage to the coating during installation." Using the Wrapid Shield™ XL is the best method of minimizing the damage to the primary coating during installation.

CANUSA-CPS
A SHAWCOR COMPANY

Wrapid Shield XL

Fiberglass Mechanical Protection for Field Joints on Directionally Drilled Pipelines

Product Description

Wrapid Shield XL is supplied within the kit and is contained in a heat-sealed foil pouch.

Installer Kit
An Installer Kit is supplied separately and includes Compression Film and Nitrile gloves.

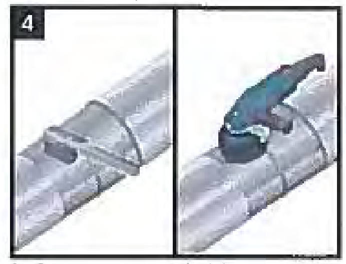
Equipment List

Appropriate tools for surface abrasion and preparation (wire brush/power wire brush or grit blaster, abrasive paper (40-80 grit), Knife, lint free rags, approved solvent and water spray bottle. Standard safety equipment: gloves, safety glasses, hard hat, etc.

Surface Preparation

Clean exposed steel and adjacent pipe coating with an approved solvent (Acetone, MEK, Alcohol >96%) to remove the presence of oil, grease, and other contaminants if present. Ensure that the pipe is dry prior to mechanical cleaning.

Surface Preparation

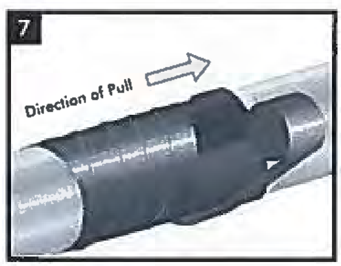


Surface preparation shall be as required for the specific corrosion coating used in conjunction with Wrapid Shield XL.

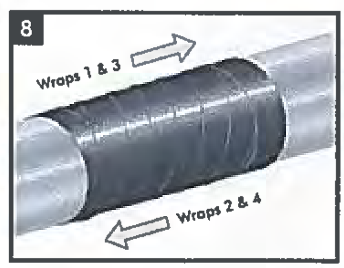
For heat-shrinkable sleeve corrosion coatings use the Canusa product specific installation guide.

Outer Wrap Application Wrapid Shield XL

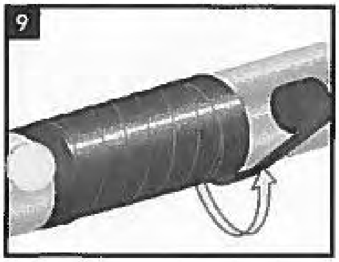
Water is needed to activate Wrapid Shield XL. Open the foil pouch, remove the roll. Once opened, the product cannot be repackaged. Wrapid Shield XL is activated using a water sprayer to mist and wet each layer as it is wrapped.



Starting at the trailing end of the field joint, begin the application at a distance of 50mm (2") past the inner corrosion coating and extend the wrap 150 mm (6") beyond the corrosion coating on the leading edge. Apply the first wrap circumferentially around the pipe at a 90° angle then begin spiral wrapping with a 50% overlap following the wrapping guideline that is printed on the roll. Apply pressure during application by pulling firmly on the roll as it is applied. Squeeze and mold firmly in the direction of the wrap until tight.

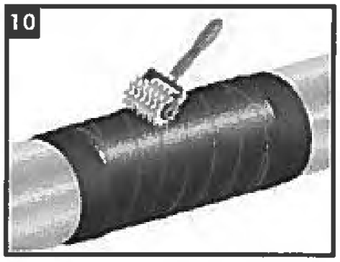


End with a circumferential wrap applied at 90° to the pipe. For high shear or impact requirements, additional layers may be required. To create thinned edges for directional drilling, reduce the overlap in the last 100mm - 150mm of the edges to 10-20% rather than 50%.



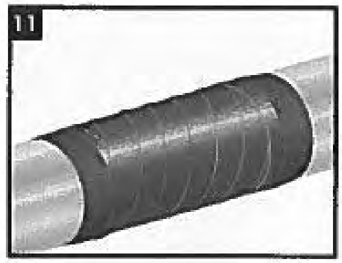
Apply compression film in the same direction as the previous layers with a 50% overlap. Start min. 50mm (2") beyond the outer edge of the Wrapid Shield XL, pulling firmly during application.

NOTE: Compression film should be applied before excess foaming is observed from the Wrapid Shield XL. A second installer should begin this step and follow the Wrapid Shield XL installer(s) as they progress with the wrapping of the pipe. The resin should be compressed and the film perforated as quickly as possible.



Perforate the compression film using a wire brush (or other perforating device) by tapping firmly on the tape with the metal bristles. Perforation allows the CO^2 gas generated by the curing process to escape. Compression film may be removed after material hardens and either discarded or left in place.

Prior to Pulling



Allow the Wrapid Shield XL to reach a Shore D Hardness of 70 prior to pulling. Wrapid Shield XL is fully cured at a Shore D Hardness of 83 @ 72°F.

Note: If holiday inspection is required it must be done after installation of the corrosion coating product is installed because the holiday detector with jeep on residual moisture in the Wrapid Shield XL installed product.

Storage & Safety Guidelines

To ensure maximum performance, store Canusa products in a dry, ventilated area. Keep products sealed in original cartons and avoid exposure to direct sunlight, rain, snow, dust or other adverse environmental elements. Avoid prolonged storage at temperatures above 35°C (95°F) or below -20°C (-4°F). Product installation should be done in accordance with local health and safety regulations.

These installation instructions are intended as a guide for standard products. Consult your Canusa representative for specific projects or unique applications.

Canusa-CPS
A division of ShawCor Ltd.

Head Office
25 Bethridge Rd.
Toronto, ON M9W 1M7 Canada
Tel: +1 416 743 7111
Fax: +1 416 743 5927

Canada
Suite 3200, 450 - 1st Street S.W.
Calgary, AB T2P 5H1 Canada
Tel: +1 403 218 8207
Fax: +1 403 264 3649

Americas
2408 Timberloch Place, Building C-8
The Woodlands, TX 77380 USA
Tel: +1 281 367 8866
Fax: +1 281 367 4304

Europe, Middle East, Africa & Russia
Unit 3, Sterling Park,
Gatwick Road, Crawley, West Sussex
RH10 9QT United Kingdom
Tel: +44 1293 541254
Fax: +44 1293 541777

Asia-Pacific
101 Thomson Road,
#11-03 United Square
307591 Singapore
Tel: +65 6749 8918
Fax: +65 6749 8919

Canusa-CPS is registered to ISO 9001:2008

Part No. 99060-228
IG_Wrapid Shield XL_rev010

LIBERTY SALES & DISTRIBUTION
2880 Bergey Road, Suite F • Hatfield, PA 19440 • Ph: 877-373-0118 • Fx: 888-850-3787

PRINCIPAL MANUFACTURERS

A.Y. MCDONALD MFG. COMPANY is the leading manufacturer of Plug and Ball style Gas Meter Shutoff Valves utilized in both residential and commercial applications up to 175 PSIG. A.Y. McDonald offers a variety of Integral Valve and Standard Configuration Meter Bars including single and multiple residential By-Pass Meter Bars and the newly developed Industrial By-Pass Bar. A full line of straight and off-set Meter Swivels, Meter Nuts, and Meter Plugs are also available in black malleable iron or a galvanized finish. 3 Part Unions in ¾" thru 2" diameters are also manufactured in a BMI finish.

BÖHMER is a worldwide leader in the manufacturing of forged, fully welded, trunnion mounted style ball valves for a variety of high pressure field applications. Nearly 60 years of German engineering and design have resulted in a state of the art production facility and one of the highest quality, flange/welded end valves available on the market. Böhmer Valves are available in diameter sizes ranging from 2" thru 56" with ANSI Class 150 to 1500 nominal pressure ratings, and made in accordance with API 6D standards.

CANUSA-CPS is the global leader in field applied corrosion protection systems. CANUSA Heat-Shrinkable Sleeves include Wraparound and Tubular Sleeve Systems and Tapes. CANUSA also offers HBE-95 Liquid Epoxy Coating for all your field joint coating needs. CANUSA products are also specified for a variety of specialty applications including Directional Drillings, Casings, Bridge Crossings, Water/Wastewater fittings, and elbows. CANUSA also recently developed Wrapid Shield™ PE, a high impact resistant rockshield to protect your corrosion coatings.

CCI PIPELINE SYSTEMS specializes in providing a complete line of Casing related products for the Gas, Oil, Water and Wastewater Industries offering Wrap-It Link Seals, High-Density Polyethylene, Carbon or Stainless Steel Casing Spacers, and Neoprene Rubber End Seals for Casing Pipe and Wall Penetration applications.

CHASE CORPORATION is a leading manufacturer of field applied coatings and tapes for the natural gas, oil, water and wastewater industries. Chase's pipeline coatings division sells the highest quality and well respected brand name products including the Tapecoat ® and Royston ® suite of corrosion protection products. Their extensive product lines include a variety of Cold and Hot Applied Tapes, Sealants, Protective Outerwraps, Liquid Epoxies, Mastics, Petrolatum Wax Tapes and Casing Fill products and services.

CITADEL TECHNOLOGIES is the leading developer and only manufacturer of the Diamond Wrap suite of products on the market. The Diamond Wrap HP, Diamond Wrap and Black Diamond systems consist of a 100% Solid Epoxy coupled with a Bi-Directional Carbon Fiber Wrap. Our Carbon Fiber Composite Repair Systems are extremely low profile and unmatched in structural integrity used to completely restore corroded/eroded piping systems to their original MAOP without service interruption.

LIBERTY SALES & DISTRIBUTION

2880 Bergey Road, Suite F · Hatfield, PA 19440 · Ph: 877-373-0118 · Fx: 888-850-3787

PRINCIPAL MANUFACTURERS

DENSO is an internationally recognized leader in corrosion prevention and sealing systems for new and rehabilitation applications. DENSO developed the original Petrolatum Wax Tape and they have completed successful applications for over 75 years. DENSO's suite of corrosion products include: Petrolatum Wax Tapes for above/below grade applications, fast curing Protal Liquid Epoxies for standard and LOW TEMP applications, Bitumen and Butyl Tape systems, and Sealing/Molding products including their Profiling Mastic for irregular shaped valves and flanged connections.

ERICO is the worldwide CP connections leader. ERICO was the first to develop the exothermic welded electrical connections that will never loosen, corrode or increase in resistance. The remotely detonated, CADWELD® PLUS system is the latest advancement in welded connections providing your crews with simple and quick installations from outside the ditch.

GLAS MESH CO. manufacturers and supplies a complete line of Fiberglass Reinforced Plastic (FRP) Corrosion/Abrasion control products for a variety of pipeline applications such as Bridge/Aerial Crossings, Compressor/Pumping Stations, and Meter Set/Station piping applications. Glas Mesh products include the FRP Shields, Spacers, Saddles, Flatties, Casing Insulators, Coated U-Bolts and EPI Seam-Sealer.

LB&A manufacturers a variety of Non-Conductive Pipe Rollers, Pipe Hangers, and related support hardware for pipeline Bridge Crossing applications. LB&A's Hangers and related support hardware are available in a variety of corrosion prevention finishes including stainless steel and a proprietary BLUECOAT system. LB&A products have been proven to provide long-term durability, weatherability and performance.

LIBERTY COATING COMPANY

A Liberty Group Company

LIBERTY COATING COMPANY, LLC is the Northeast leader in the application of anti-corrosion coatings for the gas, oil, electric, water and wastewater industries. In addition to our PRITEC® coating system, Liberty applies ID/OD Specialty Paint and Lining Systems and provides Pipe-Type Cable Flaring and Coatings. Liberty Coating is located on 35 acres with Rail and Truck access. Pipe Handling, Cutting, Storage, and Logistical Freight Services are also available.

LIBERTY SALES & DISTRIBUTION

Directional Drilling Coatings

LIBERTY SALES & DISTRIBUTION, LLC offers products from the pipeline industries leading manufacturers of HDD coating systems. These include the liquid epoxy coatings Powercrete J, Powercrete R-95, Denso ARO, Warrior 100, as well as the Canusa DDX heat shrink sleeve system. Liberty Sales readily stocks these coating systems, ensuring quick response and timely delivery.

LIBERTY SALES & DISTRIBUTION
2880 Bergey Road, Suite F • Hatfield, PA 19440 • Ph: 877-373-0118 • Fx: 888-850-3787

PRINCIPAL MANUFACTURERS

LIBERTY SALES & DISTRIBUTION
Pipeline Markers

LIBERTY SALES & DISTRIBUTION, LLC can provide you with all your marking needs for both underground and above ground infrastructure. The Liberty Dome Post, Test Station, Vent Casing Post, and Flat Marker Post are all made from impact resistant, UV stable plastics and resins that will provide long term marking protection. They are available in standard lengths and colors.

LIBERTY SALES & DISTRIBUTION
Pipeline Pigging Products

LIBERTY SALES & DISTRIBUTION, LLC serves the pipeline industry by distributing a wide selection of pipeline pigging products and accessories. Our pipeline pigging products are available in most sizes for cleaning, swabbing and batching solutions for your pipeline. Whatever the job requires, Liberty Sales can provide the proper pig, pig launcher or pig tracker, each customized to the customers specifications.

LIBERTY SALES & DISTRIBUTION
Liberty HD Rockshield®

LIBERTY HD ROCKSHIELD® provides high impact and abrasion resistance to protect all of your underground pipeline infrastructure needs. Made from a random looped, lead free, PVC material, this high-density rockshield will save you money by eliminating the need for select back fill, and provide long term abrasion resistance for the life of the pipeline. We will custom cut most orders to help reduce waste on your project. Liberty Sales and Distribution also provides a variety of lighter weight rockshields to meet all your underground pipeline protection needs.

LIBERTY SALES & DISTRIBUTION
Tracer Wire & Cathodic Protection

LIBERTY SALES & DISTRIBUTION, LLC supplies a variety of solid/stranded copper Tracer Wire and CP Wire for your damage prevention and corrosion protection needs. Our HMWPE Tracer Wire is insulated with a rugged, moisture resistant High Molecular Weight Polyethylene (HMWPE) ideal for direct burial applications in the Gas, Fiber Optic, Water and Wastewater Industries. Our CP wire is available in #2 - #8 sizes along with a variety of color options. Custom markings and packaging is available upon request.

MONTI
Tools Incorporated

MONTI TOOLS INC. produces high quality surface preparation tools that provide consistent profile depth for field joints and countless other applications. The Monti Bristle Blaster Kit is available in both electric and pneumatic models with a wide selection of attachments. They are widely used in both shop and field applications and can provide SSPC-SP10 surface cleanliness and anchor profile up to 4.7 mils depending upon the substrate.

SPY PIPELINE INSPECTION COMPANY, LTD

PIPELINE INSPECTION COMPANY produces a host of pipe inspection products including the well known SPY Holiday Detector. Each of the SPY Portable Holiday Detectors offer an indefinite adjustable voltage settings range including the Model 780 (1kV-5kV), Model 785 (1kV-15 kV) and the Model 790 (5 kV-35 kV). The positive ground light and audible alarm features are designed with safety in mind and the rugged ergonomic design and easy installation batteries makes for the most efficient and reliable Jeep on the market.

LIBERTY SALES & DISTRIBUTION

2880 Bergey Road, Suite F • Hatfield, PA 19440 • Ph: 877-373-0118 • Fx: 888-850-3787

PRINCIPAL MANUFACTURERS

TECO AMERICAS

TECO AMERICAS - The FireBag® Thermal-activated Gas Shut-off Device automatically turns off the gas supply in the event of a fire, preventing explosions and the spreading of fire. In the unfortunate event of a fire, when the external ambient temperature of The Firebag® reaches 203-212°F (95-100°C) the metal alloy that keeps the plug & cartridge together melts. Then the spring pressure pushes the plug against the gas opening closing it completely. No fire or heat detectors are required to automatically intercept gas flow. Meets AGA/CGI ANSI Z21.15, DIN 3586 and UIE EN 1775 standards for indoor gas installations.

Western Technology
Explosion Proof & Low-Voltage Lighting Specialists
& Industry's Most Complete Line of Deadman Style Remote Controls

WESTERN TECHNOLOGY INC. is the premier manufacturer and supplier of Explosion Proof and Low Voltage Lighting products, serving a variety of industries. The NEW UL Approved, CLASS I DIV I BRICK Light offers brilliant white LED lighting with safety and "kick it tough" durability. The BRICK Light provides superior lighting with minimal heat generation even after hours of operation. Western Technology also provides a complete line of Explosion Proof Products for a variety of applications in hazardous locations.

WOODARD & CURRAN

WOODARD & CURRAN has successfully served the energy market for over 20 years providing a broad scope of regulatory, environmental, and construction support services with clients specializing in the generation, transmission, distribution, and the storage of energy. Woodard & Curran's experience includes electricity, natural gas, petroleum, nuclear energy, heat/power, and the renewable energy sectors. Typical services include: design engineering, linear project routing and permitting, site evaluations, feasibility studies, regulatory compliance, wetland use and resource permitting, mapping and GIS services.

CONTACT INFORMATION

Corporate Office:

Liberty Sales and Distribution, LLC
2880 Bergey Road, Suite F
Hatfield, PA 19440
Phone: (877) 373-0118
Fax: (888) 850-3787

www.libertysales.net
www.libertyhd.net
www.libertymarkers.net

Tracey Rocchino
Office Manager
Email: trocchino@libertysales.net

Tracy Nixon
Inside Sales Representative
Email: tnixon@libertysales.net

[illegible]a Rorer
Inside Sales Representative
Email: jrorer@libertysales.net

Regional Offices:

New England Territory
Wally Armstrong
Cell: (978) 815-8336
Email: warmstrong@libertysales.net

Mid Atlantic Territory
George Rocchino
Cell: (267) 767-9423
Email: grocchino@libertysales.net

Southern Territory
Lou Taylor
Cell: (267) 664-8177
Email: ltaylor@libertysales.net

Northern Territory
Shane Quackenbush
Cell: (518) 441-5532
Email: squackenbush@libertysales.net

Outside Sales Consultants:

Mid Atlantic Territory
Chuck Lang IV
Cell: (215) 350-9990
Email: clang4@libertysales.net

New England Territory
John Maher
Cell: (207) 650-5740
Email: jmaher@libertysales.net

CANUSA-CPS
A SHAWCOR COMPANY

Wrapid Shield™ XL/XL-FC

Fiberglass Mechanical Protection for Field Joints on Directionally Drilled Pipelines

Wrapid Shield™ XL/XL-FC is a fiberglass cloth, preimpregnated with a resin that can be activated by salt or freshwater to coat and protect any diameter of pipe within minutes. The product is formulated to resist shear, impact and abrasion on pipe coating systems above and below ground such as fittings and joints on all mill-coated pipe and as an outer wrap over heat-shrinkable sleeves for added mechanical protection.

Superior Mechanical Protection

- Provides unparalleled protection against impact, indentation, abrasion, punctures and tears that may result from directional drilling, rough handling, native backfills or severe in-service conditions.
- Designed to protect the underlying field joint coating from the effect of forces associated with directional drilling.

Chemical Resistance

- Resistant to corrosive salt water, soil acids, alkalies and salts, common chemicals, chemical vapors, and exposure to outdoor weathering and sunlight.

Long Term Corrosion Protection

- In combination with a heat-shrinkable sleeve the composition of the products is such that they provide an effective barrier to water and oxygen which provides effective corrosion protection and soil stress resistance.

Different Cure Speeds Available

- Wrapid Shield™ XL is available in 2 configurations depending on project or environmental conditions.
- Wrapid Shield™ XL is the standard version and has an application time of 20 minutes at 23°C.
- Wrapid Shield™ XL-FC is a Fast Cure version and has an application time of 5 minutes at 23°C.

Applications

- Oil & Gas
- Onshore Pipelines
- Offshore Pipelines
- Girth-Weld Joints
- Directional Drilling

Wrapid Shield™ XL/XL-FC

Fiberglass Mechanical Protection for Field Joints on Directionally Drilled Pipelines

Typical Wrapid Shield™ XL Properties*	Test Method	Typical Values
Cure Time at 23°C**		20 min.
Lap Shear Strength	ASTM D3163	12 Mpa
Density	ASTM D792	1.15 g/cm³
Glass Transition Temperature (DSC)	ASTM D3418	Tg = 175 - 189°C
Tensile Strength	ASTM D638	248 MPa
Hardness	Shore D	80
Dielectric strength	ASTM D149	16 kV/mm
Flexural Strength	ASTM D790	405 MPa
Compressive Strength	ASTM D695	165 MPa
Impact Resistance	ASTM G14/G62 (MOD)	167 J
Typical Wrapid Shield™ XL-FC Properties*	**Test Method**	**Typical Values**
Cure Time at 23°C**		5 min.
Density	ASTM D792	1.14 g/cm³
Tensile Strength	ASTM D638	206 MPa
Hardness	Shore D	> 70
...xural Strength	ASTM D790	372 MPa
Impact Resistance	ASTM G14/G62 (MOD)	167 J

*With an 8 layer system

**Cure times will vary depending on substrate temperature. Please contact your local Canusa office for help in determining which configuration would work best for your project's conditions

Since 1967, Canusa-CPS has been a leading developer and manufacturer of specialty pipeline coatings for the sealing and corrosion protection of pipeline joints and other substrates. Canusa-CPS high ...ormance products are manufactured to the highest quality standards and are available in a number ...onfigurations to accommodate many specific project applications.

The product information shown here is intended as a guide for standard products.

Consult your Canusa representative for specific projects or unique applications.

Canusa-CPS
A division of ShawCor Ltd.

Head Office
25 Bethridge Rd.
Toronto, ON M9W 1M7 Canada
Tel: +1 416 743 7111
Fax: +1 416 743 5927

Canada
Suite 3200, 450 - 1st Street S.W.
Calgary, AB T2P 5H1 Canada
Tel: +1 403 218 8207
Fax: +1 403 264 3649

Americas
2408 Timberloch Place, Building C-8
The Woodlands, TX 77380 USA
Tel: +1 281 367 8866
Fax: +1 281 367 4304

Europe, Middle East, Africa & Russia
Unit 3, Sterling Park,
Gatwick Road, Crawley, West Sussex
RH10 9QT United Kingdom
Tel: +44 1293 541254
Fax: +44 1293 541777

Asia-Pacific
101 Thomson Road,
#11-03 United Square
307591 Singapore
Tel: +65 6749 8918
Fax: +65 6749 8919

Canusa-CPS is registered to ISO 9001:2008

PDS_Wrapid Shield™ XL/XL-FC_rev010

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 9/29/2015

Subject: Pipe surface preparation for shrink sleeves weld coating

Directive Number: 2015 – 010

Pipe surface preparation for Shrink Sleeves will be sandblasting using the SSPC-SP10 or NACE 2- Near-White Blast Cleaning Specificiation.

Method of surface preparation shall continue to be recorded for each weld.

Issued by (print): Christopher LeForce

Signature: ______________

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 9/30/2015

Subject: Adhesion Testing – Field Coating

Directive Number: 2015 - 011

An adhesion test shall be performed on an average of 2% of epoxy coated welds from April 1st through September 30th and 5% of epoxy coated welds from October 1st through March 31st, as well as on a minimum of one coated weld in the string for each HDD installation.

The instructions for completing these tests, "**QA/QC Adhesion Test for Field Applied Coatings (Revision 0)**," is attached to this directive.

Any questions on adhesion should be directed to Christopher LeForce or Eric Curtis.

This directive supercedes directive 2015- 008.

Issued by (print): Christopher LeForce

Signature: [signature]

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

MEMORANDUM

TO: ANGP File

FROM: Shana Kane

DATE: April 6, 2017

RE: Addison Natural Gas Project (ANGP) QA/QC Executive Summary (Twenty-two mile Section)

This QA/QC Summary covers the approximately twenty-two mile section of pipe from the north side of Geprags Park in Hinesburg to the Middlebury Gate Station , stations 979+00 to 2179+88.

VGS' quality assurance/quality control (QA/QC) for the ANGP project has undergone continuous improvement over the course of the project. VGS' inspectors have collected extensive QA/QC data including:

- Final holiday surveys
- Coating repairs (type and location)
- Adhesion testing
- Voltage readings
- Bending (locations, joint #, length, total deflection, any damage)
- Daily grade and ditching reports
- HDD and RD bores (locations, pull back dates, station locations, length)
- Pipe anomaly evaluation
- Pipe lowering, padding and backfill
- Cleanup and restoration

The data has been collated and analyzed for trends by the VGS Operations team and DPS regulators on an ongoing basis. VGS used this information to identify additional quality assurance checks as well as revisions needed to project specifications. Summaries of specific QA/QC focus areas for the pipeline south of Geprags Park are provided below, followed by a separate summary for the Geprags HDD pipeline installation, which occurred at a later date.

Coating

Coating integrity is a critical component of a pipeline system and has been a focus area of the ANGP QA/QC program. Specific items related to coating are summarized below.

Holiday Detection

Holiday detection was performed as pipe sections are welded together to identify any anomalies needing repair. Final holiday detection surveys were performed prior to the pipe being laid in the trench and as it was lowered into the ditch.

VGS plans a closed interval survey and coating holiday survey of the buried 22-mile segment in 2017.

Adhesion Testing

The lead coating inspector performed adhesion tests for the Canusa sleeves and epoxy coating, used on the Pritec-coated pipe and fusion-bonded epoxy (FBE)-coated pipe respectively. This quality control process tested the integrity of applied coating and was a key factor that identified an issue with defective Canusa wrap (see discussion below).

Canusa Wrap Failure

In 2016, adhesion testing identified failure of coating repairs that used Canusa sleeves from a set of 2013 and 2014 manufactured lots. Immediate actions included removal of the Canusa lot numbers from the project and identification of locations that had sleeves installed from these lots. Testing was performed on other lots of Canusa wrap; no additional batches were identified as having quality issues. See attachment, "Report on Canusa Shrink Sleeve Peel Tests".

Handling Damage

The Pritec coating used for the ANGP project has been susceptible to damage during pipe handling (transfer of pipe and bending). Project personnel had operator qualifications related to coating damage prevention, field bending of pipe and hauling, stringing and handling of pipe. Coating inspectors were onsite and provided field oversight of pipe handling techniques. QA checklists were completed for coating application, repairs and holiday inspections.

Bending of the pipe was performed in accordance with specifications outlined in Trenching and Backfilling (Section 312333). Inspectors performed QA/QC of the bending to ensure coating was not damaged during the bending process. It was observed that bends with a high total deflection were more likely to have coating damage. Any damage as well as high deflection bends was repaired with Canusa sleeves.

Horizontal Directional Drilling (HDD)

This pipeline segment had eleven sections of pipe installed by HDD. Michels followed VGS requirements for HDD pipe pullback and HMM completed QAQC checklists for each location.

The HDD at Monkton Swamp required approximately 158 ft. of pipe to be pulled through prior to the pipe meeting inspection criteria. VGS provided details related to the acceptance of this HDD to the Department of Public Safety on Sept. 6, 2016.

Welding

Welding was performed in accordance with project specification Section 137000 – Welding, which includes 100% visual inspection by HMM inspectors and 100% radiographical inspection.

No QAQC issues have been identified for follow-up.

Materials – Pipe Anomalies

Pipe anomalies/defects were detected at the ends of several joints of pipe. Prior to June 20, 2016, inspectors performed visual inspections of the anomalies for acceptance or mitigation.

VGS issued Directive 2016-004 on June 20, 2016 which established a procedure to measure anomalies with pit gauges or ultrasonic testing (UT) and detailed criteria for acceptance, repair or cut-out.

Anomalies were repaired by grinding or cut out, depending on the pit depth and wall thickness. UT was used to ensure pipe thickness met requirements in areas of repair by grinding.

VGS plans a closed interval survey of the buried 22-mile segment in 2017, which will assess coating integrity and an ILI survey, which will assess wall thickness. In addition, the cathodic protection system will be commissioned as soon as possible after the pipeline is fully installed.

QAQC ADDENDUM – GEPRAGS HDD

Coating

The pipe installed for the Geprags HDD has fusion-bonded epoxy (FBE) coated to the steel and Powercrete abrasive resistant overlay (ARO) coating. In addition, the welds had a sacrificial coating of Canusa Wrapid Shield fiberglass cloth for protection against possible damage during pullback.

Holiday Detection

Holiday detection (jeeping) was performed by VGS personnel. Each weld joint was jeeped after the R-95 two-part epoxy was applied and prior to the installation of the Wrapid Shield. A final survey performed as the pipe was being pulled in. No holidays were detected during either survey.

Adhesion Testing

VGS performed three adhesion tests for the R-95 epoxy coating; all were successful.

Horizontal Directional Drilling (HDD)

The HDD at Geprags Park was drilled and installed by Gabe's Construction Company following VGS requirements. Pullback met VGS' HDD acceptance criteria.

Welding

Welding was performed by Mulholland Welding in accordance with project specification Section 137000 – Welding. No cut-outs or repairs were required.

Team Industrial Services performed radiographical inspection of all welds. No issues were detected.

Report on Canusa Shrink Sleeve Peel Tests

Date: March 21, 2017, Revision 0

By: Christopher LeForce

Purpose: This report summarizes and addresses the testing performed on the Canusa Shrink Sleeves, specifically the batches from 2013 and 2014.

Background: As part of the Addison Natural Gas Project (ANGP), adhesion tests were performed on the various field applied coatings. For the Canusa K60 Shrink Sleeves, the adhesion test performed was a field peel test. The VGS Construction Team and contractors followed the Canusa procedure titled "Field Peel Test & Repair Procedure."

The adhesion test for the Canusa K60 shrink sleeve consists of cutting a 1-inch wide by 6-inch long outline into a sleeve 24 hours after it was applied, then using a utility knife to pry back the first two inches of the cut sleeve. Vice grips with an attached force gauge are attached to the 2-inch tab and used to pull the coating at a 90° angle at a rate of 4 inches per minute. The tab is pulled until cohesive failure is noted to both substrate and sleeve backing.

On August 19, 2016, a field adhesion test was initiated but failed when attempting to pry back the 2-inch tab of the coating. The sleeve backing (yellow outer layer) separated from the adhesive, which was bonded to the steel. The lot number associated with this adhesion test was 13-B-319. The "13" refers to the year it was manufactured. Eight additional adhesion tests were performed that same day; six failures occurred and were associated to 2013 lots. Two other lots were tested and passed.

The VGS lead coating inspector contacted the manufacturer, Canusa, and the distributor, Liberty Coatings, regarding the field peel test failures associated with lot 13-B-319. On August 22, 2016, representatives from both companies were on-site to witness additional field peel tests. Two adhesion tests were performed (lot 13-B-319 and 14-B-284) and received a fail rating. All parties agreed that the adhesion tests were performed according to the Field Peel Test & Repair Procedure and failed due to adhesive failure from the backing.

The Canusa representative then conducted additional tests on sleeves with batch prefix 14-B. These tests also received a fail rating due to adhesive failure from the backing. During an August 22, 2016 meeting between Canusa representative (Jeff Bertsche), Liberty Coating representatives (Shane Quakenbush and Wally Armstrong), Michels QA/QC (George Hess), and VGS lead coating inspector (Ryan Schaefer), all parties agreed that Canusa batches associated with years 2013 and 2014 should not be used until Canusa could perform laboratory tests on the batches of concern.

Actions: All welds coated with a shrink sleeve batch from 2013 or 2014 and had not been buried, were removed and replaced with a newer batch from 2015 or later. A total of 296 shrink sleeves were removed and replaced. Currently 66 shrink sleeves remain from 2013/14 batches that were installed during the 2016 construction season.

Canusa took shrink sleeves from 2013/14 batches and ran laboratory tests on them. They conducted both a Peel Test and a Lap Shear Test. The results of those tests and discussion around them is included in a document titled "Re: Canusa Peel Test / Lap Shear Review for the Vermont Gas / Michels Project" to Mr. Wally Armstrong from Mr. Paul Boczkowski on January 24, 2017.

Discussion: The Field Peel Test was used as a QA/QC check on the application of the field applied coating. The purpose of the test is to make the shrink sleeve fail. The type of failure is the important part of the test. As described in the Canusa document referenced above, there are three types of failure modes described as follows:

- Cohesive Failure – adhesive remains on both the steel substrate and PE backing
- Adhesive Failure from the Backing – all adhesive remains on the steel substrate
- Adhesive Failure from the Substrate – clean peel, no adhesive on the steel substrate

The first two are acceptable failure modes and the last one is unacceptable. Basically, the adhesive on the shrink sleeve is the corrosion protection and the outer backing layer is protection for the adhesive. The worst outcome is to have the adhesive not adhere to the steel pipe it is protecting, which is adhesive failure from the substrate.

The Peel Tests that were completed on ANGP primarily experienced cohesive failure. The Peels Tests that were completed on August 19, 2016 and August 22, 2016 experienced adhesion failure from the backing. Both were acceptable failure modes.

Canusa conducted their own laboratory tests on the shrink sleeves from 2013/2014 batches as outlined in the Canusa document referenced above. The Peel Test showed that varying the temperature can effect the failure mode between cohesive failure and adhesion failure from the backing. They did not have any test experience adhesion failure from the substrate, which would be the unacceptable result.

Further testing, specifically a Lap Shear Test, was completed on the shrink sleeves from 2013/2014 batches to closely mimic the conditions of a buried pipeline where soil stresses act on the pipe and its coating. The results of these tests show that the sleeves were compliant with Canusa's performance standards.

Report on Canusa Shrink Sleeve Peel Tests

Conclusion: With the results of the tests completed by Canusa, VGS believes no further action needs to be completed at this time. The lab test results show that the Canusa K60 Shrink Sleeves from batches manufactured in 2013 and 2014 were acceptable and the results of the Field Peel Tests on ANGP that were experienced were also acceptable.

VGS will maintain records of the installed shrink sleeves in the event a future problem develops.

January 24, 2017

Mr. Wally Armstrong
Liberty Sales & Distribution
2880 Bergey Road, Suite F
Hatfield, PA 19440

Re: Canusa Peel Test / Lap Shear Review for the Vermont Gas / Michels Project

Dear Mr. Armstrong

With respect to the above referenced Review, please be advised that Canusa has performed testing on 2013/14 manufactured K-60 heat shrink sleeves ("Sleeves"), which were supplied to Michels in August 2016, for installation on the subject Vermont Gas Addison Country Project. The results of the testing are set out here below, alongside the test methods of both Peel Tests and Lap Shear Tests used to evaluate the Sleeves.

Field Peel Test

It should be noted that the references to "failure" used throughout this document refer to a pipeline industry term used to describe how adhesives separate from the different layers. Failure is the desired outcome of the testing, the particular mode of failure being the desirable or undesirable test result.

The Field Peel Test is a quality control check, which may be used on the Right-of-way ("ROW") as a method of determining whether the heat shrink sleeve was applied properly. Visual inspection is used additionally or in the alternative. The Field Peel Test utilizes portions of the ASTM D1000 and the DIN 30672 standards as performed in a lab, however lab testing procedures naturally use more precise instrumentation providing accurate values and temperatures, which are held constant throughout the testing process. The Field Peel Test is used to measure the bond of the adhesive to the substrate.

Changing temperatures on the ROW can produce different peel values and peel modes, and therefore the peel tests completed in the field are not considered to be a reliable measure or an indicator of the product's in-use performance, rather as stated they are used to check for proper surface preparation and preheat.

Installers typically use visual inspection of the peeled area to determine the particular failure mode and to understand if the Sleeve has been applied properly. The three (3) typical modes of failure are as follows:

- Cohesive Failure – adhesive remains on both the steel substrate and PE backing
- Adhesive Failure from the Backing – all adhesive remains on the steel substrate
- Adhesive Failure from the Substrate – clean peel, no adhesive on the steel substrate

SHAWCOR
Canusa-CPS
25 Bethridge Road
Toronto, Ontario
M9W 1M7 Canada
o +1 416 743 7111
f +1 416 743 5927
Shawcor.com

Field Peel Tests can result in cohesive failure, however, adhesive failure from the backing can also occur with cooler ambient temperatures as was the case on this project. Adhesive failure from the substrate (bare pipe exposed), would be considered an undesirable and an unacceptable result, which would typically require the joint to be recoated. It is important to note that in the case of this project, this ‘adhesive failure from the substrate’ failure mode did not occur.

Peel Test

Canusa conducted peel tests for the purpose of simulating the Vermont Gas / Michels field peel test as set out below. The results of the testing show that temperature differences between the adhesive and backing can change the resultant failure mode, for example, a temperature differential of 5.3°F can produce the adhesive failure from the backing failure mode as opposed to the cohesive failure mode. Both failure modes being considered acceptable modes of failure for this test.

Figure 1: Canusa K-60/L, QA# 13-B-319 SL

Peel Test Method:

- 2016 Canusa K-60/L sleeve was applied
- Ice was placed in the bottom half of the pipe to simulate a temperature differential between the steel surface and the outer PE backing.
- Peel test was performed.

The results of the Peel Test were as follows:

- Top half of the pipe, test showed cohesive failure = a PASS
- Bottom half of the pipe, test showed adhesive failure from the backing = a PASS
- Same Sleeve, installer and peel test with two (2) different results. The only variable that changed was a lower steel pipe temperature. (Approximately 5°F).

Figure 2: Follow Up Testing Canusa K-60/L, QA# 16-B-554.

The testing and results obtained described above indicate that the Sleeve's performance was normal, acceptable and the peel testing in the field was conducted at a peel failure mode transition temperature (temperature differential). Both results would be considered a PASS.

The existence of two results may have contributed to some confusion on the ROW, since we understand the contractor had observed only one (the cohesive failure mode) thus far. In a proactive response to the concerns expressed on the ROW all 2013 and 2014 material was set aside and replaced with 2016 material until Canusa could show there were no material quality issues. We understand that Michels wanted to ensure that this 2013 and 2014 material would perform as expected.

Canusa reviewed the quality control reports at the time of manufacturing of the Sleeves and has also completed lap shear testing (to ASTM D1002). All manufacturing quality control test results (thickness, viscosity, softening point, shear, peel, etc.) were shown to be within acceptable ranges. The lap shear testing performed is discussed below.

Lap Shear Testing

The lap shear test follows ASTM D1002. This test is used to ensure that the Sleeve can withstand soil stresses such as the longitudinal shear deformation caused by temperature differences and circumferential stresses exerted during wet/dry cycles. Lap shear measures the comparative strengths of adhesives for bonding materials.

Lap Shear Test Method:

1. 1 square inch of adhesive is placed between two metal strips (or metal and PE backing strips)
2. Condition sample for several hours at required temperature
3. Place sample between grips of Instron test system
4. Pull sample apart at specified rate
5. Typical values for the Canusa K-60 is 35 N/cm^2

The lap shear test provides a good indicator of how the sleeve will perform in service. A random sample of 2013 and 2014 sleeves were pulled from the ROW and sent to the Shawcor Technology and Development Center for testing.

The Lap Shear Test results are set out in Appendix 1 to this letter and show that all values are within acceptable ranges.

In conclusion, the Peel tests and Lap Shear tests described here, the results of which are shown for both the 2013 and 2014 Canusa K-60 heat shrink sleeves, demonstrate that the Sleeves are compliant with Canusa's performance standards and expected therefore to perform normally and within our product specifications.

Should you wish to discuss these results, have questions or require any further information, please do not hesitate to contact myself or Ms. Salehpour from Canusa's Product and Technology Management, contact information below, Thank you.

Sincerely,

Paul Boczkowski
Global Product Manager
Phone: +1-416-744-5590
Paul.Boczkowski@shawcor.com

Somaieh Salehpour
Global Technology Manger
Phone: +1-416-744-5792
Samaieh.Salehpour@shawcor.com

Appendix 1

Figure A1: Results of lap shear tests on 2013 Sleeves

Lap Shear Testing for 2013 Canusa K-60 / Vermont Gas, 1cm/min, 15°C		
QA #	**Average Value**	**Image**
13 B 319 SL	45 N/cm^2 CF, backing broke	
13 B 2201 LG	49 N/cm^2, CF	
13 B 1981 SL	49 N/cm^2, CF	

Figure A2: Results of lap shear tests on 2014 Sleeves

Lap Shear Testing for 2014 Canusa K-60 / Vermont Gas, 1cm/min, 15°C		
14 B 1404 RK	44 N/ cm², CF	
14 B 108 LG	46 N/ cm², CF	

SHAWCOR

Fargo, Audrey

Subject: FW: Canusa Joint Sleeves - Confidential and Privileged Communication

From: David Berger [mailto:dave.b@verizon.net]
Sent: Wednesday, August 30, 2017 10:45 AM
To: Morris, GC <GC.Morris@vermont.gov>
Cc: Porter, Louise <Louise.Porter@vermont.gov>; Porter, James <James.Porter@vermont.gov>; David Berger <dave.b@verizon.net>
Subject: RE: Canusa Joint Sleeves - Confidential and Privileged Communication

GC,
I have searched my files and found some things but I believe that they are confidential so I cannot share them with you. However, the Canusa issue was identified in a request for a special permit by Spectra Energy (formally Duke Energy) under PHMSA Docket 08-0257 but look at things in 2011 which may have reports and findings etc. which would be non-confidential. If you want me to research this, it will have to wait awhile since I am tied up on other work for the next few days.

Dave

David Berger Associates | Office: 941.900.2226 | Cell: 516.702.7271 | Email: dave.b@verizon.net|

From: Morris, GC [mailto:GC.Morris@vermont.gov]
Sent: Wednesday, August 30, 2017 8:35 AM
To: David Berger
Subject: Canusa Joint Sleeves - Confidential and Privileged Communication

Good Morning Dave,
I hope your vacation to New York was enjoyable and you had a safe return trip to Florida.

During our discussion referenced below, you mentioned that Duke Energy had stated Canusa wraps were all fine, on a particular pipeline project, however an ILI run indicated significant pipe degradation (resultant of the wraps). Is there a report, paper or other documentation of that situation which you could forward to me? If you don't have access to written record, etc., would you provide reference to where/when? I believe you or John mentioned that PHMSA may have issued a replacement order. I mentioned it to Zack Barrett (when I saw him last week) and he offered to look for related materials to the situation, if we can't find it.

Thanks,
GC

From: David Berger [mailto:dave.b@verizon.net]
Sent: Wednesday, July 19, 2017 12:11 PM
To: Morris, GC <GC.Morris@vermont.gov>
Subject: RE: Pipeline Padding and Canusa Joint Sleeves - Confidential and Privileged Communication

GC,
Let's set a time for 1 today?

Vermont Gas

Page 1 of 2
Corrective/Preventive Action Request (CPAR)

CA ■ PA ☐
(Check appropriate box to indicate corrective or preventive action)

Initiator: K. Oxholm Corrective Action # 2015-004
or
Date: 10/19/15 Preventive Action # ______

	Date Due	By/Assigned to	Completed Initials & Date
Investigation		Kristy Oxholm	KHO 11/25/2015
Implementation		Lee Brown	
Audit			
CAR/PAR closed		John St. Hilaire	JSH 12/11/15

Description of Issue

Pipe at appx. 398+00 to 406+00 has garage/trash mixed in with backfill. Pipe is reportedly padded with select backfill, has mirify fabric laid and the backfill in question on top of the mirify. Varying reports describe the garbage/trash as mostly broken glass to chunks of metal and other household garbage/trash.

Work Processes need to be modified or ceased during investigation?: Yes ___ No x
If so, specify:

Approved by: [signature] Date: 12/11/15

Investigation Finding

In speaking with a variety of people there is clear cause for concern. At least two test pits will be dug to determine the extent of the problem and to complete this investigation.

During the period of 12/1/15 to 12/8/15 a total of 8 test pits were dug in the area of concern. No trash or garbage was found in close proximity to the installed pipe. A small amount of small items was found in the very top layer of the cover, well above the pipe. No mirify fabric was found at any of the dig sites. (see attached pictures).

Rev. 0 07/24/2015

Vermont Gas

Corrective/Preventive Action Request (CPAR)

Recommendations for Corrective / Preventive Action
As a result of the findings in the test pits, no corrective action is required. VGS will be commissioning the cathodic protection (CP) system at the gas-up of the pipeline. This will provide protection should any coating holidays exist on the pipeline because of the trash/debris. Additionally, a direct assessment type survey will be conducted in the spring of 2016. If any part of the coating is damaged in this area because of trash/debris, the survey will indicate an anomaly and it can properly be inspected and remediated.

Action Taken / Verification
Any future re-evaluation and follow-up required? Yes ___ No x___ If so, specify:
Verified by: ______________________ Date: ______________ Was action taken effective? ☐ Yes ☐ No If no, new CA/PA number: ________ ____ Comments: ______________________________________

Rev. 0 07/24/2015

Good Morning Dave,

I hope this message finds you and your family safe and healthy.

I'm unavailable this morning and early afternoon, but will keep an eye out for an indication of your status.

I've added some further references related to the ANGP coating issues [nested in brackets and attached] in the list I sent Fri 9/8/2017 3:28 PM (below).

Regards,

GC

From: Morris, GC **Sent:** Friday, September 08, 2017 3:35 PM **To:** 'David Berger' <dave.b@verizon.net> **Subject:** RE: PRIVILEGED & CONFIDENTIAL, request for Assessment(s) and Recommendation(s)

I certainly understand Dave,

I look forward to talking to you next week (and knowing that you and your family are safe & sound)

Best Wishes,

GC

From: David Berger [mailto:dave.b@verizon.net] **Sent:** Friday, September 08, 2017 3:28 PM **To:** Morris, GC <GC.Morris@vermont.gov> **Subject:** RE: PRIVILEGED & CONFIDENTIAL, request for Assessment(s) and Recommendation(s)

GC,

Today is not a good day to discuss so let us defer to sometime next week, say Tuesday if I have phone service and electric, otherwise I will email you when I am back up and running.

Dave

David Berger Associates | Office: 941.900.2226 | Cell: 516.702.7271 | Email: dave.b@verizon.net|

From: Morris, GC [mailto:GC.Morris@vermont.gov]
Sent: Friday, September 08, 2017 3:25 PM
To: David Berger
Subject: PRIVILEGED & CONFIDENTIAL, request for Assessment(s) and Recommendation(s)

Hello Dave,

Thanks for your phone message and status-email.

I was wondering how you've been doing in FL lately, given current circumstances.

I've received your recent A&R and plan to discuss it with you directly in the very near future. Are you still available this afternoon?

Regarding your phone message, I understand that our staff have authorized your production of another A&R document related to existing pipe coating conditions. I've outlined coating concerns below. We had discussed associating these concerns with the concern of Lack of Padding/support, because your recommendations to address them are similar. Occurrences of Lack of Padding/support appears to be slightly greater than the few locations acknowledged by the company; the pipeline, in several swampy areas, was installed by via excavation of soft material adjacent to pipeline allowing pipe to sink-in to position by displacement of ground beneath it. Another condition for our consideration is that trench-breakers were not installed in approximately 38 locations designated in the pipeline designs.

1) CRP-65 patch kit, adhesion failure(s)

a) Multiple locations on ANGP, unknown number

b) VGS discontinued patches per CPAR 2015-003 [found in ANGP QA/QC Executive Summary dated 12/12/2015, provided in my Fri 9/8/2017 3:59 PM email to you]

2) CRP-Ultra patch kit, adhesion failure(s)

a) Multiple locations on ANGP, unknown number

b) VGS discontinued patches per CPAR 2015-003 [found in ANGP QA/QC Executive Summary dated 12/12/2015, provided in my Fri 9/8/2017 3:59 PM email to you]

3) Mill applied patches, adhesion failure(s)

a) Multiple locations on ANGP, unknown number

b) VGS discontinued patches per CPAR 2015-003 [found in ANGP QA/QC Executive Summary dated 12/12/2015, provided in my Fri 9/8/2017 3:59 PM email to you]

4) Canusa Shrink Sleeves (wraps)

a) Multiple locations on ANGP, unknown number

b) VGS "Report on Canusa Shrink Sleeve Peel Tests" dated 3/21/2017 [found in Memorandum, ANGP QA/QC Executive Summary, dated 4/6/2017, attached to this message]

5) Coating Holiday (HDD acceptance criteria not met)

a) Location: Rte.2A crossing HDD

b) VGS accepts condition per CPAR 2015-008 [found in ANGP QA/QC Executive Summary dated 12/12/2015, provided in my Fri 9/8/2017 3:59 PM email to you]

c) 7/16/2015 EN engineering - Route 2A/Rail Crossing HDD Coating Investigation [found in ANGP QA/QC Executive Summary dated 12/12/2015, provided in my Fri 9/8/2017 3:59 PM email to you]

6) Coating Damage (HDD installation)

a) Location: Monkton Swamp

b) VGS memo/report accepting condition dated 9/6/2016 [attached to this message, sent 9/12/17 AM]

Regards,

GC

From: Adam Gero <AGero@vermontgas.com>
To: "Morris, GC" <GC.Morris@vermont.gov>, "Laperle, Michelle"
<Michelle.Laperle@vermont.gov>
CC: "Shana L. Kane" <slkane@vermontgas.com>, John St.Hilaire
<jsthilaire@vermontgas.com>, Chris LeForce <CLeForce@vermontgas.com>
Subject: RE: Items from the Matrix
Thread-Topic: Items from the Matrix
Thread-Index: AdMiU1x6aYM9TnecSOW8+Raz2h4H4AAQC2SQ
Date: Thu, 31 Aug 2017 20:02:19 +0000

Hi GC,

In reviewing the matrix of discussion items, it seems there are a few open =
items that can be closed with some simple clarifications. They are:

For AC Mitigation:

VGS is still working on the finalization of the CP and AC Mitigation System=
s. The CP and AC Mitigation Systems were installed as designed by ARK Engi=
neering and VGS is completing final checks during the annual

testing of the=
systems. Once complete and data is compiled, VGS will provide all documen=
ts related to the commissioning and testing of the systems. We expect this=
to be complete mid-Fall timeframe.

For Integration of Data, regarding Canusa sleeves:

In general, VGS will use available sources of data and integrate them when =
analyzing inspections of the pipeline.

For construction method used in swamp areas:

VGS followed the Construction Type W detailed on sheet ANGP-T-G-006 of the =
design drawings for pipe installations in swampy areas. When it was not pra=
cticable to install sandbags or other pipe supports in these areas, the con=
struction team made sure to over dig the trench and make sure that native m=
aterial was returned to the bottom of the trench as padding.

For Ratification of JanX Procedures:

See attached memorandum.

For Gas Quality review:

See attached email from Todd Lawliss.

I hope this provides some clarity on these items.

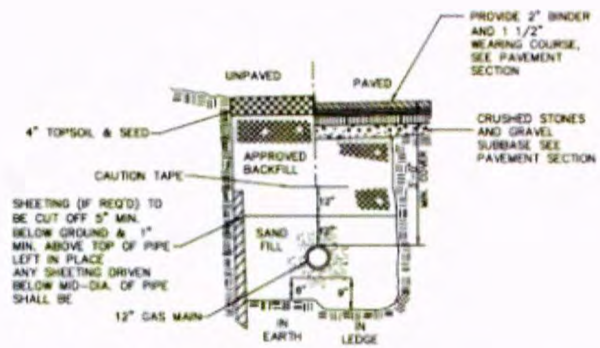
Thanks,

Adam Gero

Engineering Compliance Manager

Vermont Gas Systems, Inc.

(802)951-0329



NOTES:

1. BACKFILL MATERIAL TO CONSIST OF GRANULAR MATERIAL CONTAINING NO STONES OR CLODS LARGER THAN 3" IN GREATEST DIMENSION. IN RESOURCE AREAS BACKFILL TO CONSIST OF NATIVE SUBSOIL AND TOPSOIL.
2. BACKFILL WITH CLEAN SAND TO 12" OVER PIPE.
3. REMOVE UNSUITABLE MATERIAL BELOW GRADE IF ENCOUNTERED, TO SUITABLE DEPTHS AS DIRECTED BY ENGINEER AND REPLACE WITH CLEAN GRANULAR FILL.
4. IN RESOURCE AREAS (E.G., WETLANDS AND PAS AREAS) SUBSOIL TO BE BACKFILLED TO MATCH DEPTH OF ADJACENT NATIVE, UNDISTURBED SUBSOIL/TOPSOIL INTERFACE FOLLOWED BY BACKFILL OF NATIVE TOPSOIL. EXCESS SUBSOIL TO BE PROPERLY DISPOSED OF AND STABILIZED.
5. ALL TRENCH CONSTRUCTION TO CONFORM TO APPLICABLE FEDERAL, STATE AND LOCAL REGULATIONS.
6. ALL BACKFILL MATERIAL, WITH THE EXCEPTION OF RESOURCE AREAS (SEE NOTE #4), SHALL BE COMPACTED AT NEAR OPTIMUM MOISTURE CONTENT IN LAYERS NOT EXCEEDING 6 INCHES IN COMPACTED THICKNESS BY PNEUMATIC TAMPERS, VIBRATOR COMPACTORS, OR OTHER APPROVED MEANS.
7. THE CONTRACTOR SHALL PROVIDE TESTING TO INSURE THAT THE INPLACE DENSITY OF THE BACKFILL MEETS THE ABOVE REQUIREMENTS.

5 **Typical Trench Detail** 2/13

N.T.S. Source: CHA I.D._

Q.INTERVENORS.VGS.1-12: Admit that Attachment A was one of the "plans," "these plans" and "approved plans" referenced in paragraph 2 of the Certificate of Public Good issue in Docket No. 7970, as follows:

> Construction of the proposed Project shall be in accordance with plans and evidence as submitted in this proceeding. Any material deviation from these plans or a substantial change to the Project must be approved by the Board. Failure to obtain advance approval from the Board for a material deviation from the approved plans or a substantial change to the Project may result in the assessment of a penalty pursuant to 30 V.S.A. §§ 30 and 247.

A.INTERVENORS.VGS.1-12: Admitted that Attachment A was submitted in that Docket, and that the CPG is accurately quoted above.

Person Responsible for Response: Eileen Simollardes
Title: Vice President – Regulatory Affairs.
Date: December 1, 2017

From: Morris, GC
To: Jordan, Bill
Date: Jul 7, 2016, 10:52 AM
Subject: RE: DIRECT LAY OF LINE PIPE ON UNDISTURBED CLAY
Attachment(s): 1

Yes Sir, the Bushman paper is attached.

GC

From: Jordan, Bill **Sent:** Thursday, July 07, 2016 9:03 AM **To:** Morris, GC <GC.Morris@vermont.gov> **Subject:** RE: DIRECT LAY OF LINE PIPE ON UNDISTURBED CLAY

GC,

Please forward to me John's message from 6/17 with the attachment "Corrosion and Cathodic Protection Theory." Thank you.

Bill

William B. Jordan

Director of Engineering

Vermont Department of Public Service

112 State Street, Montpelier, VT 05620-2601

Office: (802) 828-4038; Mobile: (802) 522-3959

bill.jordan@vermont.gov

From: Morris, GC
Sent: Thursday, July 07, 2016 8:39 AM
To: Jordan, Bill; Porter, Louise
Subject: FW: DIRECT LAY OF LINE PIPE ON UNDISTURBED CLAY

Hello Bill and Louise,

I'm forwarding this message (from David Berger) to you, for your reference, regarding the ANGP specification Section 312333 which currently requires the pipe to be installed on a bed of select backfill.

GC

From: David Berger [mailto:dave.b@verizon.net]
Sent: Monday, June 20, 2016 7:24 AM
To: 'John McCauley' <jmccauley@precisionpipelinesolutions.com>; Morris, GC <GC.Morris@vermont.gov>
Cc: David Berger <dave.b@verizon.net>
Subject: RE: DIRECT LAY OF LINE PIPE ON UNDISTURBED CLAY

John,

You are correct that laying a pipeline directly on compacted clay soil is not ideal and can cause corrosion both initially due to having aerated soil above and non-aerated soil on the bottom of the pipe. Over time the bottom layer of clay could also trap moisture and thus have a lower soil resistivity and thus promote corrosion that way. Of course, the ideal situation would be to place 1 to 2' of sand under the pipeline and then place the pipe on the sand bed and fill around it with additional sand. As you suggest, they should as a minimum place the pipe on sand bags and then fill in around with select fill. They also may want to put in trench breaks to prevent ground water using the trench as new pathway since it in compacted clay. The VGS specifications appear pretty clear and the contractor should be following them. Thanks for this update and the later one on running the PCM and CIS. Do you know if they found any surprises?

Dave

David Berger Associates | Office: 631.689.1137 | Cell: 516.702.7271 | FAX:

631.689.1137 | Email: dave.b@verizon.net|

From: John McCauley [mailto:jmccauley@precisionpipelinesolutions.com] **Sent:** Friday, June 17, 2016 2:11 PM **To:** dave.b@verizon.net; Morris, GC **Subject:** DIRECT LAY OF LINE PIPE ON UNDISTURBED CLAY

Hi Dave,

It appears that this year the company intends to excavate the trench, and in areas where there is no rock in the ditch, to lay the pipe directly on the bottom without pipe supports or continuous sand padding. We have a concern, that without having sand padding below the pipe, that we are setting up a potential differential aeration corrosion cell. Attached please find the current construction standards, specifically Section 3.3(B) , which seems to indicate that select padding will be placed continously on the bottom of the trench, or the pipe supported which would allow select backfill to be shaded around the pipe.

In your opinion do you believe that laying the pipe directly on the undisturbed clay presents a potential corrosion issue, as is illustrated on page 5 of Corrosion and Cathodic Protection Theory (see attached).

Adam Gero

From: John St.Hilaire
Sent: Thursday, June 08, 2017 3:57 PM
To: Chris LeForce; Adam Gero
Subject: FW: VGS weekly meeting follow-up

From: John St.Hilaire
Sent: Friday, July 01, 2016 4:55 PM
To: Morris, GC (GC.Morris@vermont.gov)
Cc: Chris LeForce; Adam Gero; Porter, Louise (Louise.Porter@vermont.gov)
Subject: VGS weekly meeting follow-up

Hi GC.

We had two items to follow up with from our Tuesday meeting including pipe placement in the trench and induced voltage.

Pipe placement in the trench – On 6/21 we discussed this item and we understood the issue to be around the placement of the pipe at the bottom of a trench and if our spec allowed for this or were we required to add padding. We engaged our engineering firm of record to provide input on whether the spec allowed for a pipe to be placed at the bottom of the trench when suitable backfill material is present. We provided an e-mail from the engineering firm describing his wording and intent to allow pipe to be placed on the bottom of the trench when suitable material is present without bedding. This is the same interpretation our inspection and our pipeline contractors have taken in regard to the spec. During our 6/28 meeting, we learned the issue was not the mechanical aspects of placing the pipe at the bottom of a trench, it is the corrosion potential due to oxygen differentials in the soil layers. We again reached out to others to determine if this was an acceptable practice. We engaged Mott McDonald and two New England LDC's who all reported that when suitable backfill material is present in the bottom of the trench, it is acceptable and common to put the pipe on the bottom of the trench. Today (7/1) at 2pm, we discussed this with ARK engineering to understand the corrosion aspect of oxygen concentration. We reviewed the report (Bushman & Associates, Inc.) provided by Mr. McCauley and find it does walk through various corrosion mechanisms including Galvonic Corrosion, Oxygen concentration corrosion, and Corrosion caused by dissimilar soils. Further it states "corrosion can be caused due to differences in the electrolyte. These differences may be in the soil resistivity, oxygen concentration, moisture content, and various ion concentrations". The next section of the report details corrosion control mechanisms including coating pipe and cathotic protection.

Corrosion is a factor that we work to minimize on a pipeline. Corrosion can occur from oxygen concentrations at the change of soil from one geologic area to another, from an HDD to open trenching, and from moving through wetlands not only due to soil changes but due to the added moisture content of the soil. We cannot eliminate every risk of corrosion, which is why we utilize the corrosion control mechanisms listed in the Bushman report including pipe coating, cathotic protection, and compacting backfill with native soil in minimizing oxygen concentration corrosion.

Our research shows that placement of cathotically protected coated steel pipe on the bottom of a trench with suitable backfill material (no sharps, etc) is an accepted practice in the natural gas industry from a mechanical and corrosion perspective. The Bushman concludes with "When a system is designed, installed, and maintained properly, cathotic protection is one of the most effective and economical methods of preventing corrosion". With the evaluation complete, we have submitted an RFI to our engineer to officially clarify the spec and its allowance for the placement of the pipe at the bottom of a trench when suitable backfill material is present.

Induced voltage – On 6/21 we again discussed managing induced voltage. We both had been trying to get a Velco procedure to manage induced voltage. In the meantime, Michels implemented their standard management approach to induced voltage including daily measuring and installing grounding rods. We were also asked about the qualifications of the Michels safety individual who was managing the induced voltage program. During the week of 6/21 we developed a formal Michels procedure, provided a summary of the readings for the project, and the resume of the Michels regional safety manager. All readings from the start of the project were substantially below the recommended level of 15 volts. On 6/28, we provided the written procedure and asked for comments. We also agreed to provide additional information regarding the Michels safety person for Induced voltage. We reached out to Ark Engineering, two New England LDC's, and our own NACE 2 CP tech to learn about managing induced voltage on a shared ROW. We learned a procedure should be in place, testing and training should be required, and grounding installed to manage induced voltage. We learned that there is no industry certification for induced voltage and the NACE CP certifications only briefly covers induced voltage. Our research indicated that an individual with actual experience managing induced voltage on a pipeline project should be used to manage the induced voltage program. During our conversation with ARK engineering, we asked them to audit our procedure and give feedback on how we can improve the procedure. We provided the procedure to ARK on 7/1. Ark Engineering is the entity that designed the cathotic protection system for the pipeline and did an induced voltage survey of the Velco line when designing the system. We continue to be open to suggestions and ways to improve the management of induced voltage.

I am still working on the information on the Michels regional safety manager and hope to have that for you on Tuesday.

Please let me know if you have any questions.
John

Q.INTERVENORS.VGS.1-85: Admit that Attachment D is an excerpt of plans and/or directions provided by Vermont Gas Systems to contractors for construction of the ANGP, dated October 18, 2013.

A.INTERVENORS.VGS.1-85: Admitted. Please note Attachment D was a component of the bid documents provided to prospective construction contractors.

Person Responsible for Response: Chris LeForce
Title: Project Engineering Manager
Date: December 1, 2017

Q.INTERVENORS.VGS.1-86: If the prior question is not admitted without qualification, explain in detail why it was not and attach all documents which pertain to, explain, contradict or support the answer.

A.INTERVENORS.VGS.1-86: Not applicable.

Person Responsible for Response: Chris LeForce
Title: Project Engineering Manager
Date: December 1, 2017

Q.INTERVENORS.VGS.1-87: Admit that plans and/or directions to contractors of the ANGP as of 2013 included the following: "The pipe shall rest on undisturbed trench bottom provided the material does not include rocks, sharp objects and/or debris that may cause damage to the pipe."

A.INTERVENORS.VGS.1-87: Admitted that the quoted language is contained in Attachment D.

Person Responsible for Response: Chris LeForce
Title: Project Engineering Manager
Date: December 1, 2017

Q.INTERVENORS.VGS.1-88: If the prior question is not admitted without qualification, explain in detail why it was not and attach all documents which pertain to, explain, contradict or support the answer.

A.INTERVENORS.VGS.1-88: Not applicable.

Person Responsible for Response: Chris LeForce
Title: Project Engineering Manager
Date: December 1, 2017

Q.INTERVENORS.VGS.1-89: Admit that Attachment E is an excerpt of plans and/or directions provided by Vermont Gas Systems to contractors for construction of the ANGP, dated May 24, 2014.

A.INTERVENORS.VGS.1-89: Admitted.

Person Responsible for Response: Chris LeForce
Title: Project Engineering Manager
Date: December 1, 2017

Q.INTERVENORS.VGS.1-90: If the prior question is not admitted without qualification, explain in detail why it was not and attach all documents which pertain to, explain, contradict or support the answer.

A.INTERVENORS.VGS.1-90: Not applicable.

Person Responsible for Response: Chris LeForce
Title: Project Engineering Manager
Date: December 1, 2017

Q.INTERVENORS.VGS.1-91: Admit that plans and/or directions to contractors of the ANGP as of 2014 included the following: "The pipe shall rest on undisturbed trench bottom provided the material does not include rocks, sharp objects and/or debris that may cause damage to the pipe."

A.INTERVENORS.VGS.1-91: Admitted that the quoted language is contained in Attachment E.

Person Responsible for Response: Chris LeForce
Title: Project Engineering Manager
Date: December 1, 2017

Q.INTERVENORS.VGS.1-92: If the prior question is not admitted without qualification, explain in detail why it was not and attach all documents which pertain to, explain, contradict or support the answer.

A.INTERVENORS.VGS.1-92: Not applicable.

Person Responsible for Response: Chris LeForce
Title: Project Engineering Manager
Date: December 1, 2017

Q.INTERVENORS.VGS.1-93: Admit that the plans and/or directions given to contractors in 2013 and 2014 departed from the plans submitted to the Commission, and violated the CPG, because they did not require 6 inches of backfill under the pipeline in all locations.

A.INTERVENORS.VGS.1-93: Denied. VGS does not agree that the plans as submitted to the Commission in the CPG process required "6 inches of backfill under the pipeline in all locations" as stated and believes that the plans and/or directions given to contractors in 2013 and 2014 were appropriate and compliant with the CPG.

Person Responsible for Response: Chris LeForce
Title: Project Engineering Manager
Date: December 1, 2017

Q.INTERVENORS.VGS.1-94: If the prior question is not admitted without qualification, explain in detail why it was not and attach all documents which pertain to, explain, contradict or support the answer.

A.INTERVENORS.VGS.1-94: See A.INTERVENORS.VGS.1-15.

Person Responsible for Response: Chris LeForce
Title: Project Engineering Manager
Date: December 1, 2017

Q.INTERVENORS.VGS.1-95: Admit that, in fact, parts of the ANGP were constructed in accordance with the 2013 and 2014 plans – without any backfill under the pipe.

A.INTERVENORS.VGS.1-95: Objection – this question is vague and ambiguous regarding how it is using the term "backfill." VGS understands this question is asking about material under the pipeline. Without waiver of the objection, VGS admits that the pipeline was constructed in accordance with plans but VGS denies that any location was installed "without any backfill under the pipe." It is both appropriate and fully compliant with the CPG to lay pipeline directly within a trench when the material already existing at the trench bottom will provide proper and adequate support.

Person Responsible for Response: John St. Hilaire
Title: Vice President of Operations
Date: December 1, 2017

Q.INTERVENORS.VGS.1-96: If the prior question is not admitted without qualification, explain in detail why it was not and attach all documents which pertain to, explain, contradict or support the answer.

A.INTERVENORS.VGS.1-96: See A.INTERVENORS.VGS.1-95.

Person Responsible for Response: John St. Hilaire
Title: Vice President of Operations
Date: December 1, 2017

ENGINEER'S ADDENDUM NO. 01
TO THE BID DOCUMENTS (PLANS AND SPECIFICATIONS) FOR
Proposed System Expansion
Addison Natural Gas Project (ANGP)
Transmission Contract
October 18, 2013

The following changes and/or additions shall be made to the plans and/or specifications. All other requirements of the contract documents shall remain the same. Acknowledge receipt of this addendum by inserting its number and date in the Bid Proposal.

Changes/Additions to the Bid Documents:

THIS ADDENDUM is hereby made a part of the contract documents on the subject work as though originally included therein. The following amendments, additions and/or corrections shall govern this work.

This Addendum is in the following parts as follows:

Part I	- Pertaining to Drawings
Part II	- Pertaining to Technical Specifications
Part III	- Clarifications to Contractor's Questions
Part IV	- List of Attachments
Part V	- Additional Information

PART I - PERTAINING TO DRAWINGS

1. ADD the following drawings:
   a. "Colchester Launcher and Tie-In Site" dated 9/24/13 produced by CHA. The entire scope of the Colchester Launcher and Tie-In Site is now a requirement of the Transmission Contract.
   b. "Williston M&R Station" dated 9/24/13 produced by CHA. NOTE: Only information applicable to installation of the access road (outside of the M&R fenced area) is applicable.
   c. "Plank Road M&R Station" dated 9/24/13 produced by CHA. NOTE: Only information applicable to installation of the mainline valve (within the M&R fenced area) and the access road (outside of the M&R fenced area) are applicable.
   d. "Middlebury M&R Station" dated 9/24/13 produced by CHA. NOTE: Only information applicable to installation of the mainline valve (within the M&R fenced area) and the access road (outside of the M&R fenced area) are applicable.
   e. "Cathodic Protection System Design – Installation Drawings" dated 9/30/13 produced by ARK Engineering & Technical Services, Inc.
   f. "AC Mitigation System Design – Valve Site Grounding Installation Drawings" dated 9/30/13 produced by ARK Engineering & Technical Services, Inc.
   g. "Zinc Ribbon Installation Drawings" dated 10/10/13 produced by ARK Engineering & Technical Services, Inc.
2. REPLACE the following sheets with the attached sheets:
   a. ANGP-T-G-011 (EPSC Plans Only)
   b. ANGP-T-G-013 (EPSC AND Alignment Plans)
   c. ANGP-T-G-015 (EPSC AND Alignment Plans)

17-3550-INV
Intervenors'
Discovery
ATTACHMENT D

PART II - PERTAINING TO TECHNICAL SPECIFICATIONS

1. Table of Contents: REPLACE with the attached REVISED Table of Contents.
2. Invitation to Bid
    a. Sixth paragraph, last sentence shall be REPLACED with the following: "This bid shall remain valid for a period of ***sixty (60)*** days from the bid due date."
3. Instruction to Bidders
    a. Item 14 – REPLACE "forty-five (45)" with "sixty (60)".
    b. Item 15.6 – REPLACE "forty-five (45)" with "sixty (60)".
    c. Item 21.1 – REPLACE the second sentence with the following: "All Contractors must be qualified under the NGA Operator Qualification Plan."
4. Information Available to Bidders
    a. ADD the following as item #2 under "Other Data": "2. Tables for Jack/Bore Locations, Horizontal Directional Drill (HDD) Locations, Stream Crossings and Utility Infrastructure Crossings"
    b. ADD the following as item #3 under "Other Data": "3. Mainline Valve Location Table"
    c. ADD the following as item #4 under "Other Data": "4. Project Manual – Vermont Gas Systems Addison Natural Gas Project – Horizontal Directional Drill Design/Build"
5. Agreement
    a. Section 5.1 – REPLACE the first sentence as follows: "OWNER shall make progress payments on account of the Contract Price on the basis of CONTRACTOR's Applications for Payment as recommended by ENGINEER, on a Net 30 day basis during construction as provided in paragraphs 5.1.1 and 5.1.2 below."
    b. Section 5.1.2 – DELETE entire second paragraph "If Work has been 50% completed…equal to 90% of the Work completed."
    c. Section 7.8 – REPLACE the listed drawing sets with the drawings listed on the attached Table of Contents.
6. Bid Form: REPLACE with the attached REVISED Bid Form.
7. Bid Summary Form: REPLACE with the attached REVISED Bid Summary Form.
8. Supplemental Conditions: ADD the following:

    "SC-14.2

    The first sentence of paragraph 14.2 shall be REVISED as follows: "At least ten days before the date established for each progress payment, which shall be **bi-weekly**, CONTRACTOR shall submit to ENGINEER for review an Application for Payment filled out and signed by CONTRACTOR covering the work completed as of the date of the Application and accompanied by such supporting documentation as is required by the Contract Documents."

9. Division VGS – Special Construction (Gas Pipeline)
    a. Vermont Gas ANGP Project Scope of Work and Specifications Item 13.i. REPLACE with the following: "i. The pipe shall rest on undisturbed trench bottom provided the material does not include rocks, sharp objects and/or debris that may cause damage to the pipe. Structured pipe pillows shall be installed in the bottom of the trench at maximum intervals of every 16ft to protect the pipe

from lying on rocks, sharp objects and/or debris which may cause damage to the pipe or pipeline coating. The COMPANY may require the CONTRACTOR to use select fill trench bottom padding material. ~~Select fill base material for rock trench, shall provide a minimum of twelve (12) inches of padding around the entire circumference of the pipe. Select fill material and/or padding material shall not exceed 1-1/2 inches diameter and shall be placed completely around the pipe.~~ ***Select fill base material for rock trench areas and areas with cobbles/boulders, shall provide a minimum of nine (9) inches of padding below and twelve (12) inches of padding on the sides and top of the pipe. Select fill material and/or padding material shall be sand in accordance with VTrans Standard Specification 703.03 or shall be screened native material containing silts, sands and gravels with the largest material being no larger than 1-inch on the longest dimension.*** Topsoil from the RIGHT-OF-WAY shall not be used for padding material. ~~All select fill padding shall be procured from existing commercial facilities and shall be of sand.~~"

   a. Vermont Gas ANGP Project Scope of Work and Specifications Item 26.w. REPLACE with the following: "w. Pipe installed at specified crossings shall be hydrostatically tested for four hours at a pressure specified by the COMPANY, both prior to, and after installation."

10. Division 01 – General Requirements
    a. Section 011000 Summary – REPLACE with attached 01100 Summary Specification.
    b. Section 012300 Alternates – REPLACE the Specification with the attached 012300 Alternates Section

PART III – CLARIFICATIONS TO CONTRACTOR QUESTIONS

1. Answers to questions asked during the Pre-bid meeting have been addressed in the Pre-Bid Meeting Minutes (Refer to Part IV Below).
2. Additional questions for the Transmission Contract have not been asked since the Pre-Bid Meeting as of the date of this Addendum.

PART IV – LIST OF ATTACHMENTS

1. Pre-Bid Meeting Minutes titled "Addison Natural Gas Project Phase 1 – Transmission Pre-Bid Minutes of Meetings.
2. Drawings noted in PART I
3. Project Manual Table of Contents
4. Tables for Jack/Bore Locations, Horizontal Directional Drill (HDD) Locations, Stream Crossings, and Utility Infrastructure Crossings (Information Available for Bidders)
5. Mainline Valve Location Table (Information Available for Bidders)
6. HDD Contract Information – The HDD contract is available at the following location: https://www.chafiles.com/fs/v.aspx?v=8d6d6a8c60a8a27c6c97 (Information Available for Bidders)
7. HDD Duration Table (Information Available for Bidders)
8. Project Manual Bid Form

VERMONT GAS ADDISON NATURAL GAS PROJECT

SCOPE OF WORK AND SPECIFICATIONS

1. **GENERAL**
   a. The work shall be carried out in accordance with these Construction Specifications, The U.S. Department of Transportation Title 49CFR Part 192 – Transportation of Natural Gas and Other Gas by Pipeline, ASME B31.8 and API 1104. In addition the WORK shall be performed in strict compliance with the CONFORMED **DOCUMENTS,** good engineering practice and industry accepted pipeline construction and installation techniques, and all applicable rules and regulations. The work shall strictly adhere to the most current version of the Vermont Gas Systems (VGS), Inc. Operation and Maintenance Manual and Operating Procedures. The requirements detailed in the VGS Operation and Maintenance Manual and Operating Procedures shall supersede any other specifications provided with the Project Manual.
   b. The Addison Natural Gas Project has been divided into four contracts; Transmission, Horizontal Directional Drilling, Meter & Regulation Stations, and Distribution. It is a requirement of the Transmission Contract to coordinate and cooperate with other Contractors working on other/adjacent areas of the project.
2. **SURVEYS**
   a. All pre-construction, construction, and as-built survey shall be the responsibility of the **COMPANY,** and jointly coordinated between the **CONTRACTOR** and the **COMPANY. CONTRACTOR** is responsible for coordinating the survey needs via the designated **COMPANY** representative, so it does not impact work.
   b. The **COMPANY** shall reserve the right to make any minor changes in the pipeline route and such changes shall in no manner alter the terms of compensation payable under this **CONTRACT** except as they are affected by linear measurements of the work completed.
   c. The COMPANY shall stake the edges of the RIGHT-OF-WAY at regular intervals. These stakes shall remain along the RIGHT-OF-WAY for the duration of the job and be removed as part of final clean up operations when authorized by COMPANY.
   d. The **CONTRACTOR** shall be held responsible for the preservation of all stakes and field markings. If any of the stakes or field markings are disturbed by the contractor, the cost of replacing them shall be borne by the **CONTRACTOR.** When it becomes necessary to move such stakes, the **CONTRACTOR** will relocate them to the spoil side of the RIGHT-OF-WAY in a line approximately perpendicular to the centerline of the pipeline location and opposite the original location of the stake.

Stormwater Permit, Vermont 401 Water Quality Permit, Construction Line List, and landowner clean up and final restoration sign off agreement, applicable procedures and the requirements of the Land Owners Line List. This shall include backfilling the pipe trench and restoring creek banks, hillsides, or other locations that are disturbed. Backfilling of the trench shall be executed with extreme care so as not to damage pipe or coating. Hand labor shall be used during initial backfilling as deemed necessary by the **COMPANY.**

f. At all locations where the pipeline crosses roadways, walkways, and proposed roadways where the open trench method of crossing is utilized, backfill shall be placed in lifts and mechanically compacted within the limits of the existing or proposed pavements and to the satisfaction of the governing agency. The **CONTRACTOR** shall hold the **COMPANY** harmless from any and all damages resulting from open trench Construction. Unless specified otherwise, backfill compaction shall achieve at least ninety five percent (95%) Modified Proctor density by wetting and tamping at all levels in the backfill material. Approval shall be received from the COMPANY to operate compaction equipment within thirty-six (36) inches of the pipeline.

g. Attention shall be given in backfilling the pipeline near roads to ensure that proper pad dirt is place in such a manner as to completely fill the voids around and under the pipe and to prevent damage to electrolysis test site leads.

h. The **CONTRACTOR** shall compact, subject to **COMPANY** approval, ditches crossing residential and industrial yards and bell holes around all above ground pipeline appurtenances at the **CONTRACTOR'S** expense.

i. The pipe shall rest on undisturbed trench bottom provided the material does not include rocks, sharp objects and/or debris that may cause damage to the pipe. Structured pipe pillows shall be installed in the bottom of the trench at maximum intervals of every 16ft to protect the pipe from lying on rocks, sharp objects and/or debris which may cause damage to the pipe or pipeline coating. The COMPANY may require the CONTRACTOR to use select fill trench bottom padding material. Select fill base material for rock trench areas and areas with cobbles/boulders, shall provide a minimum of nine (9) inches of padding below and twelve (12) inches of padding on the sides and top of the pipe. Select fill material and/or padding material shall be sand in accordance with VTrans Standard Specification 703.03 or shall be screened native material containing silts, sands and gravels with the largest material being no larger than 1-inch on the longest dimension. Topsoil from the RIGHT-OF-WAY shall not be used for padding material.

j. The **CONTRACTOR** shall build temporary slope breakers to divert the flow of water from grades on the RIGHT-OF-WAY onto areas protected by established vegetation. See Environmental Mitigation Plan.

k. Through agricultural and pasture lands, rock three (3) inches and larger measure in any dimension shall be removed as stated in the Environmental Mitigation Plan and the Agricultural Mitigation Plan or Agreement. Rock 12 inches and

MEMORANDUM

TO: ANGP File

FROM: Adam Gero

DATE: June 6, 2017

RE: Addison Natural Gas Project (ANGP) Pipe Laid on Trench Bottom

---

This memorandum serves as justification for Vermont Gas' decision to allow the areas on ANGP where pipe was laid directly on the trench bottom to remain in place.

During the construction of the ANGP pipeline, there were a few locations where the transmission pipe was installed directly on the trench bottom or supported by sand berms or "dutchmens". At the time of occurrence it was in compliance with Technical Specification Section 312333. After the occurrences, decisions were made to adopt more stringent construction practices and no longer allow these methods.

Order of events:
August 31, 2015 – Pipe was installed between station 240+26 and station 279+75 directly on the sandy bottom of the trench. This is documented in directive 2015-005 (attached) stating that the Construction Management Team deemed that the trench bottom had adequate support and padding. This practice was allowed by the Technical Specifications:

"Pipe supports shall be installed in all locations prior to backfilling, unless otherwise directed by the Construction Management Team – refer project design drawings for further requirements. Stacked sandbags, pipe pillows, or owner approved equal are acceptable methods. Spacing shall be per manufacturers recommendations, if a commercial product, or 15' maximum intervals if sandbags." – Technical Specification for ANGP, Section 312333 part 3.5B – April 29, 2015

June, 2016 – Construction began on ANGP south of the Williston Gat Station. Technical Specification 312333 part 3.5B had been revised 05/2016 to read:

"Pipe supports may be installed in all locations prior to backfilling as an alternative to continuous pipe bedding for the entire width of the trench. However, areas around pipe shall still be padded with select backfill as shown on the contract drawings and explained in paragraph 3.3.b. above. Stacked sandbags, pipe pillows, or owner approved equal are acceptable methods. Spacing shall be per manufacturer recommendations, if a commercial product, or 15' maximum separation if sandbags." – Technical Specification for ANGP, Section 312333 part 3.5B – May, 2016

MEMORANDUM

The Construction Management Team constructed the pipeline with the knowledge that pipe installed on the trench bottom or on sand berms was in fact an "owner approved equal" for pipe support. This is solidified by the (attached) email from Brendan Kearns, CHA Engineer to John St. Hilaire on June 22, 2016 where he stated "If the material 6" below the bottom of the trench is deemed to be suitable material (per specifications) by the CM team, then the pipe can be laid in the bottom of the trench as long as it is sufficiently supported as stated in 3.3.C". The only section that was installed directly on the trench bottom in 2016 was a 360 foot section between station 564+24 and station 567+84. VGS did a test dig in that section to inspect the pipe and to analyze the trench. The report (attached) shows that the soil at the bottom of the trench was suitable for padding material.

Further discussions on this matter ensued and on July 5th, 2016 the team decided that for consistency they would no longer allow pipe to be installed on the trench bottom or supported on sand berms. This is memorialized in RFI#: ANGP-VGS-RFI-025 (attached) and then communicated to the DPS in the (attached) email From Chris LeForce to GC Morris and Louise Porter on July 7th, 2016.

Another concern was also brought up regarding soil differences potentially causing corrosion issues. This concern was quickly handled by Jeremy Bachand, Vermont Gas Corrosion Technician, NACE CP2 certified, and Bob Allen, President and Owner of ARK Engineering, NACE CP4 certified. Their conversations clarified that the conditions present in the areas where the pipe was installed directly on the ground or on sand berms were similar to those elsewhere on the project and raised no extra corrosion concern. This was documented in an email from John St. Hilaire to GC Morris and Louise Porter on July 1st, 2016 (attached).

At the time that the pipe was installed either on the trench bottom or on sand berms it was acceptable practice. VGS and the Construction Management Team then decided to remove some of the flexibility in the construction methods. After this change was made, no additional pipe was installed on the trench bottom or on sand berms.

Areas Pipe Lays on Ground or Pipe Using Dirt Berms

Date	Station From	Station To	Sand Berms	Pipe on the Ground
8/31/2015	240+26	279+75		X
6/17/2016	564+24	567+84		X
6/18/2016	889+74	892+11	X	
6/21/2016	888+38	889+74	X	
6/28/2016	863+62	864+55	X	
7/5/2016	663+00	664+50	X	

Vermont Gas

ARNGP PROJECT DIRECTIVE

Date: 9/1/2015

Subject: Construction in Sand Area

Directive Number: 2015 - 005

In 3.5(B) – Bedding and Backfilling of Section 312333 – Trenching, Pipe Laying, and Backfilling of the Technical Specifications: pipe supports shall be installed in all locations prior to backfilling, unless otherwise directed by the Construction Management Team.

This document serves to direct the construction without pipe supports in the sand area from station 240+26 to station 279+75, as the uniform sand in the trench meets requirements for select backfill.

Issued by (print): John Stamatov

Signature: [signature] J.R. [signature], Proj. Mgr

This directive expires on 12/31/2015 unless superseded or cancelled prior to that date.

Adam Gero

From: John St.Hilaire
Sent: Wednesday, June 22, 2016 9:53 AM
To: Adam Gero; Chris LeForce
Subject: FW: 312333 Trenching and Backfilling Clarification

FYI

From: Kearns, Brendan [mailto:BKearns@chacompanies.com]
Sent: Wednesday, June 22, 2016 9:37 AM
To: John St.Hilaire
Cc: 'john.r.stamatov@pwc.com'
Subject: 312333 Trenching and Backfilling Clarification

Hi John St. Hilaire,

The intent of the trenching and backfilling specification is to have suitable native material (described in the specification) around the pipe as shown in the trench details on ANGP-T-G-015. If the material 6" below the bottom of the trench is deemed to be suitable material (per specifications) by the CM team, then the pipe can be laid in the bottom of the trench as long as it is sufficiently supported as stated in 3.3.C:

"The bottom of the trench shall be accurately graded to provide a uniform layer of padding/bedding material, as required, for each section of pipe. Trim and shape trench bottoms and leave free of irregularities, lumps, and projections."

If the material in the trench is determined not suitable by the CM team, then borrow material as described in section 2.1.A.2 shall be used as select backfill and placed around the pipe according to the dimensions shown in the trench detail on sheet ANGP-T-G-015. Alternatively, the contractor may use a shaker bucket with the native material to screen out the oversized material to meet the specification. However, Part 2.1.A.1 states:

"A shaker bucket or screen may be used if native material is too large, given that the characteristics of the material are suitable for successful shaker bucket or screen use."

This clause was placed in there to clarify that if the material cannot work in a shaker bucket (e.g. clay) and that material is in large "clumps" and the CM team cannot assure that the material meets the specification, then borrow material must be brought in to bed the pipe.

As far as the Cathodic Protection issue goes, clay is not as dielectric (dielectric meaning a poor electrical conductor) as sand. However, there is nothing in the code that says you can't use clay around the pipe. Ark Engineering can speak better to this, but they studied the soils along the route in preparation for the design of the CP system.

Thanks,

Brendan

Brendan C. Kearns, P.E.*
Engineer II

CHA ~ *design/construction solutions*
Office: (802) 735-0374
Mobile: (978) 503-2333
bkearns@chacompanies.com
www.chacompanies.com
*VT

Responsibly Improving the World We Live In

ANGP Pipeline Anomaly Dig, @ station 565+85

Personnel On-Site: Darrel Crandall (Mott MacDonald), Steve Miner (VGS), Kate Marcotte (VGS), and the Michels Pipeline Construction crew

Date: 09/27/2016

The Enduro Pipeline Services caliper inspection detected a 1.7% deformation in the pipe at the 4:00/4:30 location on the pipe at station 565+85, indicating a possible dent in the pipe. Pictures below show no rocks were detected around the pipe or anywhere in the excavation. Pictures also show no indication of a dent found due to construction while inspecting the pipe.

Excavation dirt pile with clumps of clay and no rocks.

Exposed pipe section at station 565+85. Moved stake into area to show location of possible dent.

ANGP Pipeline Anomaly Dig, @ station 565+85

No dent or coating damage spotted at station 565+85 after cleaning the pipe and thoroughly inspecting the pipe by hand. Checked the pipe several feet upstream and downstream of station number.

Excavation dirt pile with clumps of clay and no rocks. Expanded excavation to locate weld 0193.

ANGP Pipeline Anomaly Dig, @ station 565+85

Exposing more pipe to weld 0193. No rocks detected just clumps of clay and clay topsoil mix.

Measurement of 17’ from weld 0193 to possible dent to confirm location.

ANGP Pipeline Anomaly Dig, @ station 565+85

Confirmation measurement came to the same location from the first location observed based point set by survey. No dent detected due to a construction condition on any part of the pipe upstream or downstream of station 565+85. Re-inspected the pipe by hand several feet upstream and down stream of station 565+85 to feel for any damage. Also inspected pipe for damage in the entire section exposed. No coating damage detected or indication of a dent due to construction in the section of pipe exposed.

.

Close up picture of station 565+85 at the 4:00/4:30 location. No coating damage or dent detected

PROJECT:

Addison Natural Gas Pipeline

Phase I

REQUEST FOR INFORMATION TRANSMITTAL

Date:	7/1/2016	RFI #: ANGP-VGS-RFI-025
RFI Title:	Trenching, Pipe Laying, And Backfilling Specification Clarification	
RFI Origin:	Name: Christopher LeForce	Contractor: Vermont Gas Systems, Inc.
RFI Submitted To:	Name: Brendan Kearns	Contractor: CHA

Discipline:

Engineering [X]
Environmental [ ]
Construction [ ]
Other (specify) [ ]

Information Requested:

VGS is requesting clarification with respect to the methods the pipeline can be placed in the trench and backfilled under *Section 312333 Trenching, Pipe Laying, And Backfilling Specification*. Please provide intent and clarification on the various methods the trench bottom can be prepared under the specification.

Information Response:

PER SPECIFICATION 31233, THE TRENCH BOTTOM MAY BE PREPARED UTILIZING TWO METHODS NOTED BELOW. WITH EITHER METHOD, THE PIPE SHALL HAVE A MINIMUM OF SIX (6) INCHES OF SELECT BACKFILL/PADDING PLACED BENEATH (BETWEEN IN-SITU NATIVE MATERIAL AND BOTTOM OF PIPE) AND ALL ON SIDES OF THE PIPE (SECTION 3.3.B).

1) THE PIPE MAY BE PLACED ON STACKED SANDBAGS, OR OTHER APPROVED SUPPORT METHOD (SECTION 3.5.B.) AND BACKFILLED AS SPECIFIED IN SECTION 312333.

2) THE PIPE MAY BE "CONTINUOUSLY SUPPORTED" WITH SELECT BACKFILL/PIPE PADDING (MINIMUM 6 INCHES) AS DESCRIBED IN SECTION 312333, PART 3.3.B, AND SHOWN ON DETAILS 3 AND 6 ON SHEET ANGP-T-G-015. THE CONTRACTOR AND CONSTRUCTION MANAGEMENT TEAM SHALL VERIFY THAT THE 6" OF PADDING MATERIAL BELOW THE PIPE MEETS SPECIFICATION 312333 PART 2.1.A.

PER THE SPECIFICATIONS AND DETAILS 3 AND 6 ON SHEET ANGP-T-G-015, LAYING THE PIPE DIRECTLY ON *IN-SITU* NATIVE MATERIAL ON BOTTOM OF TRENCH IS NOT ACCEPTABLE.

Authorized Signature: BCK

Printed Name and Title: BRENDAN KEARNS, CHA ENGINEER

Date: 7/5/16

Copies to: VGS-Office VGS - Field CHA VHB

Adam Gero

From: Chris LeForce
Sent: Thursday, July 07, 2016 6:16 PM
To: Morris, GC
Cc: John St.Hilaire; Adam Gero; Porter, Louise
Subject: VGS weekly meeting follow-up
Attachments: Adhesion Test - Field Coating Rev.2.pdf; ANGP-VGS-RFI-025-R0 RESP.pdf; Denso 35 Tape Peel test procedure 2016 0707 Rev 1.pdf; VGS Project Org Chart_06142016 v1.pdf

GC,

I have attached multiple documents that you have requested copies of or have asked for additional clarification during our weekly meetings. They are listed below with an explanation.

VGS Project Org Chart_06142016 v1.pdf – This was provided in hard copy form at our meeting on 7/5/2016. John St. Hilaire said we would send along an electronic version.

Denso 35 Tape Peel test procedure 2016 0707 Rev 1.pdf & Adhesion Test - Field Coating Rev.2.pdf – It was requested that we properly title the adhesion test procedure for the Denso 35 Tape. The final version is attached. I have also included the updated QA/QC Adhesion Test Plan, which incorporates this test for the tape. These documents will be added to the Inspector Manual on Monday morning.

ANGP-VGS-RFI-025-R0 RESP.pdf – This is the Request for Information (RFI) related to the pipe trench preparation under Section 312333 Trenching, Pipe Laying, and Backfilling Specification. VGS had asked CHA to clarify the methods that were acceptable under the specification, as it is written under its current revision.

It was our intent to allow the pipe to be installed on the trench bottom if the soil conditions were shown to be rock free, which would be completed by inspecting the trench bottom and sidewalls and also the spoil from the trench. If a determination could not be made or the soil contained rocks, then the pipe would be properly supported and padded during the installation. This is a commonly accepted construction technique used in the industry by other companies when favorable soil conditions exist. This is a similar situation to the use of the sand berms or "dutchmen" for pipe support in the trench in lieu of sandbags or pipe pillows. It is a commonly used method of installation in the industry. Both are difficult to inspect and by a pure interpretation reading of the specification, neither is allowed unless the specification was edited and updated, as shown in CHA's response to the RFI.

VGS at this time will not be using either technique and has instructed the Construction Management (CM) Team to completely pad the trench bottom or use sand bags as pipe supports unless they submit an alternative for approval. We will also circulate a copy of the RFI to the CM Team to present the interpretation. The CM Team has stated these have been the primary techniques used on the installed pipe, except for a few hundred-foot section installed south of the Williston Gate Station. We will incorporate this section into the QA/QC Program.

Regards, Chris

Adam Gero

From: John St.Hilaire
Sent: Thursday, June 08, 2017 3:57 PM
To: Chris LeForce; Adam Gero
Subject: FW: VGS weekly meeting follow-up

From: John St.Hilaire
Sent: Friday, July 01, 2016 4:55 PM
To: Morris, GC (GC.Morris@vermont.gov)
Cc: Chris LeForce; Adam Gero; Porter, Louise (Louise.Porter@vermont.gov)
Subject: VGS weekly meeting follow-up

Hi GC.

We had two items to follow up with from our Tuesday meeting including pipe placement in the trench and induced voltage.

Pipe placement in the trench – On 6/21 we discussed this item and we understood the issue to be around the placement of the pipe at the bottom of a trench and if our spec allowed for this or were we required to add padding. We engaged our engineering firm of record to provide input on whether the spec allowed for a pipe to be placed at the bottom of the trench when suitable backfill material is present. We provided an e-mail from the engineering firm describing his wording and intent to allow pipe to be placed on the bottom of the trench when suitable material is present without bedding. This is the same interpretation our inspection and our pipeline contractors have taken in regard to the spec. During our 6/28 meeting, we learned the issue was not the mechanical aspects of placing the pipe at the bottom of a trench, it is the corrosion potential due to oxygen differentials in the soil layers. We again reached out to others to determine if this was an acceptable practice. We engaged Mott McDonald and two New England LDC's who all reported that when suitable backfill material is present in the bottom of the trench, it is acceptable and common to put the pipe on the bottom of the trench. Today (7/1) at 2pm, we discussed this with ARK engineering to understand the corrosion aspect of oxygen concentration. We reviewed the report (Bushman & Associates, Inc.) provided by Mr. McCauley and find it does walk through various corrosion mechanisms including Galvonic Corrosion, Oxygen concentration corrosion, and Corrosion caused by dissimilar soils. Further it states "corrosion can be caused due to differences in the electrolyte. These differences may be in the soil resistivity, oxygen concentration, moisture content, and various ion concentrations". The next section of the report details corrosion control mechanisms including coating pipe and cathotic protection.

Corrosion is a factor that we work to minimize on a pipeline. Corrosion can occur from oxygen concentrations at the change of soil from one geologic area to another, from an HDD to open trenching, and from moving through wetlands not only due to soil changes but due to the added moisture content of the soil. We cannot eliminate every risk of corrosion, which is why we utilize the corrosion control mechanisms listed in the Bushman report including pipe coating, cathotic protection, and compacting backfill with native soil in minimizing oxygen concentration corrosion.

Our research shows that placement of cathotically protected coated steel pipe on the bottom of a trench with suitable backfill material (no sharps, etc) is an accepted practice in the natural gas industry from a mechanical and corrosion perspective. The Bushman concludes with "When a system is designed, installed, and maintained properly, cathotic protection is one of the most effective and economical methods of preventing corrosion". With the evaluation complete, we have submitted an RFI to our engineer to officially clarify the spec and its allowance for the placement of the pipe at the bottom of a trench when suitable backfill material is present.

Induced voltage – On 6/21 we again discussed managing induced voltage. We both had been trying to get a Velco procedure to manage induced voltage. In the meantime, Michels implemented their standard management approach to induced voltage including daily measuring and installing grounding rods. We were also asked about the qualifications of the Michels safety individual who was managing the induced voltage program. During the week of 6/21 we developed a formal Michels procedure, provided a summary of the readings for the project, and the resume of the Michels regional safety manager. All readings from the start of the project were substantially below the recommended level of 15 volts. On 6/28, we provided the written procedure and asked for comments. We also agreed to provide additional information regarding the Michels safety person for Induced voltage. We reached out to Ark Engineering, two New England LDC's, and our own NACE 2 CP tech to learn about managing induced voltage on a shared ROW. We learned a procedure should be in place, testing and training should be required, and grounding installed to manage induced voltage. We learned that there is no industry certification for induced voltage and the NACE CP certifications only briefly covers induced voltage. Our research indicated that an individual with actual experience managing induced voltage on a pipeline project should be used to manage the induced voltage program. During our conversation with ARK engineering, we asked them to audit our procedure and give feedback on how we can improve the procedure. We provided the procedure to ARK on 7/1. Ark Engineering is the entity that designed the cathotic protection system for the pipeline and did an induced voltage survey of the Velco line when designing the system. We continue to be open to suggestions and ways to improve the management of induced voltage.

I am still working on the information on the Michels regional safety manager and hope to have that for you on Tuesday.

Please let me know if you have any questions.
John

EVALUATION REPORT OF GAS PIPELINE & COMPRESSOR STATION CONSTRUCTION

.301		CONSTRUCTION REQUIREMENTS	S	U	N/A	N/C
	.303	Are comprehensive written construction specifications available and adhered to?		X[6]		
	.305	Are inspections performed to check adherence to the construction specifications?	X			
	.307	Is material being visually inspected at the site of installation to insure against damage that could impair its serviceability?	X			
	.309(a)	Are any defects or damage that impairs the serviceability of a length of steel pipe such as [illegible] gouge, dent, groove, or arc burn repaired or removed?	X			
	.309(c)	If repairs are made by grinding, is the remaining wall thickness in conformance with the tolerances in the pipe manufacturing specifications or the nominal wall thickness required for the design pressure of the pipe?	X			
	.313(b)	If a circumferential weld is permanently deformed during bending, is the weld nondestructively tested?			X	
	.319(a)	**When pipe is placed in the ditch, is it installed so as to fit the ditch, minimize stresses, and protect the pipe coating from damage?**		X		
	.319(b)	Does backfill provide firm support under the pipe and is the ditch backfilled in a manner that prevents damage to the pipe and coating from equipment or the backfill material?	X			
	.461(c)	External protective coating is inspected (by jeeping, etc.) prior to lowering the pipe into the ditch. Coating damage repaired, as required.	X			
	.325(a)	Is there **12 inches** clearance between [illegible] line and any other underground structure? If **12 inches** cannot be attained, are ad[illegible] made to protect the pipeline from damage that could result from the pro[illegible]ity of the other structure?	X			
	.327(a)	▪ **Is pipe in a Class 1 location installe[illegible]h 30 inches [illegible] normal soil, or 24 inches of cover in consolidated rock[illegible]**	X			
		▪ **Is pipe in Class 2, 3, and 4 locations, dr[illegible]ge d[illegible]s of public roads and railroad crossings, in[illegible] 36 inches of co[illegible]mal soil or 24 inches of cover in consolida[illegible]**	X			
		▪ Does [illegible]stalled in a [illegible]or harbor have [illegible]nches of cover in **soil** or **24 inches** of co[illegible]**onsolidated r[illegible]**	X			
		▪ [illegible] above cover can[illegible] attained, is additi[illegible]protection provided to withstand [illegible]ated external [illegible]			X	
	.328	If the [illegible]e will [illegible] MAOP standard calculated under 192.620 (80% S[illegible] Attachment 1 for additional construction requirements				

Comments:
04/28/2016 [illegible]ld observing [illegible] clearing [illegible]HDD sites from Williston to Middlebury. 05/20/16, In Williston Pipe Yard observed
contract[illegible]ving and restacking [illegible] saw nu[illegible] blue ribbon marked pipe within pile (blue ribbon indicates segregated). 5/24/16
Insp[illegible] at New Haven Pipe Y[illegible]/27/16 Inspection at New Haven Pipe Yard observed inspectors document heat numbers and
phys[illegible] inspecting pipe. Numer[illegible] coating with ineffective patches segregated. 6/3/16 PCM and line locating with ARK
Enginee[illegible]/7/16 Pipe stringing a[illegible]elding Hurricane lane. 6/8/16 Close Interval Survey Colchester launcher to Mill Pond Road.
6/14/16 o[illegible] bending and string[illegible] operations off of Rt 2A. Observed stringing prior to trench excavation outside of VGS
specification [illegible]3 36(b) . 6/15/1[illegible]bserved disbanding factory applied patch, had Chief Coating Inspector Ryan Schaefer conduct
peel test- FAILE[illegible]served a[illegible]tion of Canusa shrink sleeve. 6/16/16 observed mill defect on pipe, refered to CWI D. Love. At
kick off Williston s[illegible] obs[illegible] pipe being laid directly on trench bottom in non compliance with VGS Specification 312333
3.5(B) . Referred to [illegible]n and D. Crandall. 6/17/16 met with VELCO employee regarding induced current on pipe.
6/23/16 met with GC Mo[illegible] regarding AC mitigation. 6?24/16 Stringing at 941+00 numerous non compliance issues regarding
induced current. 7/1/1. Berms not approved, refered to Chris LaForce.6 at Sta. 680+00 sandbags and berms being used for pipe
supports. 7/2/16 Sta.691+29 lowering in of 1770 ft section. 7/7/16 Observed lowering In operation between 686+50 and 776+00
pipe supported throughout by sandbags and padding. 7/8/16 Observed backfilling at Williston Sbstation. Once again noted pipe
directly on bottom of ditch. Notified D. Crandall who advised that pipe was lowered in before directive from CHA engineering.
7/9/16 at Hurricane Lane tie in observed trench box resting on pipe, notified inspector Tom Modeen. Also put in request for
information regarding field bend at tie in, was advised 11 degree overbend. Inspection of HDD at Route 7 Middlebury and Town
Hill road. 7/13/16 Notified Michels, Hatch Mott and VGS of unbonded pipe segment at 930+00, 19.38 volts. 7/14/16 At HDD
Town Hill Road pullback completed. 7/15/16 witness lowering in at Sta. 858+00. Witness backfilling at Sta. 848+00. At Sta.

Comments:
1149+00 observed bond wire off pipe string, 35.90 volts. Notified foreman and crew as well as company notifications. 7/20/16 Observed lowering in at Williston station. 7/22/16 Inspection of HDD at 'Dragon Bore" in Middlebury.7/25/16 Lowering in at 842+00. 7/26/16 Observed lowering in at 777+80. Met with Chief Inspector Darrel Crandall regarding pipe mill anomalies and rejection criteria. Inspected NDT technician 1179+00 and rebeveling of pipe with internal mill defect. 7/28/16 observed durometer readings on Wrapid wrap coatings at 2164+25. 7/29/16 Lowering in at 800+00. 8/1/16 HDD inspection at Dragon Bore". 8/2/16 Inspection of anomaly crew at 1741+00. 8/3/16 observed installation of trench breakers at 814+83. 8/3/16 Inspection at Lewis Creek bore. 8/4/16 HDD at Lewis Creek 18" back reamer. 8/8/16 Monkton Swamp Bore. 8/9/16 Monkton Swamp pullback, coating damages observed. 8/10/16 pulled more pipe through at Monkton Swamp observed final 16' no through coating damage. 8/11/16 observed pullback at Lewis Creek bore, pipe in very good condition. 8/11/16 Lowering in at 1537+50. 8/12/16 excavating and padding on Old Stage Road. 8/15/16 observed installation of Trench Breakers, also reported to inspector need sand bags under overbend at 1549+00. 8/23/16 1115+00 Baldwin Road crossing. 8/23/16 at Station 2087+00 with ndt crew on mill defects. 8/24/16 Baldwin road tie in. 8/24/16 lowering in at 1680+00. 8/26-27/16 tie in at 753+90. 9/3/16 tie in at 1635+50. 9/6/16 Lowering in at 1412+00. 9/6/16 dewatering and padding at 2093+00. 9/8/16 reaming at 1390 +00 (peyser). 9/8/16 Tie in crew excavating at 1987+00. 9/20/16 enduro caliper pig run. 9/24/16 drying operation in process, receive pigs at 967+50. 9/24/16 tie in at 1669+50. 9/27/16 drying at 967+50. 9/28-29/16 field audit of fittings and valves. [illegible]/16 tie in at mlv2. 10/6/16 Williston Station tie in. 10/7/16 gas up to MLV 2 and then to terminus before Geprags. 10/12/16 lowering in at 379+00. 10/19/16 Audit MTRs for mainline valves. 10/19/16 NewHaven reg station dewatering. 10/20/16 conduct audit of Michels op qual identity of employees.

.451		CORROSION REQUIREMENTS	S	U	N/A	N/C
	.455(a)	(1) Does the pipeline have an effective external coating and does it meet the coating specifications?	X			
		(2) Is a cathodic protection system installed or being provided for?	X			
	.471(a)	Are test leads mechanically secure and electrically conductive?	X			
	.471(b)	Are test leads attached to the pipe by cadwelding or other means so as to minimize stress concentration on the pipe?	X			
	.471(c)	Are bare test leads and the connections to the pipe coated?	X			
	.476	Systems designed to reduce internal corrosion (a) New construction	X			
		(b) Exceptions – offshore pipelines and systems replaced before 5/23/07			X	
		(c) Evaluate changes to existing systems			X	

Comments:
4/27/16 Review VGS and ARK engineering reports on CP for Phase 1. 6/13/16 Coating application inspection R-95 coating @ Hurricane Lane. [illegible] DCVG survey with ARK engineering. 6/29/16 Mill coated repair anomalies observed Sta. 642+50. Lowering in at [illegible] and select backfill. 6/30/16 observed a butyl tape repair on top of a mill applied shrinck sleeve. Referred to [illegible]haefer. Also informed that application temperature over 115F are prohibited as per Denso specifications. 7/6/16 At Sta. 875+[illegible] observed 13 coating damages in 11 ft, appears to be from bending machine. 7/7/16 met with bending engineer at 1101+50, was advised that shoes had been adjusted and lubricant of water and soap was being applied during bending. Also try to make close radius bends in morning before heat. [illegible]/16 met with M. Reagan and D. Crandall regarding peel and adhesion tests. Sta.2067+00 observed coating application of Protol [illegible]. 7/12/16 observed numerous jeeps on protol coating near Sta. 863+50. Notified coating inspector. Sta. [illegible]+00 witnessed installation of zinc ribbon, CAD welding and field splice for AC mitigation. 7/27/16 coating inspection at 12[illegible] canusa sleeve application. 8/3/16 observed installation of zinc ribbon at 815+00. 8/4/16 Zinc ribbon installation 892+00. 8/4/16 Coating inspection [illegible]23+00. 8/20/16 coating inspections at Sta. 1116+00, replacing previous coatings due to peel test failure. 8/20/16 dewatering at [illegible]3+00. 8?25/16 inspection of coating at Quarry Road crossing. 8/26/16 had Chief inspector meet me at Baldwin road. Installation of four wire test station not in compliance with specification. Chief ordered repair. 10/6/16 zinc ribbon installation at 2080+[illegible]. 10/11/16 inspection of test station and ac mitigation MLV2.

.501		TESTING REQUIREMENTS	S	U	N/A	N/C
	.503(a)	(1) Is a hydrostatic pressure test planned to substantiate the MAOP?	X			
		(2) If the pipeline has been hydrostatically tested, have all potentially hazardous leaks been located and eliminated?	X			
	.505(a)	▪ Is there a specified hydrostatic pressure testing procedure?	X			

From : Morris, GC <GC.Morris@vermont.gov>
Subject : VGS ANGP discussion
To : Porter, James <James.Porter@vermont.gov

Mon, Aug 07, 2017 02:22 PM

Jim,

A VGS ANGP topic for our discussion:

Identify/Tabulate existing pipeline segments without support as specified (For analysis, Dave Berger needs, for each specific location, soil type, soil resistivity and coating type)

See Reference(s):VGS ANGP QA QC Summary, 12/21/2015, tab 8, (segments not identified) and

See VGS Memorandum, ANGP QA QC Executive Summary, Oct. 4, 2016, (4 segments identified)

See Memorandum, ANGP Pipe Laid on Trench Bottom, June 6, 2017, (6 segments identified, 2 of which comprise one segment referenced in memo above)

Plus segments installed by sink-in swamp-method including:

New Haven, Wetland buffer

Monkton, Red Maple Green Ash Swamp

Installation Date	Station From	Station To	Physical installation, out-of-spec.			soil type	soil resistivity	coating type	
			Sand Berms	Pipe on the Ground	Other ?			Pipe mill coating	Girth-weld, field-coating
8/31/2015	240+26	279+75		x					
6/17/2016	564+24	567+84		x(clay)					
6/18/2016	889+74	892+11	x						

6/21/2016	888+38	889+74	x						
6/28/2016	863+62	864+55	x						
7/5/2016	663+00	664+50	x						
9/3/2016	Approximately 1635+00		(removal of adjacent ground material allowed concrete coated pipe to sink-in)	(swamp, wetland buffer)					
Approximately 9/18/2016	Appox.1642+00	Appox.1666+00	(sink-in)	(swamp)					
Other?									

GC Morris Gas Engineer Vermont Dept. of Public Service 112 State St. Montpelier, VT 05620-2601 802-828-4073

Vermont Gas

Addison Natural Gas Project

Phase I

ML-DAILY INSPECTOR REPORT

Section I - Colchester to Williston

Section: 1

Date: 9/9/2014

Report: 62

W.O.:

Inspector: J.R.Kelch

Contractor: Over and Under

Super/Foreman: Fred Robinson

Weather/Temp: sunny 46-76

County/Town: Williston

JSA Topic: wear ppe

Final Report: ☑ No ☐ Yes

Item	Activity	Insp	Station From	Station To	Footage Today	Footage to Date
	Pre-Const Survey/Video	☐	0	0	0	0
	ECD Installation	☑				
	Temp Fencing/Gates	☐	0	0	0	0
	Clearing and Grubbing	☐				0
	Grading	☐	0	0	0	0
	Machine Trenching	☐	0	0	0	0
	Excavator Trenching	☑				0
	Rock Removal-Mechanical	☐		0	0	0
	Rock Removal-Blasting	☐	0	0	0	0
	Loading and Hauling Soils	☐	0	0	0	0
	Hauling and Stringing	☐	0	0	0	0
	Bending and Setup	☐	0	0	0	0
	Lowering In	☑	189+86	191+06	120'	0
	Welding	☐	0	0	0	0
	Welding-Tie-in	☐	0	0	0	0
	Welding-Tie-in-Final	☐	0	0	0	0
	NDT	☐	0	0	0	0
	Coating-Below Ground	☐	0	0	0	0
	Coating-Above Ground	☐	0	0	0	0
	CP-Zinc Ribbon	☐	0	0	0	0
	CP-Anodes	☐	0	0	0	0
	Padding and Compaction	☐				0
	Backfill	☐				
	Permanent Fencing/Gates	☐	0	0		0
	Clean-up Rough	☐	0	0	0	0
	Clean-up Final	☐	0	0	0	0
	Road Crossing Cased	☐	0	0	0	0
	Road Crossing Uncased	☐	0	0	0	0
	Boring	☐	0	0	0	0
	HDD-Pilot Hole	☐	0	0	0	0
	HDD-Reaming	☐	0	0	0	0
	HDD-Pullback	☐	0	0	0	0
	HDD-Hydro-Aboveground	☐	0	0	0	0
	HDD-Hydro-Belowground	☐	0	0	0	0
	Hydrotest-Final	☐	0	0	0	0
	Drying	☐	0	0	0	0
	Pigging	☐	0	0	0	0
	Drain Tile Repair	☐	0	0	0	0
	Road Cleaning	☐	0	0	0	0
	Pipe Offload and Tally	☐			0	0

WORK DETAILS/COMMENTS

Mikes crew lowered in from sta 189+86 to 191+06 and from sta 193+69 to 194+89 for a total of 240' today, all pritec pipe.
Ed's crew trenched from sta 552+30 to 552+90,then lowered in and welded 60' joint of concrete coated pipe. Crew then started excavating for next joint of pipe.
The environmental crew worked on putting up silt fence on hwy 289,sta 262+00 area.
Cook clearing returned today to hwy 289 sta 346+00 and unloaded feller buncher using ADA flaggers on entry ramp to hwy 289 and started cutting trees.
Over and Under also had an operator hammering rock around sta 171+00. Could not witness all activities today with 5 crews. Stayed longer with both crews lowering in pipe, one on hwy 2 and the other on hwy 289 behind Mobil station at sta 189+00 area.

ECDs and PAY ITEMS (Pay items shown in yellow)

	Item	UOM	Start Sta.	End Sta.	Today	To Date
	Silt Fence	LF				0
	Silt Soxx	LF	0	0	0	0
	Wood Chips	LF	0	0	0	0
	Super Silt Fence (reinforced)	LF	261+00	264+00	300'	
	Safety Fence	LF	0	0	0	0
	Geotech	SY	0	0	0	0
	Straw Bales	BALE	0	0	0	0
	Temp Culvert w/crushed stone	EACH	0	0	0	0
	Temp Culvert w/o crushed stone	EACH	0	0	0	0
	Timber Mats	LF	0	0	0	0
	Winter Stabilization	ACRE	0	0	0	0
	Trench Breakers	EACH		0		0
	Pipe Sacks/Saddlebags	EACH	0	0	0	0
	Select Fill/Sand	LOAD	0	0	0	0
	Concrete Coated Pipe	LF	552+30	552+90	60'	0
	Rock Haul Away	LOAD	0	0	0	0
	Stabilized Construction Entrance	CU FT	0	0		
	Mat Cleaning	EACH	0	0	0	0
	Wash Stations	EACH	0	0	0	0

Welding and X-rays

Rejected Welds

	Weld Count	Rejected	Reject Rate	Reject Repaired	Reject Balance	Reject Cut Out
Today	0	0	0%	0	0	0
To Date	0	0	0%	0	0	0

	Rejected Welds: Cut Out for Engineering	Temporary Welds: Temporary Welds X-Rayed	Temporary Welds Cut Out	Balance	Total Welds Installed
Today	0	0	0	0	0
To Date	0	0	0	0	0

BORING

Location (station/road/railroad)	**Length** (pit face to pit face)	**Pipe** (length and type)

Safety Issues

Contractor Downtime	**Hours & Reason:**	

PUBLIC INTERACTION

Agency Visitors

Agency	Name	Number	Comments

Land Owner or Protestor Interaction (If protester request for information or landowner request or complaint direct them to Dave Walker, VGS RoW Manager, 802.951.0368 and provide his business card.)

Hrs Wkd:	10	Signature:	JR Kelch

CHANGE ORDER WORK | **Change Order Number:**

Time and Materials

Contractor Personnel

Item	Name	Position	Hours	Comments

Equipment

Item	Equipment	Rent	Own	Comments
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	
		☐	☐	

Materials

Item	Description	Quantity	Loc/Station #	Comments

Vermont Gas
Addison Natural Gas Project
Phase I

Vermont Gas
CLEAN ENERGY. CLEAN AIR.

HDD-Daily Inspector Report

Section I - Colchester to Williston

Date: 5/27/2015
Report: Phase1Sec1_EC46-2
W.O.: Phase 1 Sec 1
Inspector: Eric Curtis
Final Report: ☑ No ☐ Yes

Contractor: ECI
Super/Foreman: Mike Wright
Weather/Temp: Mostly cloudy, afternoon rain, 86 / 68
County/Town: Chittendon / Williston
JSA Topic: PPE

Item or Crew	HDD # and Name:	I-89, (596+10 to 605+48)				Estimated Length:	938
	PASS	Station From	Station To	Estimated Footage Today	Estimated Footage To Date	Estimated % of Completion	Comments
	Casing	0	0	0	0	0%	
	Pilot Hole	0	0	0	0	0%	
	First Ream	0	0	0	0	0%	
	Second Ream	0	0	0	0	0%	
	Third Ream	0	0	0	0	0%	
	Fourth Ream	0	0	0	0	0%	
	Swab	0	0	0	0	0%	
	Pull Back	0	0	0	0	0%	
	Other	0	0	0	0	0%	
	Other	0	0	0	0	0%	

ECDs and PAY ITEMS (Pay items shown in yellow)

	Item	UOM	Start Sta.	End Sta.	Today	To Date	
	Silt Fence	LF	0	0	0	45	
	Silt Soxx	LF	0	0	0	0	
	Wood Chips	LF	0	0	0	0	
	Super Silt Fence	LF	0	0	0	0	
	Safety Fence	LF	0	0	0	0	
	Geotech	SY	0	0	0	0	
	Straw Bales	EA	0	0	0	0	
	Temp Culvert w/crush.stone	EA	0	0	0	0	
	Temp Culvert	EA	0	0	0	0	
	Timber Mats	LF	0	0	0	0	
	Winter Stabilization	AC	0	0	0	0	
	Trench Breakers	EA	0	0	0	0	
	Pipe Sacks/Saddlebags	EA	0	0	0	0	
	Select Fill/Sand	LOAD	0	0	0	0	
	Concrete Coated Pipe	LF	0	0	0	0	
	Rock Haul Away	LOAD	0	0	0	0	
	Stabilized Const Entrance	CU FT	0	0	0	0	
	Cleaning Mats	EA	0	0	0	0	
	Wash Stations	EA	0	0	0	0	

COMMENTS

Welding and X-rays

	Rejected Welds						
	Weld Count	Rejected	Reject Rate	Reject Repaired	Reject Balance	Reject Cut Out	Cut Out for Engineering
Today	0	0	0%	0	0	0	0
To Date	0	0	0%	0	0	0	0

	Temporary Welds				
	Temporary Welds X-Rayed	Temporary Welds Cut Out	Balance	Total Welds Installed	Comments
Today	0	0	0	0	
To Date	0	0	0	0	

WORK DETAILS/COMMENTS

Crew bagan preparing the work site and mobilizing equipment in to resume with the drilling and installation of pipe under I-89. The ditch witch JT100 drill rig and deere 160 excavator were delivered to the site. All brush and debris left from clearing was pushed into a pile then loaded into a dump truck and hauled away. The ATWS was graded. Large rocks were relocated to a central location and piled into a row along the east side of the ATWS. The ATWS was seeded and fertilized. Erosion matting was installed over the site and silt fence was installed along the ditch line parallelling Hurricane Ln. Crew plans on resuming work tomorrow (5/28/2015).

Safety Issues

Contractor Downtime

Hours/Reason:	

PUBLIC INTERACTION

Agency Visitors

Agency	Contact Name	Number	Comments

Land Owner or Protestor Interaction: (if protester request for information or landowner request or complaint direct them to Dave Walker, VGS RoW Manager, 802.951.0368 and provide his business card)

Hours Worked:	10	Signature:	*Eric Curtis*
CHANGE ORDER WORK		Change Order Number:	

Vermont Gas

Addison Natural Gas Project Phase I

ML-Daily Inspector Report

Section 1 - Colchester To Williston

Section:	Phase 1	Contractor:	Michels
Date:	8/27/2015	Super/Foreman:	Johnny Kroner/Randy Carrillo
Report:	08/27/2015_Phase1_ML_IDCR_JB27	Weather/Temp:	72/53 Cloudy
Location:	Route 289	County/Town:	Chittenden/Essex Junction
Inspector:	Jim Barton	JSA Topic:	Pinch points , Awareness , PPE

Item	Activity	Insp	Station From	Station To	Footage Today	Footage to Date
	Clearing and Grubbing	☐				
	Pot Hole	☐				
	Grading	☐				
	Stringing	☑	301+00	298+00	300	2400
	Bending	☐				
	Set-up	☐				
	Trenching	☑	299+00	291+00	800	2300
	Blasting	☐				
	Welding	☐				
	Welding Tie-In	☐				
	NDT	☐				
	Coating-Above Ground	☐				
	Coating-Below Ground	☐				
	Lowering In	☑	301+00	298+00	300	1800
	Padding	☑	301+00	298+00	300	900
	Backfill	☑	302+00	300+00	200	800
	CP-Anodes	☐				
	CP-Zinc Ribbon	☐				
	Test Leads	☐				
	Seeding	☐				
	ECD Installation	☐				
	Clean-up Rough	☐				
	Clean-up Final	☐				
	Restoration	☐				
	Temp Fencing/Gates	☐				
	Perm Fencing/Gates	☐				
	Road Crossing UnCased	☐				
	Boring	☐				
	Hydro-Aboveground	☐				
	Hydro-Belowground	☐				
	Hydrotest-Final	☐				
	Drying	☐				
	Pigging	☐				
	Drain Tile Repair	☐				
	Pipe Offload	☐				
	Pipe Tally	☐				
	Other	☐				
	Other	☐				
	Other	☐				

WORK DETAILS/COMMENTS

(1)Working out at Rt.289 we had our JSA meeting where I talked to everyone about the size of stones allowed in the ditch.(2)We strung pipe at 301+00 back to 298+00 then lowered it in , padded and backfilled it .(3)We trenched 800 Ft. of ditch today starting at 299+00 to 291+00 .(4)Built in two Trenchbreakers one each at 302+18 and 300+50 .

BORING

Location (station/road/railroad)	**Length** (pit face to pit face)	**Pipe** (length and type)

Safety Issues

James L Barton	**Signature:J L Barton**	**12**

Vermont Gas

Addison Natural Gas Project Phase I

ML-Daily Inspector Report

Section 1 - Colchester To Williston

Section: Addison Natural Gas Project Phase 1
Date: 8/27/2015
Report: 08272015_Phase1_ML_IDCR_JK_39
Location: Hwy 289 st 315+00 to 308+00 and 27+00 to 36+00
Inspector: J.R.Kelch

Contractor: Michels
Super/Foreman: Don Hargraves/ Ruben Carrillo
Weather/Temp: sunny 63/75
County/Town: Chittiden/Essex
JSA Topic: stay hydrated

Item	Activity	Insp	Station From	Station To	Footage Today	Footage to Date
	Clearing and Grubbing	☐				
	Pot Hole	☐				
	Grading	☑	84+97	109+00	2403'	13279'
	Stringing	☐				
	Bending	☐				
	Set-up	☐				
	Trenching	☑				1454'
	Blasting	☐				
	Welding	☐				
	Welding Tie-In	☐				
	NDT	☐				
	Coating-Above Ground	☐				
	Coating-Below Ground	☐				
	Lowering In	☑				1446'
	Padding	☑	315+50	308+00	750'	1449'
	Backfill	☑	315+50	308+00	750'	1449'
	CP-Anodes	☐				
	CP-Zinc Ribbon	☐				
	Test Leads	☐				
	Seeding	☐				
	ECD Installation	☐				
	Clean-up Rough	☐				
	Clean-up Final	☐				
	Restoration	☐				
	Temp Fencing/Gates	☐				
	Perm Fencing/Gates	☐				
	Road Crossing UnCased	☐				
	Boring	☐				
	Hydro-Aboveground	☐				
	Hydro-Belowground	☐				
	Hydrotest-Final	☐				
	Drying	☐				
	Pigging	☐				
	Drain Tile Repair	☐				
	Pipe Offload	☐				
	Pipe Tally	☐				
	Other	☐				
	Other	☐				
	Other	☐				

WORK DETAILS/COMMENTS

Grade crew finished skip area at st 282+00 then moved 2 hoes and 2 dozers to st 36+00 to grade back to st 27+00. Crew completed footage at stations listed above.They moved in 24 matts and used 100' of geotex. Crew bushogged st 115+00 area in the extra work space 280'x240'. The composite crew 2 padded and backfilled stations listed above and helped composite crew 1 with trenching and setting up to weld pipe for the rest of the day.

BORING

Location (station/road/railroad)	**Length** (pit face to pit face)	**Pipe** (length and type)

Safety Issues

Inspector's Name:Johnnie Kelch | **Signature:J.R.Kelch** | **11**

QAQC Checklist (Procedure # VGS-110-2, Inspection of New Transmission Facilities)		
	Yes	**No**
Did ABNORMAL working conditions adversely affect construction progress?	☐	☑
Crews affected by adverse weather, right-of-.way or other working conditions?	☐	☑
Any Contractor caused delays, down time or other reduced progress?	☐	☑

If Yes, explain Below in the COMMENTS SECTION

TRENCHING, LOWERING IN & BACKFILLING Inspector's Checklist

Complete all question below and provide an explaination in the comments section below for all R or U values.

A= Acceptable/ R=Acceptable Re-Inspection/U=Unacceptable/N/A=Non applicable

1. Digsafe notified per Sec. 312333, Part 1, Subpart 1.4, Sentence A?	☑ A	☐ R	☐ U	☐ N/A
2. Existing utilities located per Sec.312333, Part 1, Subpart 1.4, Sentence E, Item 3?	☑ A	☐ R	☐ U	☐ N/A
3. Line list/landowner agreements satisfied?	☑ A	☐ R	☐ U	☐ N/A
4. Trenching completed in a manner providing uniform pipe support consistent with Sec. 312333, Subpart 3.3?	☑ A	☐ R	☐ U	☐ N/A
5. Pipe jeeped prior to lowering in/submerging per Sec. 138000?	☑ A	☐ R	☐ U	☐ N/A
6. Holiday, if any, repaired per Sec. 138000?	☑ A	☐ R	☐ U	☐ N/A
7. Pipe installed in ditch in a manner as to minimize undo stress per 312333?	☑ A	☐ R	☐ U	☑ N/A

For all Rs and Us, explain Below in the COMMENTS SECTION

Hours	Name	Position	Hours	Equipment
	Michels Crew			
10	Don Hargraves	foreman	10	komatzu 220 excavator
10	Jarod Gorham	straw	10	cat d-6 dozer
10	Carl Gagnon	laborer	10	komatzu 240 excavator
10	Ryan Mugford	laborer	10	cat d-6 dozer
10	Colt Hendrix	operator	10	skid steer with bush hog attachment
10	Toby Rumbles	operator		
10	Bob Mcquire	operator		
10	Derrick York	operator		
10	Luke Derby	operator		
11	Ruben Carrillo	foreman	11	kamatzu 220 excavator
11	Ruben Carrillo jr	oiler	0	cat d-6 dozer
11	Martin Salinas	straw	0	cat side boom
11	Haven Mcneil	operator	11	kamatzu 220 excavator
11	Roger Hinojosa	laborer		
11	John Maltbie	operator		
11	Lou Chaisson	laborer		
11	John Cabrera	laborer		

Signature:J.R. Kelch	Inspector's Name:Johnnie Kelch	Date:8/27/15

<u>References:</u>

Technical Specification
Vermont Agency of Transportation, Standard Specification for Construction
Vtrans Standard 704.08A “Granular Backfill for Structures”
ANGP drawing set
Part 192 Subpart G-General Construction Requirements for Transmission Lines and Mains-Installation of Pipe in a Ditch.
Standard Specifications for Highway Materials and Methods of Sampling and Testing American Association of State Highway and

S D Ireland Concrete Construction Corporation
PO Box 2286
South Burlington VT 05407-2286

INVOICE

Invoice #:	56618
Date:	7/20/16
Customer No:	3611

Sold To:

MICHELS CORPORATION
PO BOX 128, 817 W. MAIN STREET
BROWNSVILLE, WI 53006-0128

Delivered To:

LINCOLN RD- ST GEORGE -

30 Pay Terms Net 30

Total: **2,022.30**

JOB # / PO # / 61103	Ticket	UM	Unit Price	Material Total	Tax	Line Total
COMM FLOWABLE FILL	19119917	18.000 CY	105.0000E	1,890.00	132.30 WVT	2,022.30
Total :			1,890.00	0.00	132.30	2,022.30
Total Invoice:			1,890.00	0.00	132.30	2,022.30

PLEASE REMIT TOP PORTION OF INVOICE WITH PAYMENT

2022.30 201/4100

61103 Cody Vincent

Payment Type: On Account

30 Pay Terms Net 30	**Total:**	**2,022.30**

North Middlebury Sand & Gravel

1555 Burpee Road
Bristol, Vermont 05443

Alan 802-349-7439

Invoice

DATE	INVOICE NO.
10/31/2016	7796C

BILL TO
Michels Pipeline Construction PO Box 128 817 West Main Street Brownsville, WI 53006

1105.58 201|4110

6163

Cody Vincent

TERMS

DATE	SLIP #	YARDS	DESCRIPTION	RATE	AMOUNT
10/5	2122	14	Screened Sand	9.50	133.00T
10/31	12771	28	topsoil	23.00	644.00T
10/27	12614	14	3/4" crushed gravel	9.50	133.00T
10/27	12637	14	1 1/2" Crushed Gravel	9.50	133.00T
			Sales Tax	6.00%	62.58

Payments/Credits $0.00

Total Due $1,105.58

S D Ireland Concrete Construction Corporation
PO Box 2286
South Burlington VT 05407-2286

INVOICE

Invoice #:	55718
Date:	6/22/16
Customer No:	3611

Sold To:

MICHELS CORPORATION
PO BOX 128, 817 W. MAIN STREET
BROWNSVILLE, WI 53006-0128

Delivered To:

RT.2A - ST.GEORGE -

30 Pay Terms Net 30

Total: **2,696.40**

JOB # / PO # / 61103	Ticket	UM	Unit Price	Material Total	Tax	Line Total
COMM FLOWABLE FILL	19118066	24 000 CY	105.0000E	2,520.00	176.40 WVT	2,696.40
Total :			2,520.00	0.00	176.40	2,696.40
	Total Invoice:		2,520.00	0.00	176.40	2,696.40

PLEASE REMIT TOP PORTION OF INVOICE WITH PAYMENT

Amount	Job #	CC
2696.40	201/4100	
Cody Vincent		
61103		Date:
Approved:		

Payment Type: On Account

30 Pay Terms Net 30 Total: 2,696.40

SCANNED

1853 Mountain Road
Bristol, VT 05443

Invoice

Date	Invoice #
8/8/2016	8377

To

Michels Pipeline Construction
PO Box 128
817 West Main Street
Brownsville, WI 53006

Hours	Yard(s)	Load(s)	Description	Amount
			6/25-7/31	
227.25			Truck @$80/hour	18,180.00
	126		Barn Sand (601.02+10%)	661.12

Thank you for your business.
1.5% Interest will be charged monthly after 30 days.

Total $18,841.12

Fax # 802-453-3388 acker6@gmavt.net

S D Ireland Concrete Construction Corporation
PO Box 2286
South Burlington VT 05407-2286

INVOICE

Invoice #:	57454
Date:	8/18/16
Customer No:	3611

Sold To:

MICHELS CORPORATION
PO BOX 128, 817 W. MAIN STREET
BROWNSVILLE, WI 53006-0128

Delivered To:

BALDWIN RD -

30 Pay Terms Net 30

Total: 8,013.60

JOB # / PO # /61103	Ticket	UM	Unit Price	Material Total	Tax 6%	Line Total
COMM FLOWABLE FILL	19121856	72 000 CY	105 0000E	7,560 00	453.60 VT	8,013 60
Total:			7,560.00	0.00	453.60	8,013.60
	Total Invoice:		7,560.00	0.00	453.60	8,013.60

PLEASE REMIT TOP PORTION OF INVOICE WITH PAYMENT

Double Sales Tax

Payment Type: On Account

30 Pay Terms Net 30	Total:	8,013.60

S D Ireland Concrete Construction Corporation
PO Box 2286
South Burlington VT 05407-2286

INVOICE

Invoice #:	57486
Date:	8/19/16
Customer No:	3611

Sold To:

MICHELS CORPORATION
PO BOX 128, 817 W. MAIN STREET
BROWNSVILLE, WI 53006-0128

Delivered To:

ROTAX RD -

30 Pay Terms Net 30

Total: 5,008.50

JOB # / PO # / FLOW	Ticket	UM	Unit Price	Material Total	Tax	Line Total
1 HR RETARDER/ HYDRATION STABILIZER	19121985	22.500 CY.	0.0000E	0.00	0.00 VT	0.00
COMM FLOWABLE FILL	19121985	9.000 CY	105.0000E	945.00	56.70 VT	1,001.70
1 HR RETARDER/ HYDRATION STABILIZER	19121958	100.120 CY.	0.0000E	0.00	0.00 VT	0.00
COMM FLOWABLE FILL	19121958	36.000 CY	105.0000E	3,780.00	226.80 VT	4,006.80
Total:			4,725.00	0.00	283.50	5,008.50
Total Invoice:			4,725.00	0.00	283.50	5,008.50

PLEASE REMIT TOP PORTION OF INVOICE WITH PAYMENT

why pay
tax twice(?).

Payment Type: On Account

30 Pay Terms Net 30 **Total:** 5,008.50

S D Ireland Concrete Construction Corporation
PO Box 2286
South Burlington VT 05407-2286

INVOICE

Invoice #:	57638
Date:	8/24/15
Customer No:	3611

Sold To:

MICHELS CORPORATION
PO BOX 128, 817 W. MAIN STREET
BROWNSVILLE, WI 53006-0128

Delivered To:

OLD STAGE RD -

30 Pay Terms Net 30

Total: 3,005.10

JOB # / PO # / MONKTON	Ticket	UM	Unit Price	Material Total	Tax	Line Total
COMM FLOWABLE FILL	19122312	27.000 CY	105.0000E	2,835.00	170.10 VT	3,005.10
Total :			2,835.00	0.00	170.10	3,005.10
Total Invoice:			2,835.00	0.00	170.10	3,005.10

PLEASE REMIT TOP PORTION OF INVOICE WITH PAYMENT

double sales tax

Payment Type: On Account

30 Pay Terms Net 30 | Total: 3,005.10

North Middlebury Sand & Gravel

1555 Burpee Road
Bristol, Vermont 05443

Alan 802-349-7439

Invoice

DATE	INVOICE NO
8/31/2016	7669C

BILL TO
Michels Pipeline Construction PO Box 128 817 West Main Street Brownsville, WI 53006

TERMS

DATE	SLIP #	YARDS	DESCRIPTION	RATE	AMOUNT
08/19	12218 ✓	56	3/4" crushed gravel	9.50	532.00T
08/19	12219 ✓	10	3/4" crushed gravel	9.50	95.00T
08/22	12221 ✓	14	1 1/2" Crushed Gravel	9.50	133.00T
08/22	12226	28	3/4" crushed gravel	9.50	266.00T
08/9	11823 ✓	28	Screened Sand	9.50	266.00T
08/26	2017 ✓	84	Screened Sand	9.50	798.00T
			Sales Tax	6.00%	125.40

2215.40 201/4165

6103 Cody Vincent

Payments/Credits	$0.00

Total Due	$2,215.40

North Middlebury Sand & Gravel

1555 Burpee Road
Bristol, Vermont 05443

Alan 802-349-7439

Invoice

DATE	INVOICE NO
8/31/2016	7670N

BILL TO
Michels Pipeline Construction PO Box 128 817 West Main Street Brownsville, WI 53006

TERMS

DATE	SLIP #	YARDS	DESCRIPTION	RATE	AMOUNT
08/22	12251	14	screened sand	9.00	126.00T
08/25	12260	14	topsoil	23.00	322.00T
			Sales Tax	7.00%	31.36

479.36 201/410

41103 Cody Vincent

Payments/Credits	$0.00

Total Due	$479.36

...SONS EXCAVATING & LANDSCAPING, INC.
...NGER INDUSTRIAL PARK, LLC
☑ RANGER ASPHALT & CONCRETE PROC., LLC

☑ Charge ☐ Paid Amt $ ________

Sold to: Michaels

1607 Malletts Bay Ave.
P.O. Box 96
Colchester, VT 05446
Phone: (802) 655-3976
Fax: (802) 655-1391

Date 9-2-16

Yardman Mike

TICKET # 136318

Disposal - In

		Qty
	Asphalt per yd	
	Concrete per yd	
	Concrete w/mesh per yd	
	Concrete w/rebar per yd	
✓	Fill-In per yd	13 yd
	Ledge/Rock per yd	
	Other:	
	Sorting Fee:	
	Oversize Fee:	

** All material must be separated.*
** Minimum Disposal Charge $20*

TOTAL ________

Material - Out

		Qty
	1" Minus Crushed Concrete per ton	
	1-1/2" Minus Crushed Concrete per ton	
	1" Minus Crushed Asphalt per ton	
	1" Plant Mix 704.05A per ton	
	1-1/2" Plant Mix 704.05A per ton	
	Woodchuck Dirt per ton	
	Topsoil per yd	
	Common Sand per ton	
	Mound Sand per ton	
	Bark Mulch per yd	
	Salt per ton	
	Other:	

SUB TOTAL ________
VT SALES TAX ________
TOTAL ________

Job ________

Driver Name [signature]

Net due 10 days. Interest at the rate of 1-1/2% per month, thereafter. All collection charges will be paid by purchaser including attorneys fees.

W.B. MASON (800) 242-5692

S D Ireland Concrete Construction Corporation
PO Box 2286
South Burlington VT 05407-2286

INVOICE

Invoice #:	57876
Date:	9/1/16
Customer No:	3611

Sold To:

MICHELS CORPORATION
PO BOX 128, 817 W. MAIN STREET
BROWNSVILLE, WI 53006-0128

Delivered To:

OLD STAGE RD -

30 Pay Terms Net 30

Total: **6,010.20**

670

JOB # / PO # / MONKTON	Ticket	UM	Unit Price	Material Total	Tax	Line Total
COMM FLOWABLE FILL	19122925	54.000 CY	105.0000E	5,670.00	340.20 VT	6,010.20
Total :			5,670.00	0.00	340.20	6,010.20
Total Invoice:			5,670.00	0.00	340.20	6,010.20

PLEASE REMIT TOP PORTION OF INVOICE WITH PAYMENT

ıyment Type: On Account

Pay Terms Net 30 — **Total:** **6,010.20**

North Middlebury Sand & Gravel

1555 Burpee Road
Bristol, Vermont 05443

Alan 802-349-7439

Invoice

DATE	INVOICE NO.
9/10/2016	7684C

BILL TO
Michels Pipeline Construction PO Box 128 817 West Main Street Brownsville, WI 53006

TERMS

DATE	SLIP #	YARDS	DESCRIPTION	RATE	AMOUNT
09/1	12334	14	1 1/2" Crushed Gravel	9.50	133.00T
09/2	12336 ✓	42	3/4" crushed gravel	9.50	399.00T
09/2	12338 ✓	28	3/4" crushed stone	12.50	350.00T
09/6	12344 ✓	28	1 1/2" Crushed Gravel	9.50	266.00T
		28	A stone	10.65	298.20T
09/6	12347 ✓	14	A stone	10.65	149.10T
09/7	12350 ✓	14	A stone	10.65	149.10T
09/7	2032 ✓	28	Screened Sand	9.50	266.00T
			Sales Tax	6.00%	120.62

} $2010.40 ✓

2131.02 201/4100

Cody Vincent

6/103 9/13

Payments/Credits $0.00

Total Due $2,131.02 ✓

Glass Bagging Enterprises, Inc.
P.O. Box 120
Duncansville, PA 16635
(814)693-6886

Invoice

Date	Invoice #
9/7/2016	37686

Bill To	Ship To
Michels Pipeline Co. P.O. Box 128 Brownsville, WI 53006	Williston, VT Staged in Starksboro

P.O. Number	Terms	Rep	Ship	Via	F.O.B	Project
w164822bs	Net 30		9/3/2016	R.J. Glass		

Quantity	Item Code	Description	Price Each	Amount
50,400	Poly Prop sac	Poly Prop Sand Sacks	2.27	114,408.00T
672	Bulk Bags	Bulk bags	27.00	18,144.00T
		Out-of-state sale, exempt from sales tax	0.00%	0.00

132,552 = 205/4300
Cody Vincent
61103

Total $132,552.00

S D Ireland Concrete Construction Corporation
PO Box 2286
South Burlington VT 05407-2286

INVOICE

Invoice #:	58092
Date:	9/9/16
Customer No:	3611

Sold To:

MICHELS CORPORATION
PO BOX 128, 817 W. MAIN STREET
BROWNSVILLE, WI 53006-0128

Delivered To:

OLD STAGE RD -

30 Pay Terms Net 30

Total: **5,008.50**

JOB # / PO # / MONKTON	Ticket	UM	Unit Price	Material Total	Tax	Line Total
COMM FLOWABLE FILL	19123467	45.000 CY	105.0000E	4,725.00	283.50 VT	5,008.50
Total:			4,725.00	0.00	283.50	5,008.50
Total Invoice:			4,725.00	0.00	283.50	5,008.50

PLEASE REMIT TOP PORTION OF INVOICE WITH PAYMENT

6%

Payment Type: On Account

30 Pay Terms Net 30	**Total:** **5,008.50**

S D Ireland Concrete Construction Corporation
PO Box 2286
South Burlington VT 05407-2286

INVOICE

Invoice #:	58349
Date:	9/19/16
Customer No:	3611

Sold To:

MICHELS CORPORATION
PO BOX 128, 817 W MAIN STREET
BROWNSVILLE, WI 53006-0128

Delivered To:

QUARRY RD -

30 Pay Terms Net 30

Total: 2,003.40

JOB # / PO # / MONKTON	Ticket	UM	Unit Price	Material Total	Tax	Line Total
COMM FLOWABLE FILL	19124281	18.000 CY	105.0000E	1,890.00	113.40 VT	2,003.40
Total:			1,890.00	0.00	113.40	2,003.40
Total Invoice:			1,890.00	0.00	113.40	2,003.40

PLEASE REMIT TOP PORTION OF INVOICE WITH PAYMENT

6% ✓

Payment Type: On Account

30 Pay Terms Net 30 **Total:** 2,003.40

North Middlebury Sand & Gravel

1555 Burpee Road
Bristol, Vermont 05443

Alan 802-349-7439

Invoice

DATE	INVOICE NO.
9/30/2016	7735N

BILL TO
Michels Pipeline Construction PO Box 128 817 West Main Street Brownsville, WI 53006

TERMS

DATE	SLIP #	YARDS	DESCRIPTION	RATE	AMOUNT
09/22	12424	28	cover material	10.00	280.00T
		56	topsoil	23.00	1,288.00T
09/23	12427	14	topsoil	23.00	322.00T
			Sales Tax	7.00%	132.30

Amount		CC
2022.30	201/4105	
	Cody Vincent	
6/11/13		
Approved:		

Payments/Credits $0.00

Total Due $2,022.30

INVOICE

Joseph P. Carrara & Sons, inc.
P.O. Box 60
North Clarendon, VT 05759
P: 802-775-2301
F: 802-775-1048

CARRARA
MASONRY & CONSTRUCTION PRODUCTS
PRECAST / READY-MIX CONCRETE

Locations:
E. Middlebury, VT
N. Clarendon, VT
Crown Point, NY

WWW.JPCARRARA.COM
WWW.CARRARACONCRETE.COM

SOLD TO: MICHELS CORPORATION
PO BOX 128
BROWNSVILLE, WI 53006-0128

SERVICE CHARGE: 1.5% per month on all amounts past due. Annual rate 18%

239058	10/6/16		61103

10/4/16	20616	CY	10.000	FLOWABLE FILL	103.00	1,030.00
10/4/16	20617	CY	10.000	FLOWABLE FILL	103.00	1,030.00
10/4/16	20618	CY	10.000	FLOWABLE FILL	103.00	1,030.00
10/4/16	20619	CY	10.000	FLOWABLE FILL	103.00	1,030.00
10/4/16	20620	CY	10.000	FLOWABLE FILL	103.00	1,030.00
10/4/16	20621	CY	10.000	FLOWABLE FILL	103.00	1,030.00
				Thank you		6,180.00
				6.00% VT Tax		370.80
				*** Invoice Total ***		6,550.80 ✓

ordered by:
ERIC BROWN
920-539-0335

INVOICE

PAGE 1

Harrison Redi-Mix Corporation
P.O. Box 2098
Georgia, Vermont 05468
(802) 849-6688

INVOICE NO.	36601
INVOICE DATE	10/11/16
CUSTOMER NO.	30485

SOLD TO:
MICHELS CORPORATION
817 WEST MAIN STREET
PO BOX 128
BROWNSVILLE, WI 53006-0128

SHIP TO:

PURCHASE ORDER NO.	ORDER DATE	ORDER NO.	SALES-PERSON	DIVISION	DATE SHIPPED	TERMS
						NET 30

QUANTITY	ITEM NUMBER	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
32.00	FLOWFILL	FLOWABLE FILL JOB #61103/SODOM RD FLO-FILL	94.00	3,008.00

SALES TAX FREIGHT	
TOTAL	3,008.00

Harrison Redi-Mix Corporation
P.O. Box 2098
Georgia, Vermont 05468
(802) 849-6688

INVOICE

PAGE 1

INVOICE NO.	36938
INVOICE DATE	11/02/16
CUSTOMER NO.	30485

SOLD TO
MICHELS CORPORATION
817 WEST MAIN STREET
PO BOX 128
BROWNSVILLE, WI 53006-0128

SHIP TO

PURCHASE ORDER NO.	ORDER DATE	ORDER NO.	SALES-PERSON	DIVISION	DATE SHIPPED	TERMS	
						NET 30	

QUANTITY	ITEM NUMBER	DESCRIPTION	UNIT PRICE	EXTENDED PRICE
64.00	FLOWFILL	250# FLOWABLE FILL	94.00	6,016.00
3.50	4000	4000 PSI CONCRETE	124.00	434.00
67.50	WINTER	WINTER CONCRETE	7.00	472.50
3.50	FIBER	FIBER MESH	8.00	28.00
1.00	MINIMUM	SMALL LOAD CHARGE	110.00	110.00

SALES TAX FREIGHT	
TOTAL	7,060.50

S D Ireland Concrete Construction Corporation
PO Box 2286
South Burlington VT 05407-2286

INVOICE

Invoice #:	56696
Date:	7/22/16
Customer No:	3611

Sold To:

MICHELS CORPORATION
PO BOX 128, 817 W. MAIN STREET
BROWNSVILLE, WI 53006-0128

Delivered To:

BELDON FALLS RD -

30 **Pay Terms** Net 30 **Total:** **2,893.81**

JOB # / PO # /920-539-03	Ticket	UM	Unit Price	Material Total	Tax	Line Total
1 HR RETARDER/ HYDRATION STABILIZER	19120096	65.010 CY	0.0000E	0.00	0.00 VT	0.00
COMM FLOWABLE FILL	19120096	26.000 CY	105.0000E	2,730.00	163.81 VT	2,893.81
Total:			**2,730.00**	**0.00**	**163.81**	**2,893.81**
Total Invoice:			**2,730.00**	**0.00**	**163.81**	**2,893.81**

PLEASE REMIT TOP PORTION OF INVOICE WITH PAYMENT

CVincent @ michels.us

Payment Type: On Account

30 **Pay Terms** Net 30	**Total:**	**2,893.81**

S D Ireland Concrete Construction Corporation
PO Box 2286
South Burlington VT 05407-2286

INVOICE

Invoice #:	56745
Date:	7/25/16
Customer No:	3611

Sold To:

MICHELS CORPORATION
PO BOX 128, 817 W. MAIN STREET
BROWNSVILLE, WI 53006-0128

Delivered To:

BELDON FALLS RD -

30 **Pay Terms** Net 30

Total: **2,893.81**

JOB # / PO # / 920-539-03	Ticket	UM	Unit Price	Material Total	Tax	Line Total
1 HR RETARDER/ HYDRATION STABILIZER	19120207	65.010 CY.	0.0000E	0.00	0.00 VT	0.00
COMM FLOWABLE FILL	19120207	26.000 CY	105.0000E	2,730.00	163.81 VT	2,893.81
Total :			**2,730.00**	**0.00**	**163.81**	**2,893.81**
Total Invoice:			**2,730.00**	**0.00**	**163.81**	**2,893.81**

PLEASE REMIT TOP PORTION OF INVOICE WITH PAYMENT

Payment Type: On Account

30 **Pay Terms** Net 30	**Total:** **2,893.81**

S D Ireland Concrete Construction Corporation
PO Box 2286
South Burlington VT 05407-2286

INVOICE

Invoice #:	56761
Date:	7/26/16
Customer No:	3611

Sold To:

MICHELS CORPORATION
PO BOX 128, 817 W. MAIN STREET
BROWNSVILLE, WI 53006-0128

Delivered To:

BREEZY VALLEY - ST.GEORGE -

30 Pay Terms Net 30 **Total:** **4,044.60**

JOB# / PO# /61103	Ticket	UM	Unit Price	Material Total	Tax	Line Total
COMM FLOWABLE FILL	19120239	36.000 CY	105.0000E	3,780.00	264.60 WVT	4,044.60
Total :			3,780.00	0.00	264.60	4,044.60
	Total Invoice:		3,780.00	0.00	264.60	4,044.60

PLEASE REMIT TOP PORTION OF INVOICE WITH PAYMENT

Payment Type: On Account

30 Pay Terms Net 30 **Total:** **4,044.60**

Invoice

Ranger Asphalt & Concrete Proc., LLC
1607 Malletts Bay Avenue
P.O. Box 96
Colchester, VT 05446

Phone: 802-655-3976 Fax: 802-655-1391

Invoice Number:
TKT#133512

Invoice Date:
Oct 15, 2015

Page:
1

Michels Pipeline Construction
Attn: Roberta Harrington
2155 Park Avenue Suite 105
Washington, PA 15301

Customer PO	Payment Terms	Due Date
	Net 30 Days	11/14/15

Description	Quantity	Unit Price	Total
Topsoil per yard	12.00	25 00	300.00

Subtotal	300.00
Sales Tax	21.00
Total Invoice Amount	321.00
Payment/Credit Applied	
TOTAL	321.00

Check/Credit Memo No:
Please pay from this invoice.
Thanks!

E-MAILED
Cody

OCT 2 8 2015

☐ ALL SEASONS EXCAVATING & LANDSCAPING, INC.
☐ RANGER INDUSTRIAL PARK, LLC
☑ RANGER ASPHALT & CONCRETE PROC., LLC

☑ Charge ☐ Paid Amt $ ______

1607 Mallets Bay Ave.
P.O. Box 96
Colchester, VT 05446
Phone: (802) 655-3976
Fax: (802) 655-1391

Sold to: ______

Date 10/15/15

Yardman BB

TICKET

	Disposal - In	Qty
	Asphalt per yd	
	Concrete per yd	
	Concrete w/mesh per yd	
	Concrete w/rebar per yd	
	Fill-in per yd	
	Ledge/Rock per yd	
	Other:	
	Sorting Fee:	
	Oversize Fee:	
	* All material must be separated.	
	* Minimum Disposal Charge $20	

TOTAL______

	Material - Out	Qty
	1" Minus Crushed Concrete per ton	
	1-1/2" Minus Crushed Concrete per ton	
	1" Minus Crushed Asphalt per ton	
	1" Plant Mix 704.05A per ton	
	1-1/2" Plant Mix 704.05A per ton	
	Woodchuck Dirt per ton	
	Topsoil per yd	12
	Common Sand per ton	
	Mound Sand per ton	
	Bark Mulch per yd	
	Salt per ton	
	Other:	

SUB TOTAL______
VT SALES TAX______
TOTAL______

Job ______

Driver Name ______

Net due 10 days. Interest at the rate of 1-1/2% per month, thereafter. All collection charges will be paid by purchaser including attorneys fees.

North Middlebury Sand & Gravel

1555 Burpee Road
Bristol, Vermont 05443

Alan 802-349-7439

Invoice

DATE	INVOICE NO.
10/31/2016	7796C

BILL TO
Michels Pipeline Construction PO Box 128 817 West Main Street Brownsville, WI 53006

1105.58 201/4100

4103

Cody Vincent

TERMS

DATE	SLIP #	YARDS	DESCRIPTION	RATE	AMOUNT
10/5	2122[illegible]	14	Screened Sand	9.50	133.00T
10/31	12771	28	topsoil	23.00	644.00T
10/27	12644	14	3/4" crushed gravel	9.50	133.00T
10/27	1263[illegible]	14	1 1/2" Crushed Gravel	9.50	133.00T
			Sales Tax	6.00%	62.58

Payments/Credits $0.00

Total Due $1,105.58

North Middlebury Sand & Gravel

1555 Burpee Road
Bristol, Vermont 05443

Alan 802-349-7439

Invoice

DATE	INVOICE NO.
11/30/2016	7806C

BILL TO
Michels Pipeline Construction PO Box 128 817 West Main Street Brownsville, WI 53006

3073.10 201/4100

6/1/03 Cody Vincent

TERMS

DATE	SLIP #	YARDS	DESCRIPTION	RATE	AMOUNT
11/1	12711	14	3/4" crushed gravel	9.50	133.00T
11/2	12719	56	3/4" crushed gravel	9.50	532.00T
11/2	12722	56	3/4" crushed gravel	9.50	532.00T
11/5	12730	14	5" stone	9.15	128.10T
11/5	12733	28	3/4" crushed gravel	9.50	266.00T
11/7	2051	42	Screened Sand	9.50	399.00T
11/8	12745	56	3/4" crushed gravel	9.50	532.00T
11/11	12812	14	3/4" crushed gravel	9.50	133.00T
11/17	12822	7	5" stone	9.15	64.05T
11/17	12825	14	5" Rip Rap	10.00	140.00T
11/22	12838	4	5" Rip Rap	10.00	40.00T
			Sales Tax	6.00%	173.95

Payments/Credits $0.00

Total Due $3,073.10

Lower-In/Padding/Backfill Daily Report

PROJECT NAME: Phase 7 Looping	DATE: 11-2-2016
PROJECT JOB #:	CONTRACTOR: Michels
PROJECT LOCATION: 263+20 to 265+00	
WEATHER CONDITIONS: 56 Sunny	

LOWERED-IN:	FROM STA.	TO STA.	DAILY TOTAL
	263+20	265+00	180'

PADDING:	EACH	FROM STA.	TO STA.	DAILY TOTAL
SANDBAG SUPPORT	15'	263+20	265+00	180'
BENTONITE				
PADDING BERM				

BACKFILL:	FROM STA.	TO STA.	DAILY TOTAL
N/A			

SAFETY:			REMARKS:
ONE CALLS MADE	YES ☐	NO ☑	
SAFETY MTG CONDUCTED	YES ☑	NO ☐	Hotlines/Pinch Points
TRAFFIC CONTROL BARRIERS & SIGN	YES ☑	NO ☐	Fence and cones installed at end of day
PPE USE COMPLIANCE	YES ☑	NO ☐	
WORK SITE HOUSEKEEPING	YES ☑	NO ☐	
JOB SITE SECURED	YES ☑	NO ☐	

ENVIRONMENTAL CONCERNS:

COMMENTS:

All O.Q.'s verified prior to tasks being performed. Michel's employees lowered in Phase VII 16" pipe and padded ditch from station 263+20 to 265+00. All work went smoothly and without incident. Road cut was backfilled with flowable fill and we will complete backfill and padding tomorrow.

INSPECTOR NAME: Scott Carlson

INSPECTOR SIGNATURE: Scott Carlson

CHIEF INSPECTOR REVIEW:

Vermont Gas

Lower-In/Padding/Backfill Daily Report

PROJECT NAME: Phase 7 Looping	DATE: 11/2/16
PROJECT JOB #:	CONTRACTOR: Michels
PROJECT LOCATION: Sandy Birch	
WEATHER CONDITIONS: Clear	

LOWERED-IN:	FROM STA.	TO STA.	DAILY TOTAL
Yes	418+50	419+91	141ft

PADDING:	EACH	FROM STA.	TO STA.	DAILY TOTAL
SANDBAG SUPPORT	15ft	418+50	419+91	141ft
BENTONITE				
PADDING BERM				

BACKFILL:	FROM STA.	TO STA.	DAILY TOTAL
No	N/A	N/A	N/A

SAFETY:			REMARKS:
ONE CALLS MADE	YES ☑	NO ☐	
SAFETY MTG CONDUCTED	YES ☑	NO ☐	
TRAFFIC CONTROL BARRIERS & SIGN	YES ☑	NO ☐	
PPE USE COMPLIANCE	YES ☑	NO ☐	
WORK SITE HOUSEKEEPING	YES ☑	NO ☐	
JOB SITE SECURED	YES ☑	NO ☐	

ENVIRONMENTAL CONCERNS:

N/A

COMMENTS:

From 418+50 to 418+75 ML valve was installed.

INSPECTOR NAME: Bo Reeves

INSPECTOR SIGNATURE: Bo Reeves

CHIEF INSPECTOR REVIEW:

Lower-In/Padding/Backfill Daily Report

Vermont Gas

PROJECT NAME: **Addison Natural Gas Project Phase 1**	DATE: 11-02-16
PROJECT JOB #: **28757**	CONTRACTOR: **Michels**
PROJECT LOCATION: Rotax rd station number 1309+61	
WEATHER CONDITIONS: Partly cloudy highs in the mid 50's	

LOWERED-IN:	**FROM STA.**	**TO STA.**	**DAILY TOTAL**

PADDING:	**EACH**	**FROM STA.**	**TO STA.**	**DAILY TOTAL**
SANDBAG SUPPORT				
BENTONITE				
PADDING BERM				

BACKFILL:	**FROM STA.**	**TO STA.**	**DAILY TOTAL**
	1309+42	1309+86	44 feet

SAFETY:			**REMARKS:**
ONE CALLS MADE	YES ☐	NO ☐	
SAFETY MTG CONDUCTED	YES ☐	NO ☐	
TRAFFIC CONTROL BARRIERS & SIGN	YES ☐	NO ☐	
PPE USE COMPLIANCE	YES ☐	NO ☐	
WORK SITE HOUSEKEEPING	YES ☐	NO ☐	
JOB SITE SECURED	YES ☐	NO ☐	

ENVIRONMENTAL CONCERNS:

COMMENTS:

Station 1309+61 contractor backfilled the main line valve and fabrication.

INSPECTOR NAME: Bill Jackson

INSPECTOR SIGNATURE: [signature]

CHIEF INSPECTOR REVIEW:

Lower-In/Padding/Backfill Daily Report

PROJECT NAME: **Addison Natural Gas Project Phase 1**	DATE: 6/1116
PROJECT JOB #: **28757**	CONTRACTOR: **Michels**
PROJECT LOCATION:	
WEATHER CONDITIONS: Drizzle/rain 50's	

LOWERED-IN:	FROM STA.	TO STA.	DAILY TOTAL
line pipe	885+20	887+00	180

PADDING:	EACH	FROM STA.	TO STA.	DAILY TOTAL
SANDBAG SUPPORT		885+20	887+00	
BENTONITE				
PADDING BERM				

BACKFILL:	FROM STA.	TO STA.	DAILY TOTAL
	885+40	886+60	120

SAFETY:			REMARKS:
ONE CALLS MADE	YES ☑	NO ☐	
SAFETY MTG CONDUCTED	YES ☑	NO ☐	
TRAFFIC CONTROL BARRIERS & SIGN	YES ☑	NO ☐	
PPE USE COMPLIANCE	YES ☑	NO ☐	
WORK SITE HOUSEKEEPING	YES ☑	NO ☐	
JOB SITE SECURED	YES ☑	NO ☐	

ENVIRONMENTAL CONCERNS:

COMMENTS:

INSPECTOR NAME: Stephen Taylor

INSPECTOR SIGNATURE: Stephen L Taylor

CHIEF INSPECTOR REVIEW:

Steel Pipelines Crossing Railroads and Highways

API RECOMMENDED PRACTICE 1102
SEVENTH EDITION, DECEMBER 2007

ERRATA, NOVEMBER 2008
ERRATA 2, MAY 2010

Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

Foreword

The need for an industry-recommended practice to address installation of pipeline crossings under railroads was first recognized by the publication of American Petroleum Institute (API) Code 26 in 1934. This code represented an understanding between the pipeline and railroad industries regarding the installation of the relatively small-diameter lines then prevalent.

The rapid growth of pipeline systems after 1946 using large-diameter pipe led to the reevaluation and revision of API Code 26 to include pipeline design criteria. A series of changes were made between 1949 and 1952, culminating in the establishment in 1952 of Recommended Practice 1102. The scope of Recommended Practice 1102 (1952) included crossings of highways in anticipation of the cost savings that would accrue to the use of thin-wall casings in conjunction with the pending construction of the Defense Interstate Highway System.

Recommended Practice 1102 (1968) incorporated the knowledge gained from known data on uncased carrier pipes and casing design and from the performance of uncased carrier pipes under dead and live loads, as well as under internal pressures. Extensive computer analysis was performed using Spangler's Iowa Formula [1] to determine the stress in uncased carrier pipes and the wall thickness of casing pipes in instances where cased pipes are required in an installation.

The performance of carrier pipes in uncased crossings and casings installed since 1934, and operated in accordance with API Code 26 and Recommended Practice 1102, has been excellent. There is no known occurrence in the petroleum industry of a structural failure due to imposed earth and live loads on a carrier pipe or casing under a railroad or highway. Pipeline company reports to the U.S. Department of Transportation in compliance with 49 *Code of Federal Regulations* Part 195 corroborate this record.

The excellent performance record of uncased carrier pipes and casings may in part be due to the design process used to determine the required wall thickness. Measurements of actual installed casings and carrier pipes using previous Recommended Practice 1102 design criteria demonstrate that the past design methods are conservative. In 1985, the Gas Research Institute (GRI) began funding a research project at Cornell University to develop an improved methodology for the design of uncased carrier pipelines crossing beneath railroads and highways. The research scope included state-of-the-art reviews of railroad and highway crossing practices and performance records [2, 3]. three-dimensional finite element modeling of uncased carrier pipes beneath railroads and highways, and extensive field testing on full-scale instrumented pipelines. The results of this research are the basis for the new methodology for uncased carrier pipe design given in this edition of Recommended Practice 1102. The GRI summary report, *Technical Summary and Database for Guidelines for Pipelines Crossing Railroads and Highway* by Ingraffea et al. [4], includes the results of the numerical modeling, the full derivations of the design curves used in this recommended practice, and the data base of the field measurements made on the experimental test pipelines.

This recommended practice contains tabular values for the wall thickness of casings where they are required in an installation. The loading values that were employed are Cooper E-80 with 175% impact for railroads and 10,000 lbs (44.5 kN) per tandem wheel with 150% impact for highways. Due notice should be taken of the fact that external loads on flexible pipes can cause failure by buckling. Buckling occurs when the vertical diameter has undergone 18% to 22% deflection. Failure by buckling does not result in rupture of the pipe wall, although the metal may be stressed far beyond its elastic limit. Recommended Practice 1102 (1993) recognizes this performance of a properly installed flexible casing pipe, as opposed to heavy wall rigid structures, and has based its design criteria on a maximum vertical deflection of 3% of the vertical diameter. Measurement of actual installed casing pipe using Recommended Practice 1102 (1981) design criteria demonstrates that the Iowa Formula is very conservative, and in most instances, the measures long-term vertical deflection has been 0.65% or less of the vertical diameter.

Recommended Practice 1102 has been revised and improved repeatedly using the latest research and experience in measuring actual performance of externally loaded uncased pipelines under various environmental conditions and using new materials and construction techniques developed since the recommended practice was last revised. The current Recommended Practice 1102 (2007) is the seventh edition and reflects the most recent design criteria and technology.

The seventh edition of Recommended Practice 1102 (2007) has been reviewed by the API Pipeline Operations Technical Committee utilizing the extensive knowledge and experiences of qualified engineers responsible for design construction, operation and maintenance of the nation's petroleum pipelines. API appreciatively acknowledges their contributions.

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually and updated quarterly by API, 1220 L Street, N.W., Washington, D.C. 20005.

Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, D.C. 20005, standards@api.org.

Contents

Contents

Steel Pipelines Crossing Railroads and Highways

1 Scope

1.1 General

This recommended practice, *Steel Pipelines Crossing Railroads and Highways*, gives primary emphasis to provisions for public safety. It covers the design, installation, inspection, and testing required to ensure safe crossings of steel pipelines under railroads and highways. The provisions apply to the design and construction of welded steel pipelines under railroads and highways. The provisions of this practice are formulated to protect the facility crossed by the pipeline, as well as to provide adequate design for safe installation and operation of the pipeline.

1.2 Application

The provisions herein should be applicable to the construction of pipelines crossing under railroads and highways and to the adjustment of existing pipelines crossed by railroad or highway construction. This practice should not be applied retroactively. Neither should it apply to pipelines under contract for construction on or prior to the effective date of this edition. Neither should it be applied to directionally drilled crossings or to pipelines installed in utility tunnels.

1.3 Type of Pipeline

This practice applies to welded steel pipelines.

1.4 Provisions for Public Safety

The provisions give primary emphasis to public safety. The provisions set forth in this practice adequately provide for safety under conditions normally encountered in the pipeline industry. Requirements for abnormal or unusual conditions are not specifically discussed, nor are all details of engineering and construction provided. The applicable regulations of federal [5, 6], state, municipal, and regulatory institutions having jurisdiction over the facility to be crossed shall be observed during the design and construction of the pipeline.

1.5 Approval for Crossings

Prior to the construction of a pipeline crossing, arrangements should be made with the authorized agent of the facility to be crossed.

2 Symbols, Equations, and Definitions

2.1 Symbols

A_p Contact area for application of wheel load, in in.^{2} or m^2.

B_d Bored diameter of crossing, in in. or mm.

B_e Burial factor for circumferential stress from earth load.

D External diameter of pipe, in in. or mm.

E Longitudinal joint factor.

E' Modulus of soil reaction, in kips/in.^{2} or MPa.

E_e Excavation factor for circumferential stress from earth load.

E_r Resilient modulus of soil, in kips/in.^{2} or MPa.

E_s Young's modulus of steel, in psi or kPa.

F Design factor chosen in accordance with standard practice or code requirement.

F_i Impact factor.

G_{Hh} Geometry factor for cyclic circumferential stress from highway vehicular load.

G_{Hr} Geometry factor for cyclic circumferential stress from rail load.

G_{Lh} Geometry factor for cyclic longitudinal stress from highway vehicular load.

G_{Lr} Geometry factor for cyclic longitudinal stress from rail load.

H Depth to top of pipe, in ft or m.

HVL Highly volatile liquid.

K_{He} Stiffness factor for circumferential stress from earth load.

K_{Hh} Stiffness factor for cyclic circumferential stress from highway vehicular load.

K_{Hr} Stiffness factor for cyclic circumferential stress from rail load.

K_{Lh} Stiffness factor for cyclic longitudinal stress from highway vehicular load.

K_{Lr} Stiffness factor for cyclic longitudinal stress from rail load.

L Highway axle configuration factor.

L_G Distance of girth weld from centerline of track, in ft or m.

$MAOP$ Maximum allowable operating pressure for gases, in psi or kPa.

MOP Maximum operating pressure for liquids, in psi or kPa.

N_H Double track factor for cyclic circumferential stress.

N_L Double track factor for cyclic longitudinal stress.

N_t Number of tracks at railroad crossing

P Wheel load. in lb or kN.

P_s Single axle wheel load, in lb or kN.

P_t Tandem axle wheel load, in lb or kN.

p Internal pipe pressure, in psi or kPa.

R	Highway pavement type factor.
R_F	Longitudinal stress reduction factor for fatigue.
S_{eff}	Total effective stress, in psi or kPa.
S_{FG}	Fatigue resistance of girth weld, in psi or kPa.
S_{FL}	Fatigue resistance of longitudinal weld in psi or kPa.
S_{He}	Circumferential stress from earth load, in psi or kPa.
S_{Hi}	Circumferential stress from internal pressure calculated using the average diameter, in psi or kPa.
S_{Hi} (Barlow)	Circumferential stress from internal pressure calculated using the Barlow formula, in psi or kPa.
S_1, S_2, S_3	Principal stresses in pipe, in psi or kPa: S_1 = maximum circumferential stress; S_2 = maximum longitudinal stress; S_3 = maximum radial stress.
$SMYS$	Specified minimum yield strength, in psi or kPa.
T	Temperature derating factor.
T_1, T_2	Temperatures (°F or °C).
t_w	Pipe wall thickness, in in. or mm.
w	Applied design surface pressure, in psi or kPa.
α_T	Coefficient of thermal expansion, per °F or per °C.
γ	Unit weight of soil, in lb/in.^{3} or kN/m^3.
ΔS_H	Cyclic circumferential stress, in psi or kPa.
ΔS_{Hh}	Cyclic circumferential stress from highway vehicular load, in psi or kPa.
ΔS_{Hr}	Cyclic circumferential stress from rail load in psi or kPa.
ΔS_L	Cyclic longitudinal stress, in psi or kPa.
ΔS_{Lh}	Cyclic longitudinal stress from highway vehicular load, in psi or kPa.
ΔS_{Lr}	Cyclic longitudinal stress from rail load, in psi or kPa.
ν_s	Poisson's ratio of steel.

2.2 Equations

NOTE All stresses below have units of psi or kPa.

Equation	No.
Earth Load:	
$S_{He} = K_{He} B_e E_e \gamma D$	(1)
Live Load:	
$w = P / A_P$	(2)
$\Delta S_{Hr} = K_{Hr} G_{Hr} N_H F_i w$	(3)
$\Delta S_{Lr} = K_{Lr} G_{Lr} N_L F_i w$	(4)
$\Delta S_{Hh} = K_{Hh} G_{Hh} R L F_i w$	(5)
$\Delta S_{Lh} = K_{Lh} G_{Lh} R L F_i w$	(6)
Internal Load:	
$S_{Hi} = p(D - t_w) / 2t_w$	(7)
Natural gas:	
$[S_{Hi}(\text{Barlow}) = pD / 2t_w] \leq F \times E \times T \times SMYS$	(8a)
Liquids:	
$[S_{Hi}(\text{Barlow}) = pD / 2t_w] \leq F \times E \times T \times SMYS$	(8b)
Limits of Calculated Stresses:	
Circumferential:	
$S_1 = S_{He} + \Delta S_H + S_{Hi}$	(9)
Longitudinal:	
$S_2 = \Delta S_L - E_s \alpha_T (T_2 - T_1) + \nu_s (S_{He} + S_{Hi})$	(10)
Radial:	
$S_3 = -p = -MAOP \text{ or } -MOP$	(11)
$S_{eff} = \sqrt{\frac{1}{2}[(S_1 - S_2)^2 + (S_2 - S_3)^2 + (S_3 - S_1)^2]}$	(12)
$S_{eff} \leq SMYS \times F$	(13)
$\Delta S_L \leq S_{FG} \times F$	(14)

$$\Delta S_{Lr}/N_L \leq S_{FG} \times F \quad (15)$$

$$R_F \Delta S_{Lr}/N_L \leq S_{FG} \times F \quad (16)$$

$$\Delta S_{Lh} \leq S_{FG} \times F \quad (17)$$

$$\Delta S_H \leq S_{FL} \times F \quad (18)$$

$$\Delta S_{Hr}/N_H \leq S_{FL} \times F \quad (19)$$

$$\Delta S_{Hh} \leq S_{FL} \times F \quad (20)$$

2.3 Definitions

The following definitions of terms apply to this practice:

2.3.1
carrier pipe
A steel pipe for transporting gas or liquids.

2.3.2
cased pipeline or **cased pipe**
A carrier pipe inside a casing that crosses beneath a railroad or highway.

2.3.3
casing
A conduit through which the carrier pipe may be placed.

2.3.4
flexible casing
Casing that may undergo permanent deformation or change of shape without fracture of the wall.

NOTE Steel pipe is an example of a flexible casing.

2.3.5
flexible pavement
A highway surface made of viscous asphaltic materials.

2.3.6
girth weld
A full circumferential butt weld joining two adjacent sections of pipe.

2.3.7
highly volatile liquid (HVL)
A hazardous liquid that will form a vapor cloud when released to the atmosphere and that has a vapor pressure exceeding 40 psia (276 kPa) at 100 °F (37.8 °C).

2.3.8
highway
Any road or driveway that is used frequently as a thoroughfare and is subject to self-propelled vehicular traffic.

2.3.9
longitudinal weld
A full penetration groove weld running lengthwise along the pipe made during fabrication of the pipe.

2.3.10
maximum allowable operating pressure (*MAOP*) or **maximum operating pressure (*MOP*)**
The maximum pressure at which a pipeline or segment of a pipeline may be operated with limits as determined by applicable design codes and regulations.

2.3.11
percussive moling
A construction method in which a device is used to advance a hole as sections of pipe are jacked simultaneously into place behind the advancing instrument.

2.3.12
pipe jacking with anger boring
A construction method for pipeline crossings in which the excavation is performed by a continuous auger as sections of pipe are welded and then jacked simultaneously behind the front of the advancing auger.

2.3.13
pressure testing
A continuous, uninterrupted test of specified time duration and pressure of the completed pipeline or piping systems, or segments thereof, which qualifies them for operation.

2.3.14
railroad
Rails fixed to ties laid on a roadbed providing a track for rolling stock drawn by locomotives or propelled by self-contained motors.

2.3.15
rigid pavement
Highway surface or subsurface made of Portland cement concrete.

2.3.16
split casing
A casing made of a pipe that is cut longitudinally and rewelded around the carrier pipe.

2.3.17
trenchless construction
Any construction method, other than directional dirlling, for installing pipelines by subsurface excavation without the use of open trenching.

2.3.18
uncased pipeline or **uncased pipe**
Carrier pipe without a casing that crosses beneath a railroad or highway.

3 Provisions for Safety

3.1 The applicable regulations of federal, state, municipal or other regulating bodies having jurisdiction over the pipeline or the facility to be crossed shall be observed during the installation of a crossing.

3.2 As appropriate to the hazards involved, guards (watch persons) should be posted; warning signs, lights, and flares should be placed; and temporary walkways, fences, and barricades should be provided and maintained.

3.3 Permission should be obtained from an authorized agent of the railroad company before any equipment is transported across a railroad track at any location other than a public or private thoroughfare.

3.4 The movement of vehicles, equipment, material, and personnel across a highway should be in strict compliance with the requirements of the appropriate jurisdictional authority. Precautionary and preparatory procedures should be used, such as posting flagpersons to direct traffic and equipment movement and protecting the highway from surface or structural damage. Highway surfaces should be kept free of dirt, rock, mud, oil, or other debris that present an unsafe condition.

3.5 Equipment used and procedures followed in constructing a crossing should not cause damage to, or make unsafe to operate, any structure or facility intercepted by or adjacent to the crossing.

3.6 The functioning of railroad and highway drainage ditches should be maintained to avoid flooding or erosion of the roadbed or adjacent properties.

4 Uncased Crossings

4.1 Type of Crossing

The decision to use an uncased crossing must be predicated on careful consideration of the stresses imposed on uncased pipelines, versus the potential difficulties associated with protecting cased pipelines from corrosion. This section focuses specifically on the design of uncased carrier pipelines to accommodate safely the stresses and deformations imposed at railroad and highway crossings. The provisions apply to the design and construction of welded steel pipelines under railroads and highways.

4.2 General

4.2.1 The carrier pipe should be as straight as practicable and should have uniform soil support for the entire length of the crossing.

4.2.2 The carrier pipe should be installed so as to minimize the void between the pipe and the adjacent soil.

4.2.3 The carrier pipe shall be welded in accordance with the latest approved editions of API Standard 1104, *Welding of Pipelines and Related Facilities* [7], and ASME B31.4 or B31.8 [8, 9], whichever is applicable.

4.3 Location and Alignment

4.3.1 The angle of intersection between a pipeline crossing and the railroad or highway to be crossed should be as near to 90 degrees as practicable. In no case should it be less than 30 degrees.

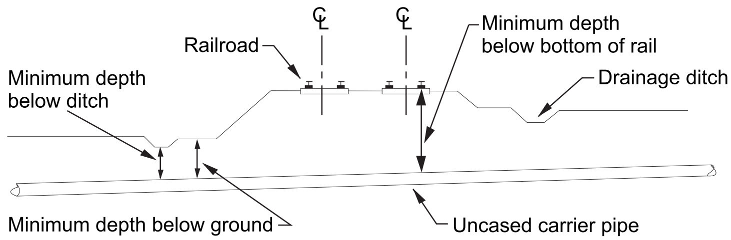
4.3.2 Crossings in wet or rock terrain, and where deep cuts are required, should be avoided where practicable.

4.3.3 Vertical and horizontal clearances between the pipeline and a structure or facility in place must be sufficient to permit maintenance of the pipeline and the structure or facility.

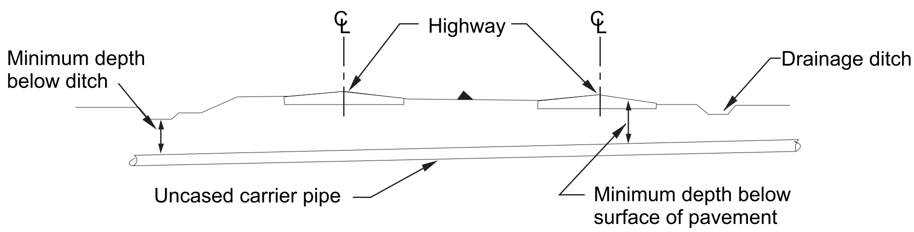
4.4 Cover

4.4.1 Railroad Crossings

Carrier pipe under railroads should be installed with a minimum of cover, as measured from the top of the pipe to the base of the rail, as follows (see Figure 1):



RAILROAD CROSSING



HIGHWAY CROSSING

Figure 1—Examples of Uncased Crossing Installations

Location	Minimum Cover
a) Under track structure proper.	6 ft (1.8 m)
b) Under all other surfaces within the right-of-way or from the bottom of ditches.	3 ft (0.9 m)
c) For pipelines transporting HVL, from the bottom of ditches.	4 ft (1.2 m)

4.4.2 Highway Crossings

Carrier pipe under highways should be installed with minimum cover, as measured from the top of the pipe to the top of the surface, as follows (see Figure 1).

Location	Minimum Cover
a) Under highway surface proper.	4 ft (1.2 m)
b) Under all other surfaces within the right-of-way.	3 ft (0.9 m)
c) For pipelines transporting HVL, from the bottom of ditches.	4 ft (1.2 m)

4.4.3 Mechanical Protection

If the minimum coverage set forth in 4.4.1 and 4.4.2 cannot be provided, mechanical protection shall be installed.

4.5 Design

To ensure safe operation, the stresses affecting the uncased pipeline must be accounted for comprehensively, including both circumferential and longitudinal stresses. The recommended design procedure is shown schematically in Figure 2. It consists of the following steps:

a) Begin with the wall thickness for the pipeline of given diameter approaching the crossing. Determine the pipe, soil, construction, and operational characteristics.

b) Use the Barlow formula to calculate the circumferential stress due to internal pressure, S_{Hi} (Barlow). Check S_{Hi} (Barlow) against the maximum allowable value.

c) Calculate the circumferential stress due to earth load, S_{He}.

d) Calculate the external live load, w, and determine the appropriate impact factor, F_i.

e) Calculate the cyclic circumferential stress, ΔS_H, and the cyclic longitudinal stress, ΔS_L due to live load.

f) Calculate the circumferential stress due to internal pressure, S_{Hi}.

g) Check effective stress, S_{eff} as follows:

1) Calculate the principal stresses, S_1 in the circumferential direction, S_2 in the longitudinal direction, and S_3, in the radial direction.

2) Calculate the effective stress, S_{eff}.

3) Check by comparing S_{eff} against the allowable stress, $SMYS \times F$.

h) Check welds for fatigue as follows:

1) Check with weld fatigue by comparing ΔS_L against the girth weld fatigue limit, $S_{FG} \times F$.

2) Check longitudinal weld fatigue by comparing, ΔS_H against the longitudinal weld fatigue limit, $S_{FL} \times F$.

i) If any check fails, modify the design conditions in Item a appropriately and repeat the steps in Items b through h.

Recommended methods for performing the steps in Items b through h, above, are described in 4.6 through 4.8. In 4.6 through 4.8, several figures give design curves for specific material properties or geometric conditions. *Interpolations between the design curves may be done. Extrapolations beyond the design curve limits are not recommended.*

4.6 Loads

4.6.1 General

4.6.1.1 A carrier pipe at an uncased crossing will be subjected to both internal load from pressurization and external loads from earth forces (dead load) and train or highway traffic (live load). An impact factor should be applied to the live load. Recommended methods for calculating these loads and impact factors are described in the following subsections.

4.6.1.2 Other loads may be present as a result of temperature fluctuations caused by changes in season; longitudinal tension due to end effects; fluctuations associated with pipeline operating conditions, unusual surface loads associated with specialized equipment; and ground deformations arising from various sources, such as shrinking and swelling soils, frost heave, local instability, nearby blasting, and undermining by adjacent excavations.

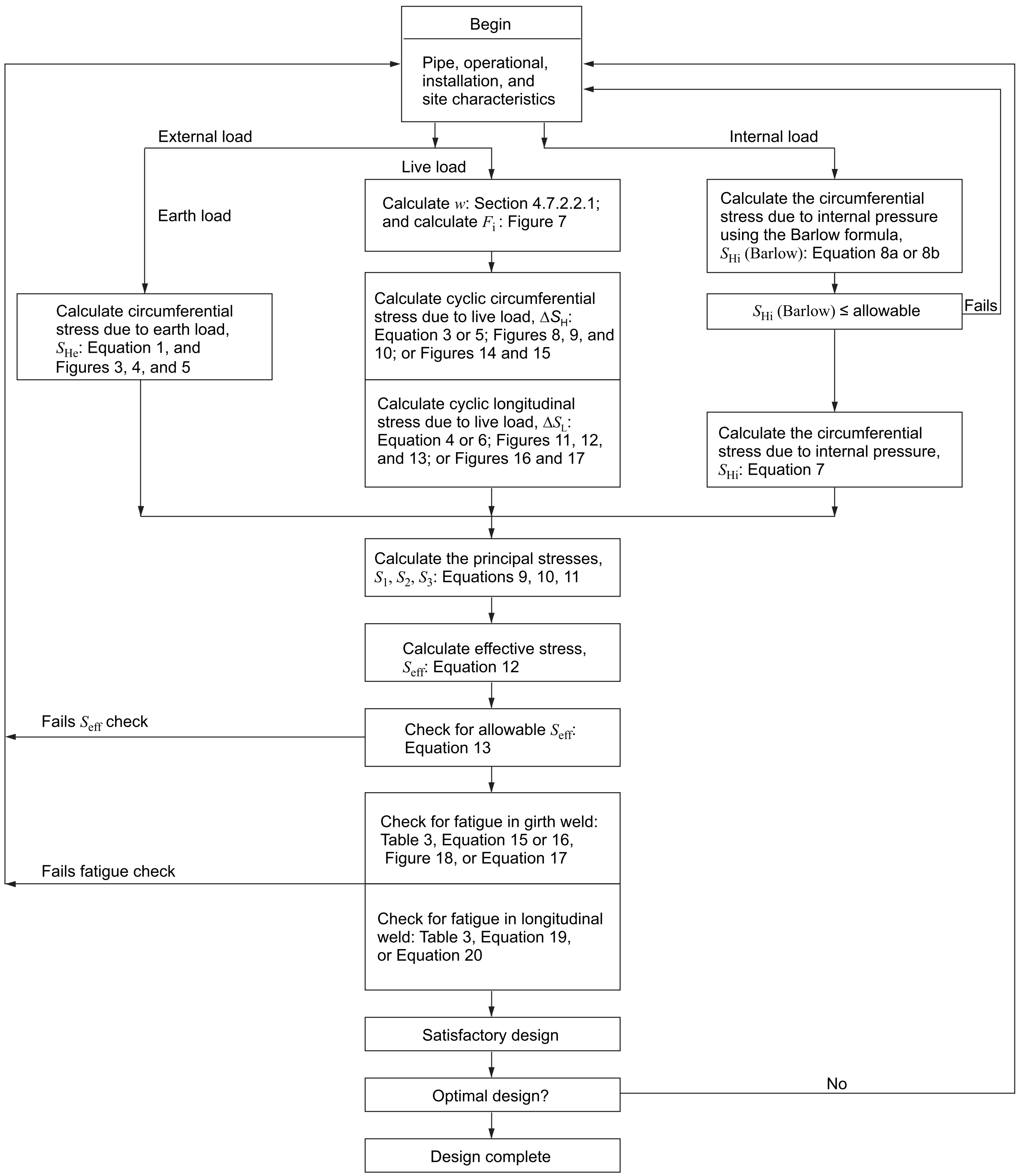


Figure 2—Flow Diagram of Design Procedure for Uncased Crossings of Railroads and Highways

Pipe stresses induced by temperature fluctuations can be included. All other loads are a result of special conditions. Loads of this nature must be evaluated on a site-specific basis and, therefore, are outside the scope of this recommended practice. Ingraffea et al. [4] describe how pipeline stresses can be influenced by longitudinal bends and tees in the vicinity of the crossing, and they give equations to evaluate such effects.

4.6.2 External Loads

4.6.2.1 Earth Load

The earth load is the force resulting from the weight of the overlying soil that is conveyed to the top of pipe. The earth load is calculated according to the procedures widely adopted in practice for ditch conduits [10]. Such procedures have been used in pipeline design for many years and have been included in specifications adopted by various professional organizations [11, 12, 13].

4.6.2.2 Live Load

4.6.2.2.1 Railroad Crossing

It is assumed that the pipeline is subjected to the load from a single train as would be applied on either track shown in Figure 1. For simultaneous loading of both tracks, stress increment factors for the cyclic longitudinal and cyclic circumferential stress are used. The crossing is assumed to be oriented at 90 degrees with respect to the railroad and is an embankment-type crossing as illustrated in Figure 1. This type of orientation generally is preferred in new pipeline construction and is likely to result in pipeline stresses larger than those associated with pipelines crossing at oblique angles to the railroad.

4.6.2.2.2 Highway Crossing

It is assumed that the pipeline is subjected to the loads from two trucks traveling in adjacent lanes, such that there are two sets of tandem or single axles in line with each other. The crossing is assumed to be oriented at 90 degrees with respect to the highway and is an embankment-type crossing, as shown in Figure 1. This type of orientation generally is preferred in new pipeline construction and is likely to result in pipeline stresses larger than those associated with pipelines crossing at oblique angles to the highway.

4.6.3 Internal Load

The internal load is produced by internal pressure, p, in pounds per square inch (psi) or kilopascals (kPa). The maximum allowable operating pressure, $MAOP$ or maximum operating pressure, MOP should be used in the design.

4.7 Stresses

4.7.1 General

For detailed information on the methods used to develop the design approaches and design curves for determining stresses, see Ingraffea et al. [4].

4.7.2 Stresses Due to External Loads

External loading on the carrier pipe will produce both circumferential and longitudinal stresses. Recommended procedures for calculating each component of these stresses follow. It is assumed that all external loads are conveyed vertically across a 90 degree arc centered on the pipe crown and resisted by a vertical reaction distributed across a 90 degree arc centered on the pipe invert.

4.7.2.1 Stresses Due to Earth Load

The circumferential stress at the pipeline invert caused by earth load. S_{He} (psi or kPa), is determined as follows:

$$S_{He} = K_{He}B_eE_e\gamma D \tag{1}$$

where

K_{He} is the stiffness factor for circumferential stress from earth load.

B_e is the burial factor for earth load.

E_e is the excavation factor for earth load.

γ is the soil unit weight, in lb/in.^{3} or kN/m^3.

D is the pipe outside diameter, in in. or m.

It is recommended that γ be taken as 120 lb/ft^3 (18.9 kN/m^3) (equivalent to 0.069 lb/in.^{3}) for most soil types unless a higher value is justified on the basis of field or laboratory data.

The earth load stiffness factor, K_{He}, accounts for the interaction between the soil and pipe and depends on the pipe wall thickness to diameter ratio, t_w/D, and modulus of soil reaction, E'. Figure 3 shows K_{He} plotted for various E', as a function of t_w/D. Values of E' appropriate for auger borer construction may range from 0.2 to 2.0 kips/in.^{2} (1.4 to 13.8 mPa). It is recommended that E' be chosen as 0.5 kips/in.^{2} (3.4 mPa), unless a higher value is judged more appropriate by the designer. Table A-1 in Annex A gives typical values for E'.

The burial factor, B_e, is presented as a function of the ratio of pipe depth to bored diameter, H/B_d for various soil conditions in Figure 4. If the bored diameter is unknown or uncertain at the time of design, it is recommended that B_d be taken as D + 2 in. (51 mm). For trenched construction and new structures constructed over existing pipelines, $B_d = D$ can be assumed, recognizing that soil compaction in the trench would lead to higher E' values than those for auger bored installations.

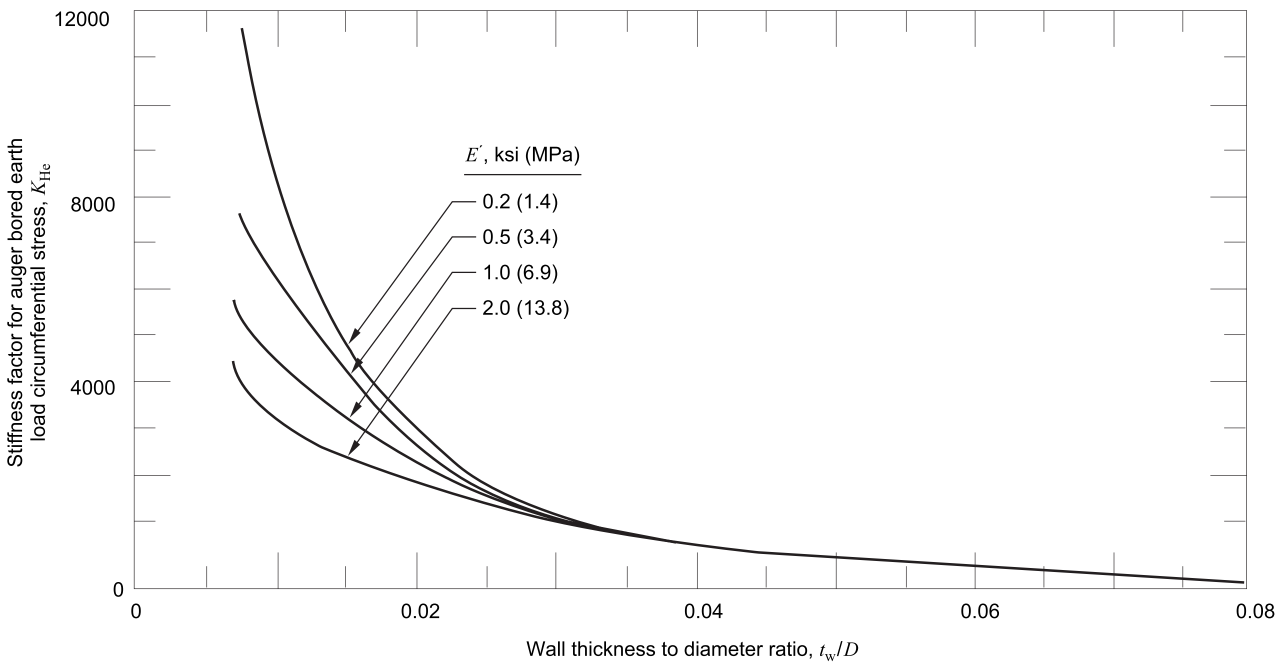
The excavation factor, E_e, is presented as a function of the ratio of bored diameter to pipe diameter, B_d/D in Figure 5. If the bored diameter is unknown or uncertain at the time of design, E_e should be assumed equal to 1.0. For trenched construction and new structures constructed over existing pipelines, E_e can be assumed equal to 1.0.

4.7.2.2 Stresses Due to Live Load

4.7.2.2.1 Surface Live Loads

The live, external rail load is the vehicular load, w, applied at the surface of the crossing. It is recommended that Cooper E-80 loading of w = 13.9 psi (96 kPa) be used, unless the loads are known to be greater. This is the load resulting from the uniform distribution of four 80-kip (356-kN) axles over an area 20 ft by 8 ft (6.1 m by 2.4 m).

The live external highway load, w, is due to the wheel load, P, applied at the surface of the roadway. For design, only the load from one of the wheel sets needs to be considered. The design wheel load should be either the maximum wheel load from a truck's single axle, P_s, or the maximum wheel load from a truck's tandem axle set, P_t. Figure 6 shows the methods by which axle loads are converted into equivalent single wheel loads P_s and P_t. For example, a truck with a single axle load of 24 kips (106.8 kN) would have a design single wheel load of P_s = 12 kips (53.4 kN) and a truck with a tandem axle load of 40 kips (177.9 kN) would have a design tandem wheel load of P_t = 10 kips (44.5 kN). The maximum single axle wheel load recommended for design is P_s = 12 kips (53.4 kN). The maximum tandem axle wheel load recommended for design is P_t = 10 kips (44.5 kN). The decision as to whether single or tandem axle loading is more critical depends on the carrier pipe diameter, D; the depth of burial, H; and whether the



NOTE See Table A-1 for soil descriptions.

Figure 3—Stiffness Factor for Earth Load Circumferential Stress, K_{He}

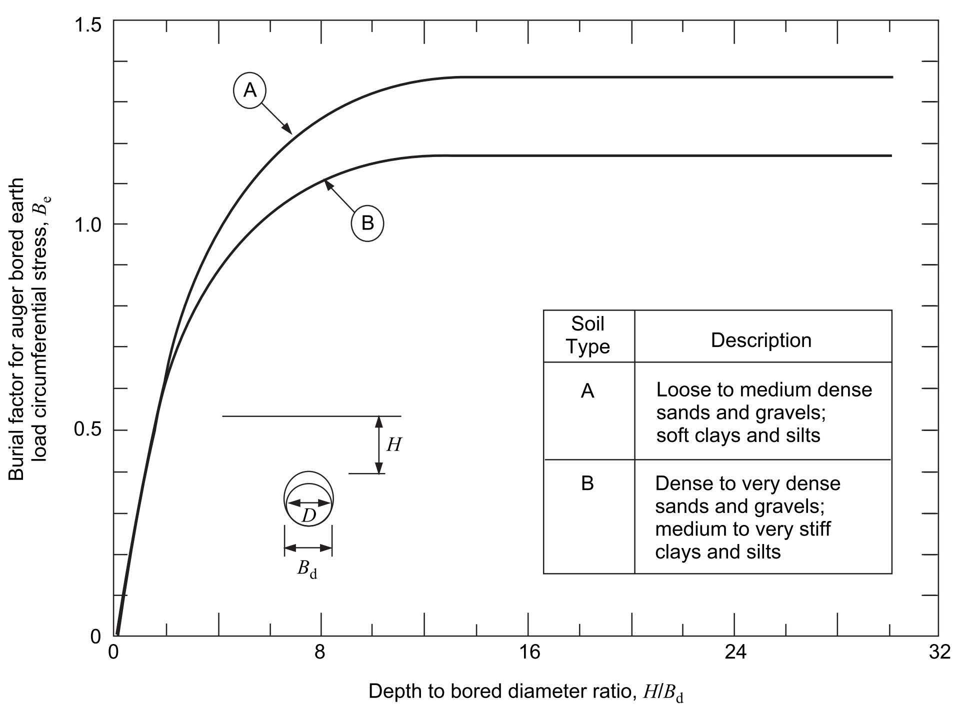


Figure 4—Burial Factor for Earth Load Circumferential Stress, B_e

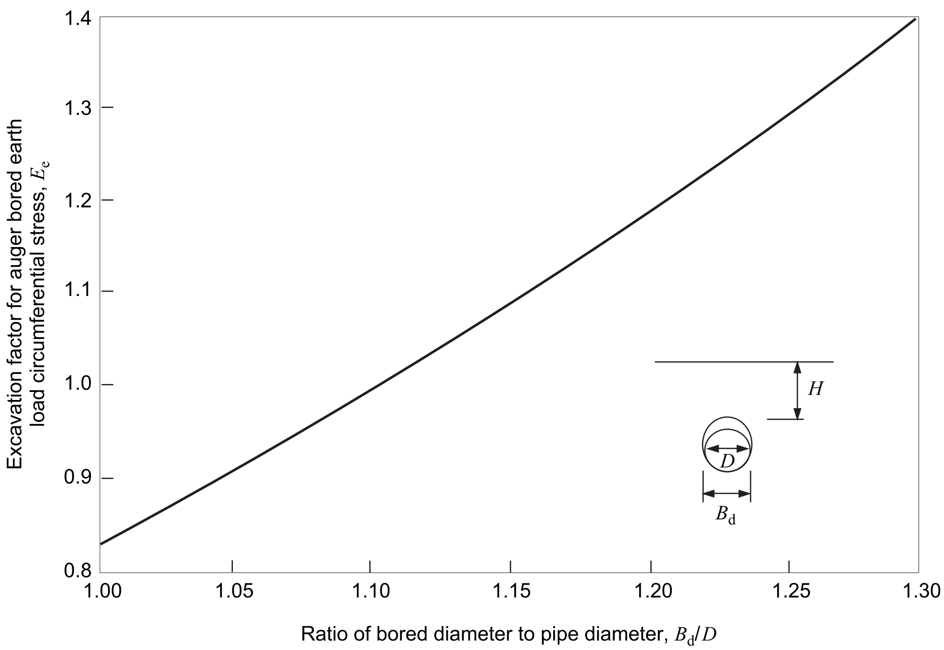


Figure 5—Excavation Factor for Earth Load Circumferential Stress, E_e

road surface has a flexible pavement, has no pavement, or has a rigid pavement. For the recommended design loads of P_s = 12 kips (53.4 kN) and P_t = 10 kips (44.5 kN), the critical axle configuration cases for the various pavement types, burial depths, and pipe diameters are given in Table 1.

The applied design surface pressure, w (lb/in.^{2} or kN), then is determined as follows:

$$w = P/A_P \tag{2}$$

where

P is the either the design single wheel load, P_s, or the design tandem wheel load, P_t, in lbs (kN).

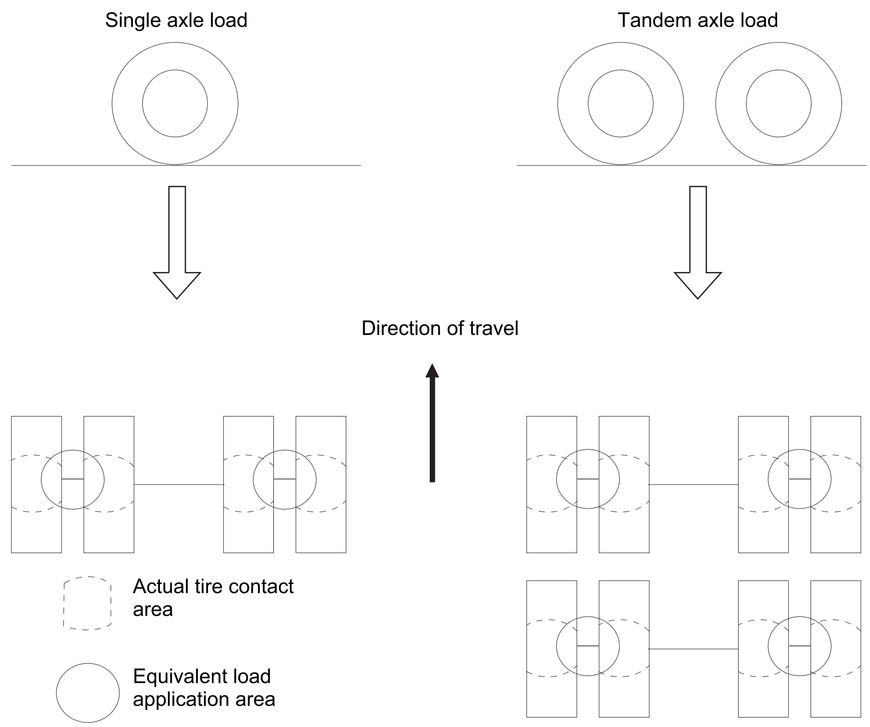
A_p is the contact area over which the wheel load is applied; A_p is taken as 144 in.^{2} (0.093 m^2).

For the recommended design loads of P_s = 12 kips = 12,000 lbs (53.4 kN) and P_t = 10 kips = 10,000 lbs (44.5 kN) the applied design surface pressures are as follows:

a) Single axle loading: w = 83.3 psi (574 kPa).

b) Tandem axle loading: w = 69.4 psi (479 kPa).

For design wheel loads different from the recommended maximums, refer to Annex A.



$$P_s = \frac{\text{Single axle load}}{2} \qquad P_t = \frac{\text{Tandem axle load}}{4}$$

Figure 6—Single and Tandem Wheel Loads, P_s and P_t

Table 1—Critical Axle Configurations for Design Wheel Loads of P_s = 12 Kips (53.4 kN) and P_t = 10 Kips (44.5 kN)

Depth of burial, H, < 4 ft (1.2 m) and diameter, D, ≤ 12 in. (305 mm)	
Pavement Type	Critical Axle Configuration
Flexible pavement No pavement Rigid pavement	Tandem axles Single axle Tandem axles
Depth, H, < 4 ft (1.2 m) and diameter, D, > 12 in. (305 mm) Depth, H, ≥ 4 ft (1.2m) for all diameters	
Pavement Type	Critical Axle Configuration
Flexible pavement No pavement Rigid pavement	Tandem axles Tandem axles Tandem axles

4.7.2.2.2 Impact Factor

It is recommended that the live load be increased by an impact factor, F_i, which is a function of the depth of burial, H, of the carrier pipeline at the crossing. The impact factor for both railroad and highway crossings is shown graphically in Figure 7. The impact factors are 1.75 for railroads and 1.5 for highways, each decreasing by 0.03 per ft (0.1 per m) of depth below 5 ft (1.5 m) until the impact factor equals 1.0.

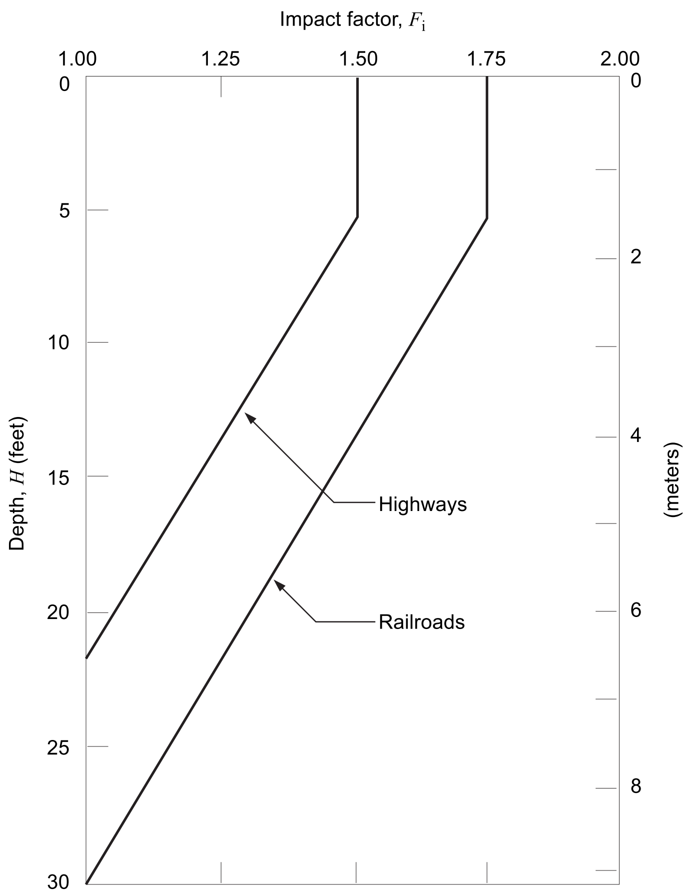


Figure 7—Recommended Impact Factor Versus Depth

4.7.2.2.3 Railroad Cyclic Stresses

4.7.2.2.3.1 The cyclic circumferential stress due to rail load, ΔS_{Hr}, (psi or kPa), may be calculated as follows:

$$\Delta S_{Hr} = K_{Hr} G_{Hr} N_H F_i w \quad (3)$$

where

K_{Hr} is the railroad stiffness factor for cyclic circumferential stress.

G_{Hr} is the railroad geometry factor for cyclic circumferential stress.

N_H is the railroad single or double track factor for cyclic circumferential stress.

F_i is the impact factor.

w is the applied design surface pressure, in psi or kPa.

The railroad stiffness factor, K_{Hr}, is presented as a function of the pipe wall thickness to diameter ratio, t_w/D, and soil resilient modulus, E_r, in Figure 8. Table A-2 in Annex A gives typical values for E_r.

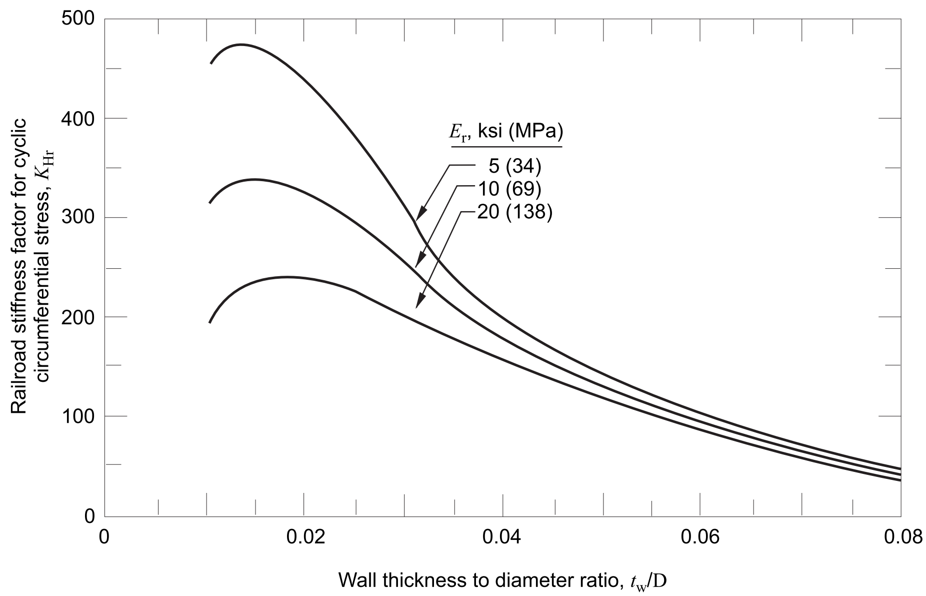


Figure 8—Railroad Stiffness Factor for Cyclic Circumferential Stress, K_{Hr}

The railroad geometry factor, G_{Hr}, is presented as a function of pipe diameter, D, and depth of burial, H, in Figure 9.

The single track factor for cyclic circumferential stress is, N_H = 1.00. The N_H factor for double track is shown in Figure 10.

4.7.2.2.3.2 The cyclic longitudinal stress due to rail load, ΔS_{Lr} (psi or kPa) may be calculated as follows:

$$\Delta S_{Lr} = K_{Lr} G_{Lr} N_L F_i w \quad (4)$$

where

K_{Lr} is the railroad stiffness factor for cyclic longitudinal stress.

G_{Lr} is the railroad geometry factor for cyclic longitudinal stress.

N_L is the railroad single or double track factor for cyclic longitudinal stress.

F_i is the impact factor.

w is the applied design surface pressure, in psi or kPa.

The railroad stiffness factor, K_{Lr}, is presented as a function of t_w/D and E_r in Figure 11.

The railroad geometry factor, G_{Lr}, is presented as a function of D and H in Figure 12.

The single track factor for cyclic longitudinal stress is N_L = 1.00. The N_L factor for double track is shown in Figure 13.

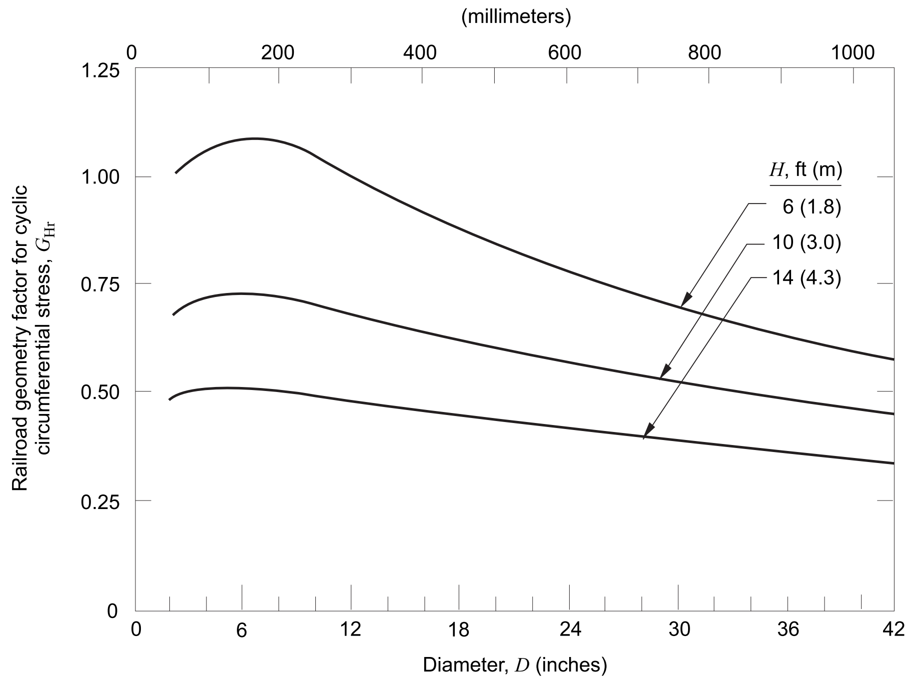


Figure 9—Railroad Geometry Factor for Cyclic Circumferential Stress, G_{Hr}

4.7.2.2.4 Highway Cyclic Stresses

4.7.2.2.4.1 The cyclic circumferential stress due to highway vehicular load, ΔS_{Hh} (psi or kPa), may be calculated from the following

$$\Delta S_{Hh} = K_{Hh} G_{Hh} R L F_i w \quad (5)$$

where

K_{Hh} is the highway stiffness factor for cyclic circumferential stress.

G_{Hh} is the highway geometry factor for cyclic circumferential stress.

R is the highway Pavement type factor.

L is the highway axle configuration factor.

F_i is the impact factor.

w is the applied design surface pressure, in psi or kPa.

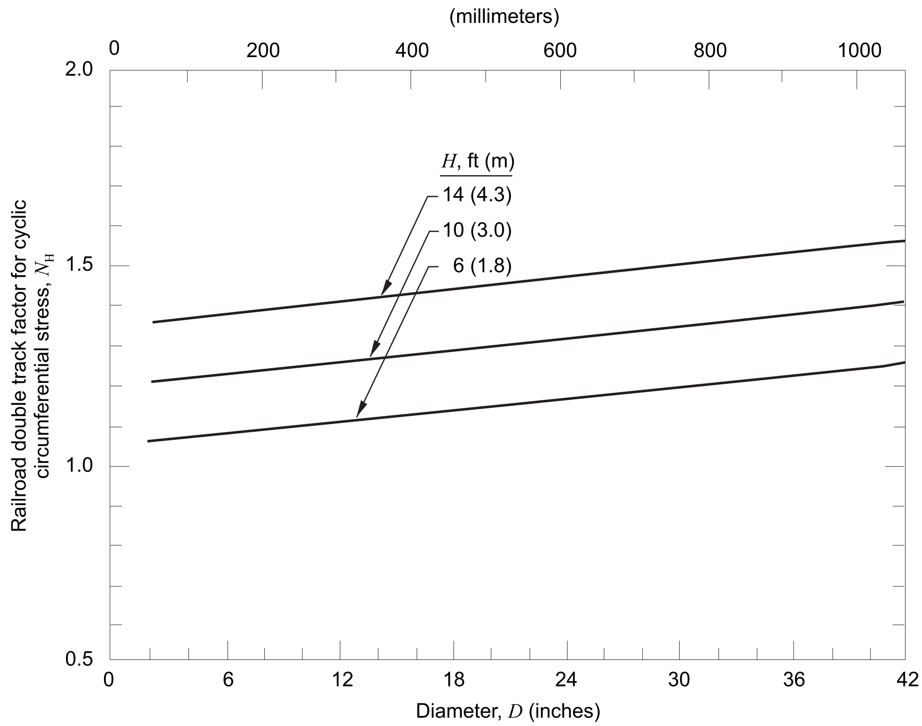


Figure 10—Railroad Double Track Factor for Cyclic Circumferential Stress, N_H

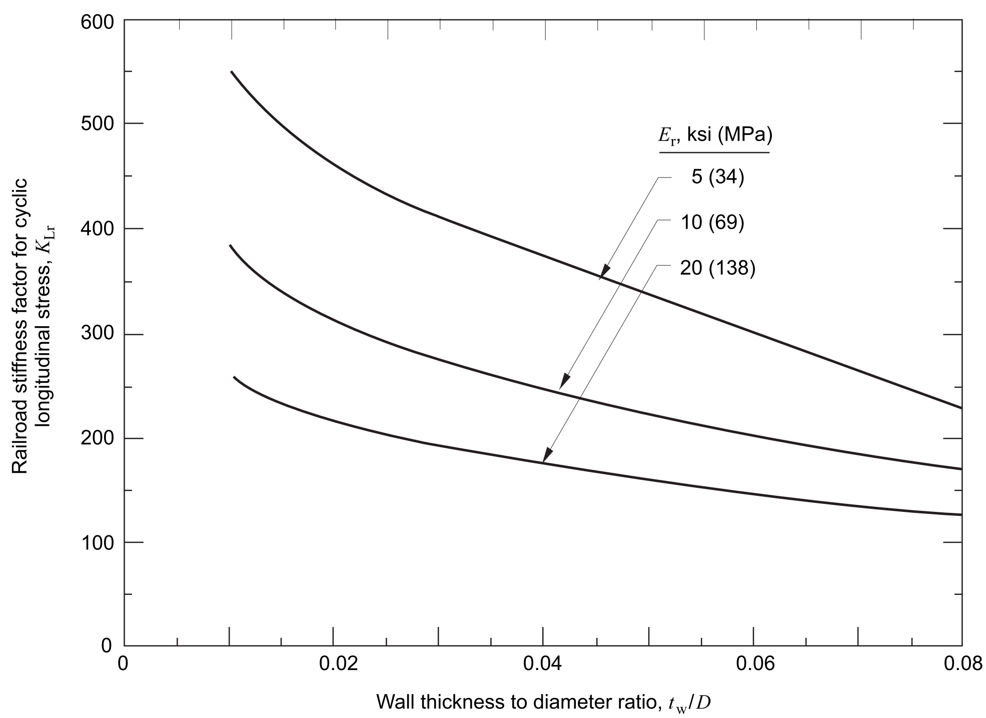


Figure 11—Railroad Stiffness Factor for Cyclic Longitudinal Stress, K_{Lr}

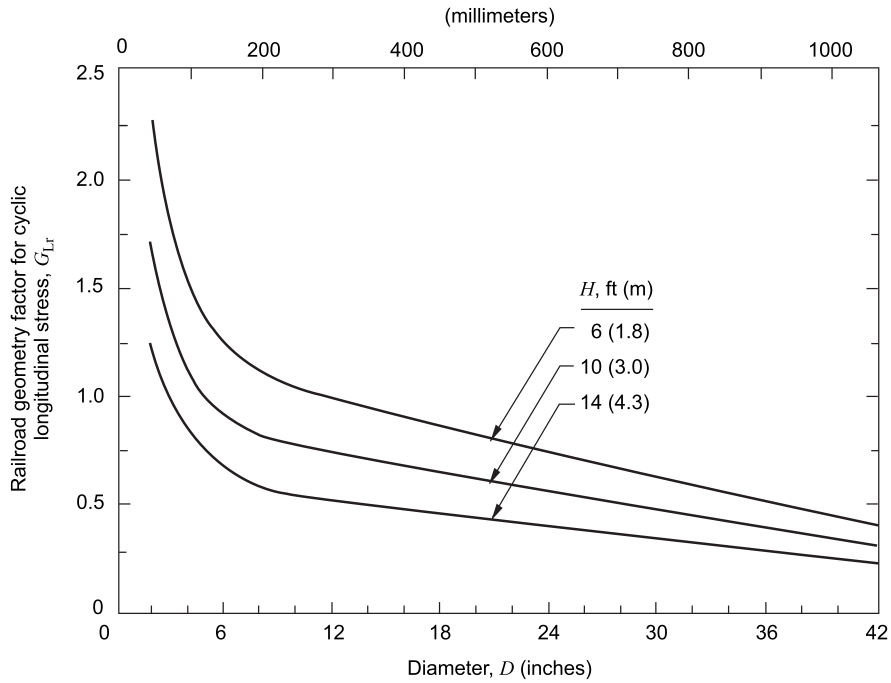


Figure 12—Railroad Geometry Factor for Cyclic Longitudinal Stress, G_{Lr}

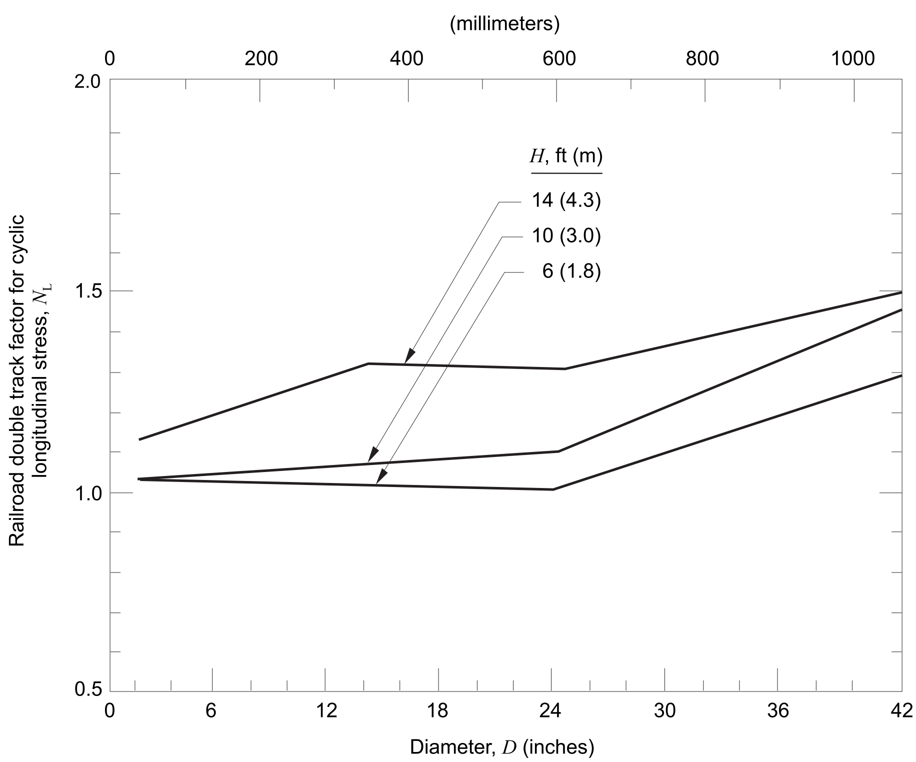


Figure 13—Railroad Double Track Factor for Cyclic Longitudinal Stress, N_L

The highway pavement type factor, R, and axle configuration factor, L, depend on the burial depth, H; pipe diameter, D; and design axle configuration (single or tandem). The decision on the design axle configuration has been described in 4.7.2.2.1. Table 2 presents the R and L factors for various H, D, pavement types, and axle configurations.

The highway stiffness factor, K_{Hh} is presented as a function of t_w/D and E_r in Figure 14.

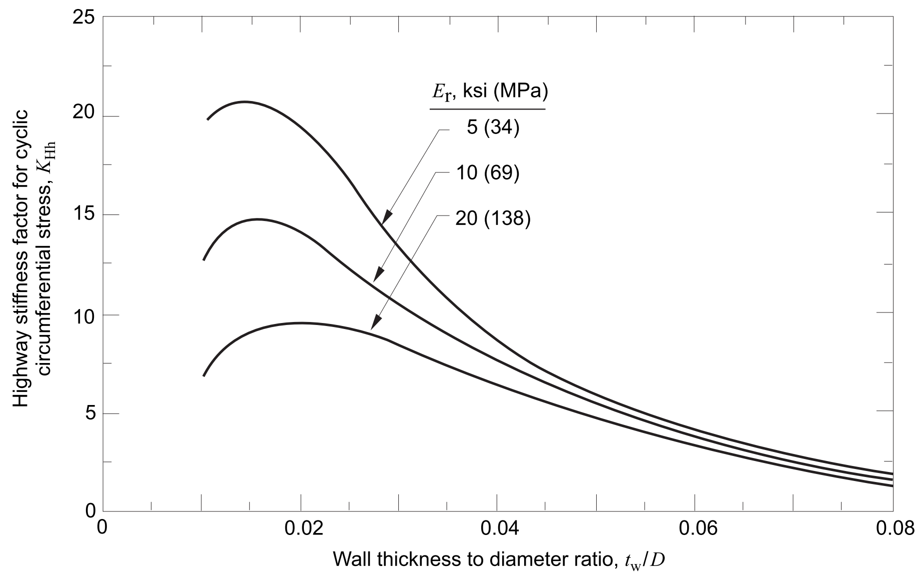


Figure 14—Highway Stiffness Factor for Cyclic Circumferential Stress, K_{Hh}

The highway geometry factor, G, is presented as a function of D and H in Figure 15.

4.7.2.2.4.2 The cyclic longitudinal stress due to highway vehicular load, ΔS_{Lh} (psi or kPa), may be calculated from the following:

$$\Delta S_{Lh} = K_{Lh} G_{Lh} R L F_i w \quad (6)$$

where

K_{Lh} is the highway stiffness factor for cyclic longitudinal stress.

G_{Lh} is the highway geometry factor for cyclic longitudinal stress.

R is the highway pavement type factor.

L is the highway axle configuration factor.

F_i is the impact factor.

w is the applied design surface pressure, in psi or kPa.

The pavement type factor, R, and axle configuration factor, L, are the same as given in Table 2.

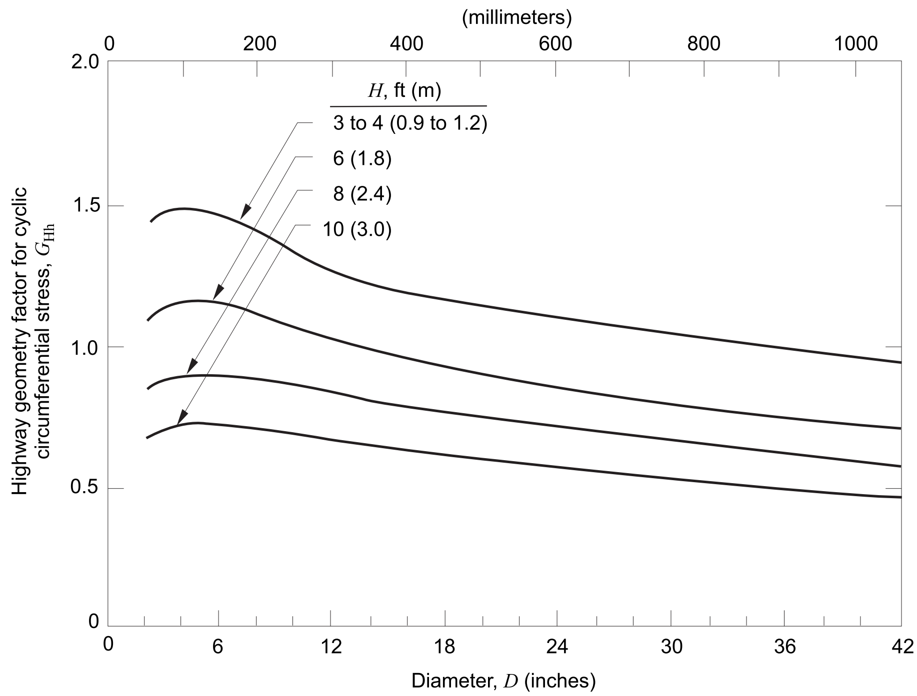


Figure 15—Highway Geometry Factor for Cyclic Circumferential Stress, G_{Hh}

The highway stiffness factor, K_{Lh}, is presented as a function of t_w/D and E_r in Figure 16.

The highway geometry factor, G_{Lh}, is presented as a function of D and H in Figure 17.

4.7.3 Stresses Due to Internal Load

The circumferential stress due to internal pressure, S_{Hi} (psi or kPa), may be calculated from the following:

$$S_{Hi} = p(D - t_w)/2t_w \quad (7)$$

where

p is the internal pressure, taken as the *MAOP* or *MOP*, in psi or kPa.

D is the pipe outside diameter, in in. or mm.

t_w is the wall thickness, in in. or mm.

4.8 Limits of Calculated Stresses

The stresses calculated in 4.7 may not exceed certain allowable values. The allowable stresses for controlling yielding and fatigue in the pipeline are described in the following subsections.

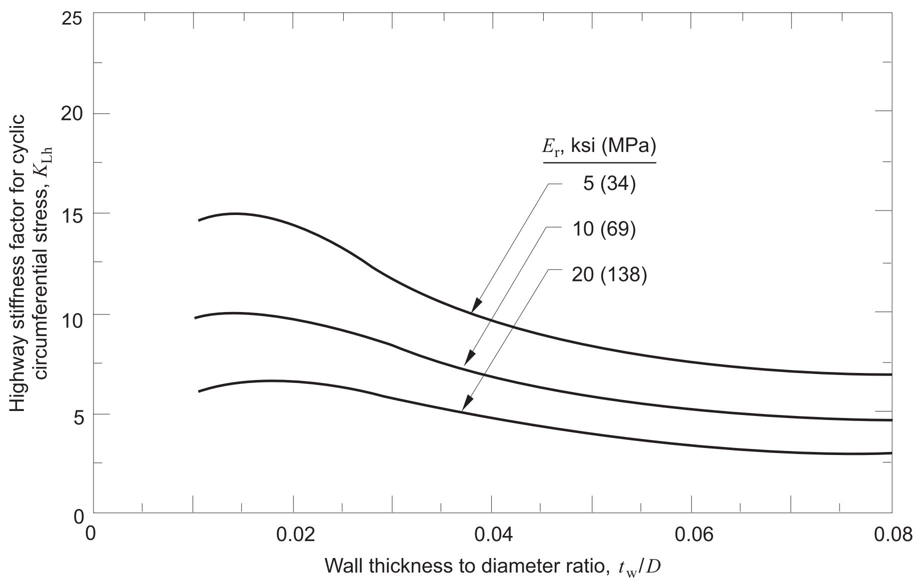


Figure 16—Highway Stiffness Factor for Cyclic Longitudinal Stress, K_{Lh}

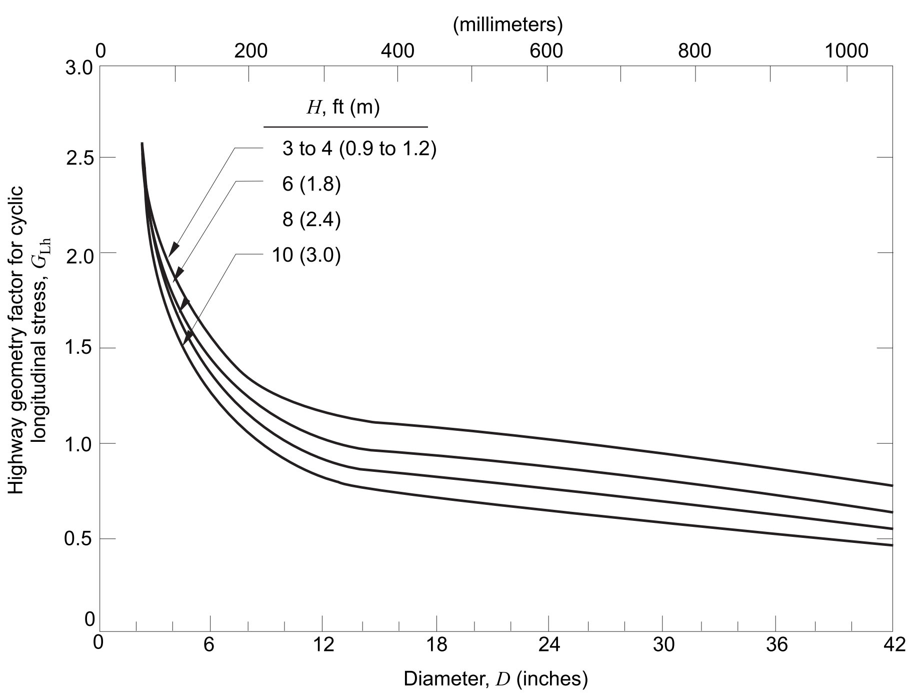


Figure 17—Highway Geometry Factor for Cyclic Longitudinal Stress, G_{Lh}

Table 2—Highway Pavement Type Factors, *R*, and Axle Configuration Factors, *L*

Depth, H, < 4 ft (1.2 m) and diameter, D, ≤ 12 in. (305 mm)			
Pavement Type	Design Axle Configuration	R	L
Flexible pavement	Tandem axle	1.00	1.00
	Single axle	1.00	0.75
No pavement	Tandem axle	1.10	1.00
	Single axle	1.20	0.80
Rigid pavement	Tandem axle	0.90	1.00
	Single axle	0.90	0.65
Depth, H, < 4 ft (1.2 m) and diameter, D, > 12 in. (305 mm) Depth H, ≥ 4 ft (1.2 m) for all diameters			
Pavement Type	Design Axle Configuration	R	L
Flexible pavement	Tandem axle	1.00	1.00
	Single axle	1.00	0.65
No pavement	Tandem axle	1.10	1.00
	Single axle	1.10	0.65
Rigid pavement	Tandem axle	0.90	1.00
	Single axle	0.90	0.65

4.8.1 Check for Allowable Stresses

4.8.1.1 Two checks for the allowable stress are required. The first is specified by 49 *Code of Federal Regulations* Part 192 or Part 195 [5, 6]. The circumferential stress due to internal pressurization, as calculated using the Barlow formula, S_{Hi} (Barlow) (psi or kPa), must be less than the factored specified minimum yield strength. This check is given by the following:

$$[S_{Hi}(\text{Barlow}) = pD/2t_w] \leq F \times E \times T \times SMYS$$

for natural gas, and (8a)

$$[S_{Hi}(\text{Barlow}) = pD/2t_w] \leq F \times E \times T \times SMYS$$

for liquids and other products (8b)

where

p is the internal pressure, taken as the *MAOP* or *MOP*, in psi or kPa.

D is the pipe outside diameter, in in. or mm.

t_w is the wall thickness. in in. or mm.

F is the design factor chosen in accordance with 49 *Code of Federal Regulations* Part 192.111 or Part 195.106.

E is the longitudinal joint factor.

T is the temperature derating factor.

SMYS is the specified minimum yield strength, in psi or kPa.

4.8.1.2 The second check for the allowable stress is accomplished by comparing the total effective stress, S_{eff} (psi or kPa), against the specified minimum yield strength multiplied by a design factor, F. Principal stresses, S_1, S_2, and S_3, (psi or kPa), are used to calculate S_{eff}. The principal stresses are calculated from the following:

$$S_1 = S_{He} + \Delta S_H + S_{Hi} \quad (9)$$

where

- S_1 is the maximum circumferential stress.
- ΔS_H is ΔS_{Hr}, in psi or kPa, for railroads, and

  is ΔS_{Hh}, in psi or kPa for highways.

$$S_2 = \Delta S_L - E_s \alpha_T (T_2 - T_1) + \nu_s (S_{He} + S_{Hi}) \quad (10)$$

where

- S_2 is the maximum longitudinal stress.
- ΔS_L is ΔS_{Lr} in psi or kPa, for railroads, and

  is ΔS_{Lh} in psi or kPa, for highways.
- E_s is Young's modulus of steel, in psi or kPa.
- α_T is the coefficient of thermal expansion of steel, per °F or per °C.
- T_1 is the temperature at time of installation, in °F or °C.
- T_2 is the maximum or minimum operating temperature, in °F or °C.
- v_s is Poisson's ratio of steel.

NOTE Table A-3, in Annex A gives typical values for E_s, v_s and α_T.

$$S_3 = -p = -MAOP \text{ or } -MOP \quad (11)$$

where

- S_3 is the maximum radial stress.

NOTE The Poisson effects from S_{He} and S_{Hi} are reflected in S_2 as v_s (S_{He} + S_{Hi}). The Poisson effect of ΔS_L on S_1 is not directly represented in the equation for S_1. The values of ΔS_H and ΔS_L in this recommended practice were derived from finite element analyses, thus they already embody the appropriate Poisson effects.

4.8.1.3 The total effective stress, S_{eff} (psi or kPa), may be calculated from the following:

$$S_{eff} = \sqrt{\frac{1}{2}[(S_1 - S_2)^2 + (S_2 - S_3)^2 + (S_3 - S_1)^2]} \quad (12)$$

The check against yielding of the pipeline may be accomplished by assuring that the total effective stress is less than the factored specified minimum yield strength, using the following equation:

$$S_{eff} \leq SMYS \times F \quad (13)$$

where

SMYS is the specified minimum yield strength, in psi or kPa.

F is the design factor.

The designer should use values for the design factor, *F*, consistent with standard practice or code requirements.

4.8.2 Check for Fatigue

The check for fatigue is accomplished by comparing a stress component normal to a weld in the pipeline against an allowable value of this stress, referred to as a fatigue endurance limit. These limits have been determined from *S-N* (fatigue strength versus number of load cycles) data [14, 15], and the minimum ultimate tensile strengths as given in API Specification 5L [16].

4.8.2.1 Girth Weld

The cyclic stress that must be checked for potential fatigue in a girth weld located beneath a railroad or highway crossing is the longitudinal stress due to live load. The design check is accomplished by assuring that the live load cyclic longitudinal stress is less than the factored fatigue endurance limit. The fatigue endurance limit of girth welds is taken as 12,000 psi (82,740 kPa), as shown in Table 3 for all steel grades and weld types..

Table 3—Fatigue Endurance Limits, S_{FG}, and S_{FL}, for Various Steel Grades

Steel Grade	*SMYS* (psi)	Minimum Ultimate Tensile Strength (psi)	S_{FG} (psi)	S_{FL} (psi)	
			All welds	Seamless and ERW	SAW
A25	25000	45000	12000	21000	12000
A	30000	48000	12000	21000	12000
B	35000	60000	12000	21000	12000
X42	42000	60000	12000	21000	12000
X46	46000	63000	12000	21000	12000
X52	52000	66000	12000	21000	12000
X56	56000	71000	12000	23000	12000
X60	60000	75000	12000	23000	12000
X65	65000	77000	12000	23000	12000
X70	70000	82000	12000	25000	13000
X80	80000	90000	12000	27000	14000
NOTE 1 pound per square inch (psi) = 6.895 kilopascals (kPa).					

The general form of the design check against girth weld fatigue is given by the following:

$$\Delta S_L \leq S_{FG} \times F \tag{14}$$

where

ΔS_L is ΔS_{Lr}, in psi or kPa, for railroads, and

is ΔS_{Lh} in psi or kPa, for highways.

S_{FG} is the fatigue endurance limit of girth yield = 12,000 psi (82,740 kPa).

F is the design factor

4.8.2.1.1 Railroad Crossing

4.8.2.1.1.1 Equation 14 is the general form of the girth weld fatigue check. Since the value of $\Delta S_L = \Delta S_{Lr}$ is influenced by whether a single or double track crossing was selected, this must be accounted for in the fatigue checks. It is overly conservative to assume that all of the applied load cycles will be those generated by simultaneous loading of both tracks, with the train wheel sets always in phase directly above the crossing. Therefore, the cyclic longitudinal stress used in the girth weld fatigue check at railroad crossings is based on the live load stress from a single track loading situation. The resulting equation is given by the following:

$$\Delta S_{Lr}/N_L \leq S_{FG} \times F \qquad (15)$$

where

ΔS_{Lr} is the cyclic longitudinal stress determined from Equation 4, in psi or kPa.

N_L is the single or double track factor used in Equation 4 (see note).

S_{FG} is the fatigue endurance limit of girth weld = 12,000 psi (82,740 kPa).

F is the design factor.

NOTE N_L = 1.00 for single track crossings.

4.8.2.1.1.2 Equation 15 is applicable to railroad crossings in which a girth weld is located at a distance, L_G less than 5 ft (1.5 m) from the centerline of the track. For other locations of a girth weld. Equation 15 is replaced by the following:

$$R_F \Delta S_{Lr}/N_L \leq S_{FG} \times F \qquad (16)$$

where

R_F is the longitudinal stress reduction factor for fatigue.

R_F is obtained from Figures 18-A and 18-B. Figure 18-A is for values of L_G greater than or equal to 5 ft (1.5 m) but less than 10 ft (3 m). Figure 18-B is for values of L_G greater than or equal to 10 ft (3 m).

4.8.2.1.2 Highway Crossing

Longitudinal stress reduction factors to account for girth weld locations are not used, nor are double lane factors used, since adjacent truck loadings already are considered in the design curves. The cyclic longitudinal stress for highway crossings is determined using Equation 6. The girth weld fatigue check is given by the following:

$$\Delta S_{Lh} \leq S_{FG} \times F \qquad (17)$$

4.8.2.2 Longitudinal Weld

4.8.2.2.1 The cyclic stress that must be checked for potential fatigue in a longitudinal weld located beneath a railroad or highway crossing is the circumferential stress due to live load. The check may be accomplished by assuring that the live load cyclic circumferential stress is less than the factored fatigue endurance limit.

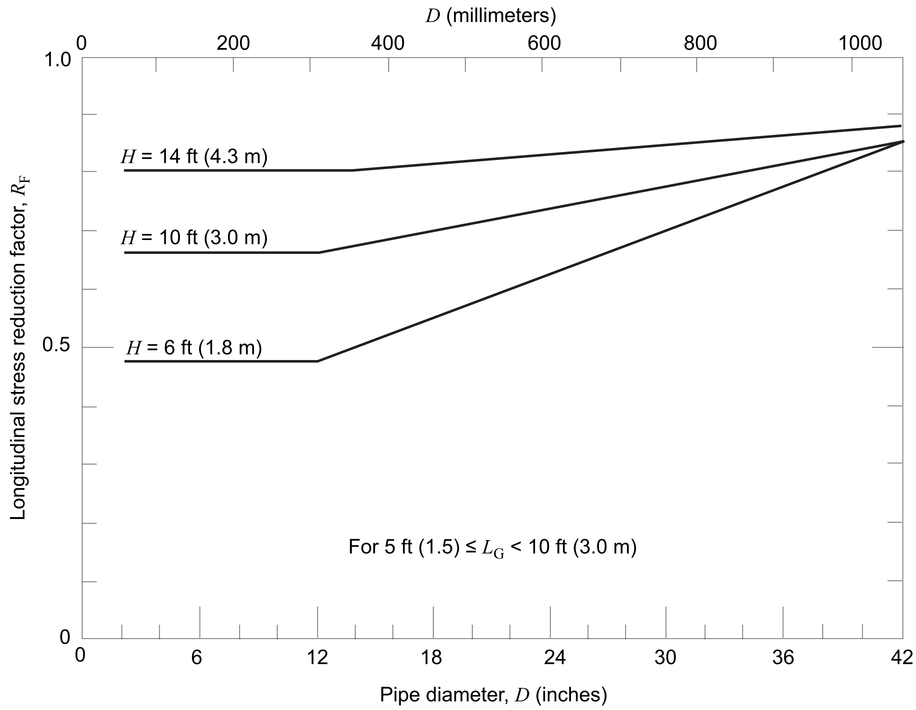


Figure 18-A—Longitudinal Stress Reduction Factors, R_F, for L_G Greater Than or Equal to 5 ft (1.5 m) but Less Than 10 ft (3 m)

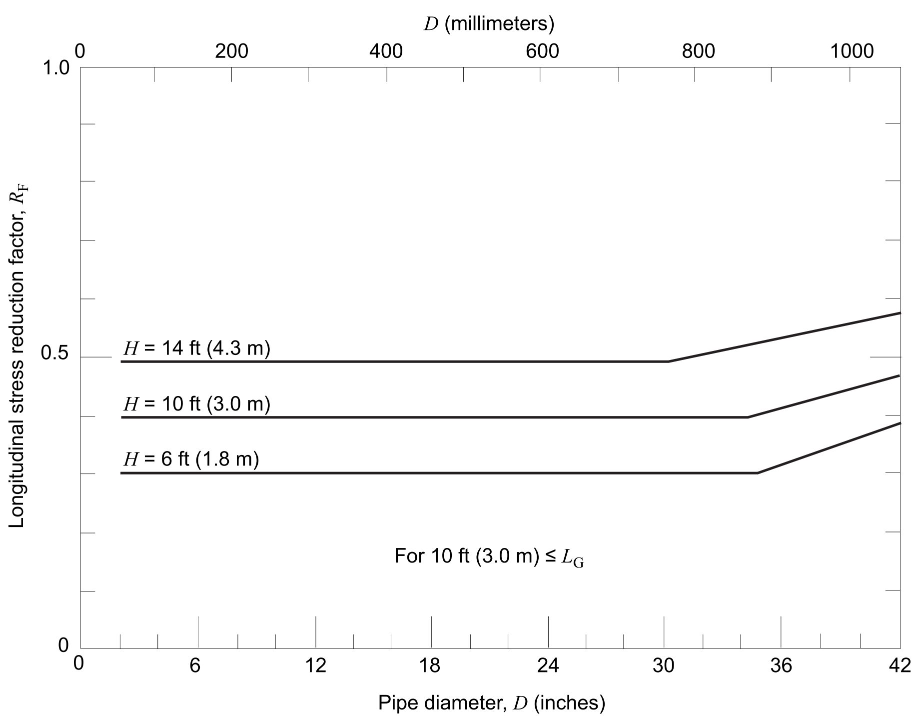


Figure 18-B—Longitudinal Stress Reduction Factors, R_F, for L_G Greater Than or Equal to 10 ft (3 m)

The fatigue endurance limit of longitudinal welds, S_{FL}, is dependent on the type of weld and the minimum ultimate tensile strength. Table 3 gives the fatigue endurance limits for seamless, ERW, and SAW longitudinal welds made in various grade steels. For *SMYS* values intermediate to those listed in Table 3, the fatigue endurance limits for the closest *SMYS* listed that is lower than the particular intermediate value should be used. For example, if the *SMYS* is 54,000 psi (372 mPa), the fatigue endurance limits for X52 grade steel would be used.

The general form of the design check most longitudinal weld fatigue is as follows:

$$\Delta S_H \le S_{FL} \times F \tag{18}$$

where

ΔS_H is ΔS_{Hr}, in psi or kPa, for railroads, and

is ΔS_{Hh}, in psi or kPa, for highways.

S_{FL} is the fatigue endurance limit of longitudinal weld obtained from Table 3, in psi or kPa.

F is the design factor.

4.8.2.2.2 Railroad Crossing

Equation 18 is the general form of the longitudinal weld fatigue check. As described in 4.8.2.1.1 dealing with girth weld fatigue at railroad crossings, it is overly conservative to use double track cyclic stresses for fatigue purposes. Therefore, the cyclic circumferential stress used in the longitudinal weld fatigue check at railroad crossings is the live load stress from a single track loading situation. The resulting equation is as follows:

$$\Delta S_{Hr} / N_H \le S_{FL} \times F \tag{19}$$

where

ΔS_{Hr} is the cyclic circumferential stress determined from Equation 3, in psi or kPa.

N_H is the single or double track factor used in Equation 3 (see note).

S_{FL} is the fatigue endurance limit of longitudinal weld obtained from Table 3, in psi or kPa.

F is the design factor.

NOTE N_H = 1.00 for single track crossings.

4.8.2.2.3 Highway Crossing

The cyclic circumferential stress for highway crossings is determined using Equation 5. The longitudinal weld fatigue check is as follows:

$$\Delta S_{Hh} \le S_{FL} \times F \tag{20}$$

Double lane factors are not used in the highway fatigue check since the design curves take adjacent truck loadings into account. The longitudinal weld fatigue endurance limits are given in Table 3.

4.9 Orientation of Longitudinal Welds at Railroad and Highway Crossings

The design checks against longitudinal weld fatigue in this recommended practice are based on the maximum value of the cyclic circumferential stress, ΔS_H. Thus, if the design check against longitudinal weld fatigue is satisfactory, locating the weld at any location is acceptable. However, it may be advantageous to consider the circumferential orientation of the pipeline welds during construction. The optimal location of all longitudinal welds is at the 45, 135, 225, or 315 degree position with the crown at the zero degree position. For any of these orientations, Equations 3 and 5 will predict conservative values of cyclic circumferential stress. Accordingly, these optimal weld locations listed provide an additional margin of safety against longitudinal weld fatigue.

4.10 Location of Girth Welds at Railroad Crossings

The optimal location of a girth weld at railroad crossings is at a distance, L_G, of at least 10 ft (3 m) from the centerline of the track for a single track crossing. As indicated in 4.8.2.1.1, substantial reductions in the value of applied cyclic longitudinal stress may be obtained in this case. No reduction factor should be taken for the fatigue check when evaluating pipeline crossings beneath two or more adjacent tracks. No reduction factor should be taken for the fatigue check associated with highway crossings. The variable positioning of highway traffic makes it impractical to locate girth welds for minimum cyclic loading effects.

5 Cased Crossings

5.1 Carrier Pipe Installed within a Casing

Design procedures for casings beneath railroad and highway crossings have been established and used in practice for many years. The relevant specifications for selecting minimal wall thickness in casings under railroads are given by the American Railway Engineering Association [11], and design practices suitable for casings beneath railroads and highways are provided by the American Society of Civil Engineers [13] and the American Society of Mechanical Engineers [8, 9, 12]. Carrier pipe for cased crossings should conform to the material and design requirements of the latest edition of ASME B31.4 or B3.1.8. Casings may be coated or bare.

5.2 Casings for Crossings

Suitable materials for casings are new or used line pipe, mill reject pipe, or other available steel tubular goods, including longitudinally split casings.

5.3 Minimum Internal Diameter of Casing

The inside diameter of the casing pipe should be large enough to facilitate installation of the carrier pipe, to provide proper insulation for maintenance of cathodic protection, and to prevent transmission of external loads from the casing to the carrier pipe. The casing pipe should be at least two nominal pipe sizes larger than the carrier pipe.

5.4 Wall Thickness

5.4.1 Bored Crossings

The minimum nominal wall thickness for steel casing pipe in bored crossings should equal or exceed the values shown in Annex C.

5.4.2 Open Trenched Crossings

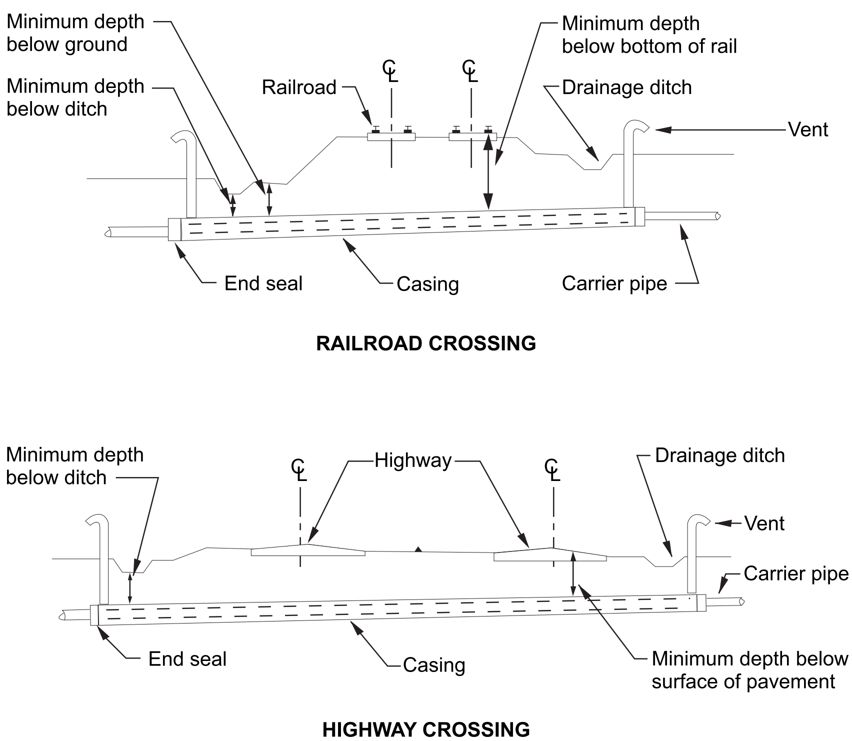
If the requirements of 5.7 are fulfilled at open cut or trenched installations, the minimum nominal wall thickness for steel casing for bored crossings in Annex C may be used. If the requirements of 5.7 cannot be met, installation of casing at greater depths, the use of heavier wall casing pipe, stabilized backfill, or other accepted methods should be utilized.

5.5 General

5.5.1 The casing pipe should be free of internal obstructions, should be as straight as practicable, and should have a uniform bedding for the entire length of the crossing. In addition to being properly compactable, padding and backfill must be of appropriate quality to prevent damage to pipeline and/or casing coatings.

5.5.2 The casing pipe should be installed with an overbore as small as possible so as to minimize the void between the pipe and the adjacent soil.

5.5.3 Steel casing pipe should be joined completely to ensure a continuous casing from end to end.



NOTE For simplicity, drawing does not include insulators/spacers (5.8 and 5.11) or test stations (6.3.6)

Figure 19—Examples of Cased Crossing Installations

5.6 Location and Alignment

5.6.1 Where casing pipe is installed, it should extend a minimum of 2 ft (0.6 m) beyond the toe of slope or base grade, 3 ft (0.9 m) beyond the bottom of the drainage ditch, whichever is greater (see Figure 19). Additionally for railroad crossings, the casing pipe should extend a minimum distance of 25 ft (7.6 m) each side from centerline of outside track when casing is sealed at both ends, or a minimum distance of 45 ft (13.7 m) each side of the centerline of the outside track when casing is open at both ends.

5.6.2 The angle of intersection between pipeline crossings and the railroad or highway to be crossed should be as near to 90 degrees as practicable. In no case should it be less than 30 degrees.

5.6.3 Crossings in wet or rock terrain, and where deep cuts are required, should be avoided where practicable.

5.6.4 Vertical and horizontal clearances between the pipeline and a structure or facility in place must be sufficient to permit maintenance of the pipeline and the structure or facility.

5.7 Cover

5.7.1 Railroad Crossings

Casing pipe under railroads should be installed with a minimum cover, as measured from the top of the pipe to the base of the rail, as follows (see Figure 19):

Location	Minimum Cover
a) Under track structure proper, except secondary and industry tracks.	5.5 ft (1.7 m)
b) Under track structure proper for secondary and industry tracks.	4.5 ft (1.4 m)
c) Under all other surfaces within the right-of-way or from bottom of ditches.	3 ft (0.9 m)
d) For pipelines transporting HVL, from the bottom of ditches.	4 ft (1.2 m)

5.7.2 Highway Crossings

Casing pipe under highways should be installed with a minimum cover, as measured from the top of the pipe to the top of the surface as follows (see Figure 19):

Location	Minimum Cover
a) Under highway surface proper.	4 ft (1.2 m)
b) Under all other surfaces within the right-of-way.	3 ft (0.9 m)
c) For pipelines transporting HVL, from the bottom of ditches.	4 ft (1.2 m)

5.7.3 Mechanical Protection

If the minimum coverage set forth in 5.7.1 and 5.7.2 cannot be provided, mechanical protection shall be installed.

5.8 Installation

5.8.1 Carrier pipe installed in a casing should be held clear of the casing pipe by properly designed supports, insulators, or other devices, and installed so that no external load will be transmitted to the carrier pipe. This also may be accomplished by building up a ring of layers of coating and outer wrap, or by a concrete jacket. Where manufactured insulators are used, they should be uniformly spaced and securely fastened to the carrier pipe.

5.8.2 Multiple carrier pipes may be installed with one casing pipe where restricted working areas, structural difficulties, or special needs are encountered. The stipulations in the above paragraph should apply, and each carrier pipe should be insulated from other carrier pipes, as well as from the casing pipe.

5.9 Casing Seals

The casing should be fitted with end seals at both ends to reduce the intrusion of water and fines from the surrounding soil. It should be recognized that a water-tight seal may not always be possible under field conditions, and in some circumstances water infiltration should be anticipated. The seal should be formed with a flexible material that will inhibit the formation of a waterway through the casing,

5.10 Casing Vents

5.10.1 Vents are not required on casings.

5.10.2 One or two vent pipes may be installed, if used, vent pipe should be not less than 2 in. (51 mm) in diameter, should be welded to the casing, and should project through the ground surface at the right-of-way line or fence line (see Figure 19). A hole through the casing not less than one-half the vent pipe diameter must be made prior to welding the casing vent over it.

5.10.3 Vent pipe should extend not less than 4 ft (1.2 m) above the ground surface. The tops of vents should be fitted with suitable weather caps.

5.10.4 Two vent pipes maybe installed to facilitate filling the casing with a "casing filler" by connecting the vent pipe at the low end of the casing to the bottom of the casing and connecting the vent pipe at the high end of the casing to the top of the casing.

5.11 Insulators

Insulators electrically isolate the carrier pipe from the casing by providing a circular enclosure that prevents direct contact between the two. The insulator should be designed to promote minimal bearing pressure between the insulator and carrier coating.

5.12 Inspection and Testing

Supervision and inspection should be provided during construction of the crossing. Before installation, the section of carrier pipe used at the crossing should be inspected visually for defects. All girth welds should be inspected by radiographic or other nondestructive methods. After a cased crossing is installed, a test should be performed to determine that the carrier pipe is electrically isolated from the casing pipe.

6 Installation

6.1 Trenchless Installation

6.1.1 General

Pipe jacking with an auger borer is the predominant means in U.S. practice of pipeline installation beneath railroads and highways. Percussive molding also is used but is restricted to small pipelines, typically less than 6 in. (150 mm) in diameter. For trenchless construction techniques that excavate an oversized hole relative to the size of the pipe, the diameter of the bored hole, B_d, needs to be known or specified before construction. By means of Figure 5, the designer can account for the influence of the bored hole diameter, B_d, on the earth load transmitted to the pipe.

When the auger is adjusted to excavate a hole equal in size to the pipe, or when percussive molding or a similar insertion method is used, the designer should assume that the bored diameter is equal to the pipe diameter, $B_d = D$.

6.1.2 Boring, Jacking, or Tunneling

6.1.2.1 Auger boring for a pipeline crossing often is performed with an auger that is a fraction of an inch to as much as 2 in. (51 mm) larger in diameter than the pipe, under circumstances in which the auger is advanced in front of the casing. Modifications of the method, such as reducing the auger size and fitting the pipe or casing with stops to prevent the auger from leading the pipe, can substantially reduce overexcavation. Reduction in the amount of overexcavation will decrease the chances of disturbing the surrounding soil and overlying facility and can diminish the amount of earth load imposed on the pipe. It should be recognized, however, that reductions in overcutting generally will increase frictional and adhesive resistance to the advance of the pipe. It may be necessary, therefore, to require trackmounted equipment in the launching pit with a suitable end bearing wall so that adequate jacking forces can be mobilized. For long or sensitive crossings, the use of bentonite slurry to lubricate the jacked pipe may be helpful.

6.1.2.2 The following provisions apply to bored, jacked, or tunneled crossings:

a) The diameter of the hole for bored or jacked installations should not exceed by more than 2 in. (51 mm) the outside diameter of the carrier pipe (including coating). In tunneled installations, the annular space between the outside of the pipe and the tunnel should be held to a minimum.

b) Where unstable soil conditions exist, boring, jacking, or tunneling operations should be conducted in a manner that will not be detrimental to the facility to be crossed.

c) If too large a hole results or if it is necessary to abandon a bored, jacked, or tunneled hole, prompt remedial measures should be taken to provide adequate support for the facility to be crossed.

6.1.3 Excavation

The pipe is jacked from an excavation, referred to as a launching pit, into an excavation, referred to as a receiving pit. Both the launching and receiving pits should be excavated and supported in accordance with applicable regulations to ensure the safety of construction personnel and to protect the adjacent railroad or highway.

6.1.4 Backfilling

Carefully placing and compacting the backfill under the carrier pipe in the launching and receiving pits helps reduce the settlement of the carrier pipe adjacent to the crossing. This, in turn, decreases the bending stress in the carrier pipe where it enters the backfilled launching and receiving pits. Good backfilling practice includes, but is not limited to, removing remolded and disturbed soil from the bedding of the carrier pipe and placing fill compacted in sufficiently small lifts to achieve a dense bedding for the carrier. Earth- or sand-filled bags or other suitable means should be used to firmly support the carrier pipe adjacent to the crossing prior to backfill. Support materials subject to biological attack, such as wooden blocking, may decompose and increase the chance of local corrosion.

6.2 Open Cut or Trenched Installation

6.2.1 General Conditions

6.2.1.1 Work on all trenched crossings from ditching to restoration of road surface should be scheduled to minimize interruption of traffic.

6.2.1.2 Where an open cut is used, the trench shall be sloped or shored in accordance with Occupational Safety and Health Administration (OSHA) requirements. The pipe as laid should be centered in the ditch so as to provide equal clearance on both sides between the pipe and the sides of the ditch.

6.2.1.3 The bottom of the trench should be prepared to provide the pipe with uniform bedding throughout the length of the crossing. In addition to being properly compactable, padding and backfill must be of appropriate quality to prevent damage to pipeline and/or casing coatings.

6.2.2 Backfill

Backfill should be compacted sufficiently to prevent settlement detrimental to the facility to be crossed. Backfill should be placed in layers of 12 in. (305 mm) or less (uncompacted thickness) and compacted thoroughly around the sides and over the pipe to densities consistent with that of the surrounding soil. Trench soil used for backfill (or a substituted backfill material) must be capable of producing the required compaction. In addition to being properly compactable, padding and backfill must be of appropriate quality to prevent damage to pipeline and/or casing coatings.

6.2.3 Surface Restoration

The surface of pavement that has been cut should be restored promptly in accordance with the appropriate highway or railroad authority's specifications.

6.3 General

The considerations listed in 6.3.1 through 6.3.7 apply to trenchless and open cut pipeline installation, irrespective of uncased or cased crossings.

6.3.1 Construction Supervision

Construction should be supervised by personnel qualified to oversee the welding of line pipe and the types of pipeline installation referred to in 6.1 and 6.2. The work should be coordinated, and close communication should be maintained between construction supervisors in the field and authorized agents of the railroad or highway to be crossed. Precautionary measures should be taken when transporting construction equipment across railroads and highways. Railroad and highway facilities should be protected at all times, and drainage ditches should be maintained to avoid flooding or erosion of the roadbed and adjacent properties.

6.3.2 Inspection and Testing

Inspection should be provided during the construction of the crossing. Before installation, the section of carrier pipe used at the crossing should be inspected visually for defects.

6.3.3 Welding

Carrier pipe at railroad or highway crossings should be welded with welding procedures developed in accordance with the latest approved edition of API Standard 1104, *Welding, of Pipelines and Related Facilities* [7]. Nondestructive testing in accordance with the aforementioned specification is required for all girth welds beneath or adjacent to the crossing. At uncased crossings, nondestructive testing normally will be required for girth welds within a horizontal distance of 50 ft (15 m) from either the outside or inside rail and from either the outside or inside highway pavement line. For cased crossings, the same applies for welds within 50 ft (15 m) of the end seals of the casing.

6.3.4 Pressure Testing

The carrier pipe section should be pressure tested before startup in accordance with 49 *CFR*, Part 192 or Part 195 requirements.

6.3.5 Pipeline Markers and Signs

Pipeline markers and signs should be installed as set forth in the latest approved edition of API Recommended Practice 1109, *Marking, Liquid Petroleum Pipeline Facilities* [17].

6.3.6 Cathodic Protection

6.3.6.1 Cathodic protection systems at cased crossings should be reviewed carefully. Casings may reduce or eliminate the effectiveness of cathodic protection. The introduction of a casing creates a more complicated electrical system than would prevail for uncased crossings, so there may be difficulties in securing and interpreting cathodic protection measurements at cased crossings. Test stations with test leads attached to the carrier pipe and casing pipe should be provided at each cased crossing.

6.3.6.2 A cased carrier pipe can be exposed to atmospheric corrosion as a result of air circulation through vents attached to the casing and moisture condensation in the casing annulus. A proper coating, jeep testing, proper spacing and end seals reduce the potential for atmospheric corrosion or electrical shorts. This problem may be minimized by filling the casing with a high dielectric casing filler, corrosion inhibitor, or inert gas. This is most easily accomplished immediately after construction.

6.3.7 Pipe Coatings

Pipeline coatings should be selected with due consideration of the construction technique and the abrasion and contact forces associated with pipeline installation. There are a variety of coatings that are tough and exhibit good resistance to surface stress, moisture adsorption, and cathodic disbondment. In areas where damage to the protective coating is likely, consideration should be given to applying an additional protective coating, such as concrete, over the carrier pipe coating prior to installation.

7 Railroads and Highways Crossing Existing Pipelines

7.1 Adjustment of Pipelines at Crossings

If an existing pipeline at a proposed railroad or highway crossing complies with the requirements of this practice, no adjustment of the pipeline is necessary. However, other considerations outside the scope of this recommended practice may necessitate an adjustment to an existing pipeline. If adjustments are required, the pipeline crossing should be lowered, repaired, reconditioned, replaced, or relocated in accordance with this practice.

7.2 Adjustment of In-service Pipelines

7.2.1 Lowering Operations

If lowering of the pipeline at a crossing in place is required, care should be exercised during the design phase and the lowering operation to prevent undue stress on the pipeline, in accordance with the latest approved edition of API Recommended Practice 1117, *Lowering In-Service Pipelines* [18]. The pipeline should be uncovered for a sufficient distance on either side of the crossing so that the carrier pipe may be uniformly lowered to fit the ditch at the required depth by natural sag. All movements of liquid petroleum pipelines should comply with the U.S. Department of Transportation's required maximum operating pressures, as contained in 49 *Code of Federal Regulations* Part 195 [6].

7.2.2 Split Casings

Where stress due to external loads of the railroad or highway necessitates casing of a pipeline, the casing may be installed by using the split casing method. This method provides for cutting the casing into two longitudinal segments and welding the segments together over the carrier pipe after the coating is repaired and casing insulators are installed. Precautions should be taken to prevent weld splatter from the welding operation from causing damage to the carrier pipe coating or the insulating spacers.

7.2.3 Temporary Bypasses

A temporary bypass utilizing suitable mechanical means to isolate the section to be adjusted may be installed to avoid interruption of service.

7.3 Adjustments of Pipelines Requiring Interruption of Service

When a pipeline cannot be taken out of service for more than a few hours for a required adjustment, a new separate crossing generally is constructed. In such cases, the only shutdown required is the time necessary for making the tie in connections of the new pipeline to the existing line.

7.4 Protection of Pipelines During Highway or Railroad Construction

An agreement between the pipeline company and the party constructing the crossing should be made to protect the pipeline from excessive loads or damage from grading (cut or fill) by work equipment during the construction of the railroad or highway. The pipeline alignment should be clearly marked with suitable flags, stakes, or other markers at the crossing. This recommended practice should be used to determine expected stresses on the pipeline. As necessary, suitable bridging, reinforced concrete slabs, or other measures should be employed to protect the pipeline.

Annex A

Supplemental Material Properties and Uncased Crossing Design Values

This annex contains tables and figures on material properties and design values that give supplemental information to that contained in the body of this recommended practice.

A.1 Tables of Typical Values

Table A-1—Typical Values for Modulus of Soil Reaction, E'

Soil Description	E', ksi (MPa)
Soft to medium clays and silts with high plasticities	0.2 (1.4)
Soft to medium clays and silts with low to medium plasticities; loose sands and gravels	0.5 (3.4)
Stiff to very stiff clays and silts; medium dense sands and gravels	1.0 (6.9)
Dense to very dense sands and gravels	2.0 (13.8)

Table A-2—Typical Values for Resilient Modulus, E_r

Soil Description	E_r, ksi (MPa)
Soft to medium clays and silts	5 (34)
Stiff to very stiff clays and silts; loose to medium dense sands and gravels	10 (69)
Dense to very dense sands and gravels	20 (138)

Table A-3—Typical Steel Properties

Property	Typical Range
Young's modulus, E_s, psi (kPa)	$28 - 30 \times 10^6$ $(1.9 - 2.1 \times 10^8)$
Poisson's ratio, v_s	0.25 – 0.30
Coefficient of thermal expansion, α_T, per °F (per °C)	$6 - 7 \times 10^{-6}$ $(1.6 - 1.9 \times 10^{-5})$

A.2 Critical Highway Axle Configurations

For design wheel loads different from the recommended maximums of P_s = 12 kips (53.4 kN) and P_t = 10 kips (44.5 kN), the critical axle configuration may be different than given in Table 1. Figure A-1 is used to determine whether single or tandem axle configurations produce greater carrier pipe live load stresses. If the design P_s and P_t coordinate ties above the line in Figure A-1 for a particular design pavement type, burial depth, H, and carrier pipe diameter, D, then single axle configurations are more critical. If the design P_s and P_t coordinate lies below the line in Figure A-1 for a particular design pavement type, then tandem axle configurations are more critical. In Figure A-1, the plotted points represent the recommended design loads of P_s = 12 kips (53.4 kN) and P_t = 10 kips (44.5 kN), with the resulting critical axle configurations as given in Table 1 in the main body of this recommended practice.

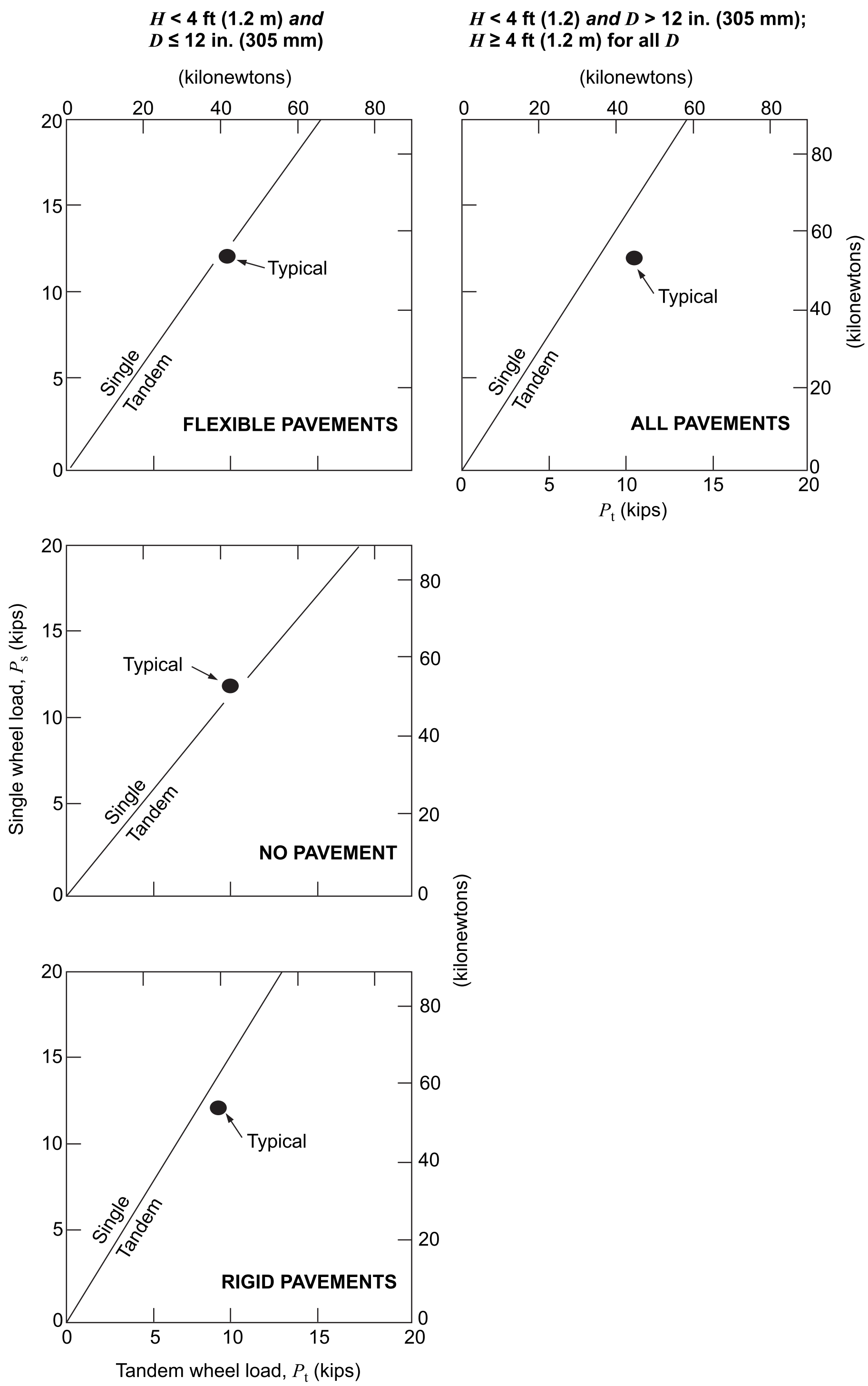


Figure A-1—Critical Case Decision Basis for Whether Single or Tandem Axle Configuration Will Govern Design

Annex B

Uncased Design Example Problems

B.1 Highway Crossing Design

A 12.75-in. (324-mm) diameter liquid product pipeline with a wall thickness of 0.250 in. (6.4 mm) is intended to cross a major highway that is paved with asphaltic concrete. The pipe is constructed of Grade X42 steel with ERW welds and will operate at a maximum pressure of 1000 psi (6.9 MPa). The pipeline will be installed without a casing at a design depth of 6 ft (1.8 m), using auger boring construction with a 2-in. (51-mm) overbore. The soil at the site was determined to be a loose sand with a resilient modulus of 10 kips/in.^{2} (69 MPa).

Using API Recommended Practice 1102, check whether the proposed design is adequate to withstand the applied earth load highway live load, and internal pressure. Ignore any change in pipe temperature.

Step a—initial Design Information

Pipe and operational characteristics:

Outside diameter, D	= 12.75 in.
Operating pressure, p	= 1,000 psi
Steel grade	= X42
Specified minimum yield strength, $SMYS$	= 42,000 psi
Design factor, F	= 0.72
Longitudinal joint factor, E	= 1.00
Installation temperature, T_1	= N/A
Maximum or minimum operating temperature, T_2	= N/A
Temperature derating factor, T	= N/A
Wall thickness, t_w	= 0.250 in.

Installation and site characteristics:

Depth, H	= 6.0 ft
Bored diameter, B_d	= 14.8 in.
Soil type	= Loose sand
Modulus of soil reaction, E'	= 0.5 ksi
Resilient modulus, E_r	= 10 ksi
Unit weight, γ	= 120 lb/ft^3 = 0.069 lb/in.^{3}
Type of longitudinal weld	= ERW
Design wheel load from single axle, P_s	= 12 kips
Design wheel load from tandem axles, P_t	= 10 kips
Pavement type	= Flexible

Other pipe steel properties:

Young's modulus, E_s	= 30,000 ksi
Poisson's ratio, v_s	= 0.30
Coefficient of thermal expansion, α_T	= 6.5×10^{-6} per °F

Step b—Check Allowable Barlow Stress

Equation 8b with:	p = 1,000 psi	S_{Hi} (Barlow) = 25,500 psi
	D = 12.75 in.	
	t_w = 0.250 in.	
	F = 0.72	$F \times E \times T \times SMYS$ = N/A
	E' = 1.00	$F \times E \times SMYS$ = 30,240 psi

		T = N/A $SMYS$ = 42,000 psi	
			S_{Hi} (Barlow) ≤ Allowable? Yes

Step c—Circumferential Stress Due to Earth Load

c.1	Figure 3 with:	t_w/D = 0.020 E' = 0.5 ksi	K_{He} = 3,024
c.2	Figure 4 with:	H/B_d = 4.9 Soil type = Loose sand = A	B_c = 1.09
c.3	Figure 5 with:	B_d/D = 1.16	E_e = 1.11
c.4	Equation 1 with:	D = 12.75 in. γ = 120 lb/ft^3 = 0.069 lb/in.^{3}	S_{He} = 3,219 psi

Step d—impact Factor, F_i,and Applied Design Surface Pressure, w

d.l	Figure 7 for highways with:	H = 6 ft	F_i = 1.47
d.2	Applied design surface pressure, w Section 4.7.2.2.1: Critical case: tandem axles	 Flexible pavement	 P_t = 10 kips w = 69.4 psi

Step e—Cyclic Stresses, ΔS_{Hh} and ΔS_{Lh}

e.1	Cyclic circumferential stress. ΔS_{Hh}		
e.1.1	Figure 14 with:	t_w/D = 0.020 E_r = 10 ksi	K_{Hh} = 14.3
e.1.2	Figure 15 with:	D = 12.75 in. H = 6 ft	G_{Hh} = 0.99
c.1.3	Table 2 with: Flexible pavement Tandem axles	 H = 6 ft D = 12.75 in.	R = 1.00 L = 1.00
e.1.4	Equation 5:		ΔS_{Hh} = 1,444 psi
e.2	Cyclic longitudinal stress, ΔS_{Lh}		
e.2.1	Figure 16 with:	t_w/D = 0.020 E_r = 10 ksi	K_{Lh} = 9.9
e.2.2	Figure 17 with:	D = 12.75 in. H = 6 ft	G_{Lh} = 1.01
e.2.3	Table 2 with: Flexible pavement Tandem axles	 H = 6 ft D = 12.75 in.	R = 1.00 L = 1.00
e. 2.4	Equation 6:		ΔS_{Lh} = 1,020 psi

Step f—Circumferential Stress Due to Internal Pressurization, S_{Hi}

Equation 7 with:	p = 1,000 psi D = 12.75 in. t_w = 0.250 in.	S_{Hi} = 25,000 psi

Step g—Principal Stresses, S_1, S_2, S_3

	$E_s = 30 \times 10^6$ psi $\alpha_T = 6.5 \times 10^{-6}$ per °F T_1 = N/A T_2 = N/A v_s = 0.30	
g.1 Equation 9 with:	S_{He} = 3,219 psi ΔS_{Hh} = 1,444 psi S_{Hi} = 25,000 psi	S_1 = 29,663 psi
g.2 Equation 10 with:	ΔS_{Lh} = 1,020 psi S_{He} = 3,219 psi S_{Hi} = 25,000 psi	S_2 = 9,486 psi
g.3 Equation 11 with:	p = 1,000 psi	S_3 = –1,000 psi
g.4 Effective stress, S_{eff} Equation 12 with:	S_1 = 29,663 psi S_2 = 9,486 psi S_3 = –1,000 psi	S_{eff} = 26,994 psi
g.5 Check allowable effective stress	F = 0.72 $SMYS$ = 42,000 psi	
Equation 13 with:	S_{eff} = 26,994 psi $SMYS \times F$ = 30,240 psi	
		$S_{eff} < SMYS \times F$? Yes

Step h—Check Fatigue

h.1 Girth welds	F = 0.72	
Table 3		S_{FG} = 12,000 psi
Equation 17 with:	ΔS_{Lh} = 1,020 psi $S_{FG} \times F$ = 8,640 psi	$\Delta S_{Lh} \leq S_{FG} \times F$? Yes
h.2 Longitudinal welds	F = 0.72	
Table 3		S_{FL} = 21,000 psi (ERW)
Equation 20 with:	ΔS_{Hh} = 1,444 psi $S_{FL} \times F$ = 15,120 psi	$\Delta S_{Hh} \leq S_{FL} \times F$? Yes

B.2 Railroad Crossing Design

The same 12.75-in. (324-mm) diameter, 0.250-in. (6.4-mm) wall thickness liquid product pipeline described in the highway example problem now will cross underneath two adjacent railroad tracks. The depth of the uncased carrier is 6 ft (1.8 m). All other design parameters are the same as those used for the highway crossing.

Using API Recommended Practice 1102, check whether the proposed design is adequate to withstand the applied earth load, railroad live load, and internal pressure. Ignore any changes in pipe temperature. Assume that there will be a girth weld within 5 ft (1.5 m) of either track centerline.

B.2.1 Railroad Example Problem

Step a—Initial Design Information

Pipe and operational characteristics:

Outside diameter, D	= 12.75 in.
Operating pressure, p	= 1,000 psi
Steel grade	= X42
Specified minimum yield strength, $SMYS$	= 42,000 psi
Design factor, F	= 0.72
Longitudinal joint factor, E	= 1.00
Installation temperature, T_1	= N/A
Maximum or minimum operating temperature, T_2	= N/A
Temperature derating factor, T	= N/A
Wall thickness, t_w	= 0.250 in.

Installation and site characteristics:

Depth, H	= 6.0 ft
Bored diameter, B_d	= 14.8 in.
Soil type	= Loose sand
Modulus of soil reaction, E'	= 0.5 ksi
Resilient modulus, E_r	= 10 ksi
Unit weight, γ	= 120 lb/ft^3 = 0.069 lb/in.^{3}
Type of longitudinal weld	= ERW
Distance of girth weld from track centerline, L_G	= 0 ft
Number of tracks (1 or 2)	= 2
Rail loading	= E-80

Other pipe steel properties:

Young's modulus, E_s	= 30,000 ksi
Poisson's ratio, v_s	= 0.30
Coefficient of thermal expansion, α_T	= 6.5 × 10^{-6} per °F

Step b—Check Allowable Barlow Stress

Equation 8b with:	p = 1,000 psi	S_{Hi} (Barlow) = 25,500 psi
	D = 12.75 in.	
	t_w = 0.250 in.	
	F = 0.72	$F \times E \times T \times SMYS$ = N/A
	E = 1.00	$F \times E \times SMYS$ = 30,240 psi
	T = N/A	
	$SMYS$ = 42,000 psi	
		S_{Hi} (Barlow) ≤ Allowable? Yes

Step c—Circumferential Stress Due to Earth Load

c.1	Figure 3 with:	t_w/D = 0.020 E' = 0.5 ksi	K_{He} = 3,024
c.2	Figure 4 with:	H/B_d = 4.9 Soil type = Loose sand = A	B_e = 1.09
c.3	Figure 5 with:	B_d/D = 1.16	E_e = 1.11
c.4	Equation 1 with:	D = 12.75 in. γ = 120 lb/ft^3 = 0.069 lb/in.^{3}	S_{He} = 3,219 psi

Step d—Impact Factor, F_i, and Applied Design Surface Pressure, w

d.1	Figure 7 for railroads with:	H = 6 ft	F_i = 1.72
d.2	Applied design surface pressure, w Section 4.7.2.2.1:	Rail loading = E-80	w = 13.9 psi

Step e—Cyclic Stresses, ΔS_{Hr} and ΔS_{Lr}

e.1 Cyclic circumferential stress. ΔS_{Hr}

e.1.1	Figure 8 with:	t_w/D = 0.020 E_r = 10 ksi	K_{Hr} = 332
e.1.2	Figure 9 with:	D = 12.75 in. H = 6 ft	G_{Hr} = 0.98
e.1.3	Section 4.7.2.2.3 and Figure 10 with:	N_t = 2	N_H=1.11
e.1.4	Equation 3:		ΔS_{Hr} = 8,634 psi

e.2 Cyclic longitudinal stress, ΔS_{Lr}

e.2.1	Figure 11 with:	t_w/D = 0.020 E_r = 10 ksi	K_{Lr} = 317
e.2.2	Figure 12 with:	D = 12.75 in. H = 6 ft	G_{Lr} = 0.98
e.1.3	Section 4.7.2.2.3 and Figure 13 with:	N_t = 2	N_L = 1.00
e.2.4	Equation 4:		ΔS_{Lr} = 7,427 psi

Step f—Circumferential Stress Due to Internal Pressurization, S_{Hi}

Equation 7 with:	p = 1,000 psi D = 12.75 in. t_w = 0.250 in.	S_{Hi} = 25,000 psi

Step g—Principal Stresses, S_1, S_2, S_3

	$E_s = 30 \times 10^6$ psi $\alpha_T = 6.5 \times 10^{-6}$ per °F T_1 = N/A T_2 = N/A $v_s = 0.30$	
g.1 Equation 9 with:	$S_{He} = 3{,}219$ psi $\Delta S_{Hr} = 8{,}634$ psi $S_{Hi} = 25{,}000$ psi	$S_1 = 36{,}853$ psi
g.2 Equation 10 with:	$\Delta S_{Lr} = 7{,}427$ psi $S_{He} = 3{,}219$ psi $S_{Hi} = 25{,}000$ psi	$S_2 = 15{,}893$ psi
g.3 Equation 11 with:	$p = 1{,}000$ psi	$S_3 = -1{,}000$ psi
g.4 Effective stress, S_{eff} Equation 12 with:	$S_1 = 36{,}853$ psi $S_2 = 15{,}893$ psi $S_3 = -1{,}000$ psi	$S_{eff} = 32{,}845$ psi
g,5 Check allowable effective stress	$F = 0.72$ $SMYS = 42{,}000$ psi	
Equation 13 with:	$S_{eff} = 32{,}845$ psi $SMYS \times F = 30{,}240$ psi	
		$S_{eff} \leq SMYS \times F$? No

B.2.2 Railroad Example Problem (Revised Wall Thickness)

Step a—Revised Design Information

Pipe and operational characteristics:

Outside diameter, D	= 12.75 in.
Operating pressure, p	= 1,000 psi
Steel grade	= X42
Specified minimum yield strength, $SMYS$	= 42,000 psi
Design factor, F	= 0.72
Longitudinal joint factor, E	= 1.00
Installation temperature, T_1	= N/A
Maximum or minimum operating temperature, T_2	= N/A
Temperature degrating factor, T	= N/A
Wall thickness, t_w	= 0.281 in.

Installation and site characteristics:

Depth, H	= 6.0 ft
Bored diameter, B_d	= 14.8 in.
Soil type	= Loose sand
Modulus of soil reaction, E'	= 0.5 ksi
Resilient modulus, E_r	= 10 ksi
Unit weight, γ	= 120 lb/ft^3 = 0.069 lb/in.^{3}
Type of longitudinal weld	= ERW

Distance of girth weld from track centerline, L_G	= 0 ft
Number of tracks (1 or 2)	= 2
Rail loading	= E-80

Other pipe steel properties:

Young's modulus, E_s	= 30,000 ksi
Poisson's ratio, v_s	= 0.30
Coefficient of thermal expansion, α_T	= 6.5×10^{-6} per °F

Step b—Check Allowable Barlow Stress

Equation 8a with:	p = 1.000 psi	S_{Hi} (Barlow) = 22,687 psi
	D = 12.75 in.	
	t_w = 0.281 in.	
	F = 0.72	$F \times E \times T \times SMYS$ = N/A
	E = 1.00	$F \times E \times SMYS$ = 30,240 psi
	T= N/A	
	$SMYS$ = 42,000 psi	
		S_{Hi} *(Barlow)* ≤ Allowable? Yes

Step c—Circumferential Stress Due to Earth Load

c.1 Figure 3 with:	t_w/D = 0.022 E'= 0.5 ksi	K_{He} = 2,500
c.2 Figure 4 with:	H/B_d = 4.9 Soil type = Loose sand = A	B_e = 1.09
c.3 Figure 5 with:	B_d/D = 1.16	E_e = 1.11
c.4 Equation 1 with:	D = 12.75 in γ = 120 lb/ft^3 = 0.069 lb/in.^{3}	S_{He} = 2,661 psi

Step d—Impact Factor, F_i, and Applied Design Surface Pressure, w

d.1 Figure 7 for railroads with:	H = 6 ft	F_i = 1.72
d.2 Applied design surface pressure, w Section 4.7.2.2.1:	Rail loading = E-80	w = 13.9 psi

Step e—Cyclic Stresses, ΔS_{Hr} and ΔS_{Lr}

e.1 Cyclic circumferential stress, ΔS_{Hr}

e.1.1 Figure 8 with:	t_w/D = 0.022 E_r = 10 ksi	K_{Hr} = 320
e.1.2 Figure 9 with:	D = 12.75 in. H = 6 ft	G_{Hr} = 0.98
e.1.3 Section 4.7.2.2.3 and Figure 10 with:	N_t = 2	N_H = 1.11
e.1.4 Equation 3:		ΔS_{Hr} = 8,322 psi

e.2 Cyclic longitudinal stress, ΔS_{Lr}

e.2.1	Figure 11 with:	t_w/D = 0.022 E_r = 10 ksi	K_{Lr} = 305
e.2.2	Figure 12 with:	D = 12.75 in. H = 6 ft	G_{Lr} = 0.98
e.2.3	Section 4.7.2.2.3 and Figure 13 with:	N_t = 2	N_L = 1.00
e.2.4	Equation 4:		ΔS_{Lr} = 7,146 psi

Step f—Circumferential Stress Due to Internal Pressurization, S_{Hi}

Equation 7 with:	p = 1,000 psi D = 12.75 in. t_w = 0.281 in.	S_{Hi} = 22,187 psi

Step g—Principal Stresses, S_1, S_2, S_3

		E_s = 30 × 10^6 psi α_T = 6.5 × 10^{-6} per °F T_1 = N/A T_2 = N/A v_s = 0.30	
g.1	Equation 9 with:	S_{He} = 2,661 psi ΔS_{Hr} = 8,322 psi S_{Hi} = 22,187 psi	S_1 = 33,170 psi
g.2	Equation 10 with:	ΔS_{Lr} = 7,146 psi S_{He} = 2,661 psi S_{Hi} = 22,187 psi	S_2 = 14,600 psi
g.3	Equation 11 with:	p = 1,000 psi	S_3 = -1,000 psi
g.4	Effective stress, S_{eff} Equation 12 with:	S_1 = 33,170 psi S_2 = 14,600 psi S_3 = –1,000 psi	S_{eff} = 29,629 psi
g.5	Check allowable effective stress Equation 13 with:	F = 0.72 $SMYS$ = 42,000 psi S_{eff} = 29,629 psi $SMYS \times F$ = 30,240 psi	$S_{eff} \leq SMYS \times F$? Yes

Step h—Check Fatigue

h.1	Girth welds	F = 0.72	
	Table 3		S_{FG} = 12,000 psi

h.1.1	If L_G < 5 ft (1.5 m) use:		
	Equation 15 with:	ΔS_{Lr} = 7,146 psi	$\Delta S_L / N_L \le S_{FG} \times F$? Yes
		N_L = 1.00	
		$\Delta S_{Lr}/N_L$ = 7,146 psi	
		$S_{FG} \times F$ = 8,640 psi	
h.1.2	If L_G > 5 ft (1.5 m) use:		
	Figure 18 with:	L_G =	R_F =
	Equation 16 with:	ΔS_{Lr} =	$R_F\ \Delta S_{Lr}/N_L \le S_{FG} \times F$?
		N_L =	
		$R_F\ \Delta S_{Lr}/N_L$ =	
		$S_{FG} \times F$ =	

h.2 Longitudinal welds

	F = 0.72	
Table 3		S_{FL} = 21,000 psi (ERW)
Equation 19 with:	ΔS_{Hr} = 8,322 psi	$\Delta S_{Hr}/N_H \le S_{FL} \times F$? Yes
	N_H = 1.11	
	$\Delta S_{Hr}/N_H$ = 7,498 psi	
	$S_{FL} \times F$ = 15,120 psi	

Annex C

Casing Wall Thicknesses

Table C-1—Minimum Nominal Wall Thickness for Flexible Casing in Bored Crossings

Nominal Pipe Diameter (in.)	Minimum Nominal Wall Thickness (in.)		
	Railroads		Highways
	When Coated or Cathodically Protected	When Not Coated or Cathodically Protected	
12.75 and under	0.188	0.188	0.134
14	0.188	0.250	0.134
16	0.219	0.281	0.134
18	0.250	0.312	0.134
20	0.281	0.344	0.134
22	0.281	0.344	0.164
24	0.312	0.375	0.164
26	0.344	0.406	0.164
28	0.375	0.438	0.164
30	0.406	0.469	0.164
32	0.438	0.500	0.164
34	0.469	0.531	0.164
36	0.469	0.531	0.164
38	0.500	0.562	0.188
40	0.531	0.594	0.188
42	0.562	0.625	0.188
44	0.594	0.656	0.188
46	0.594	0.656	0.219
48	0.625	0.688	0.219
50	0.656	0.719	0.250
52	0.688	0.750	0.250
54	0.719	0.781	0.250
56	0.750	0.812	0.250
58	0.750	0.812	0.250
60	0.781	0.844	0.250

Annex D

Unit Conversions

Table D-1—Unit Conversions

To Convert From	To	Multiply By
feet (ft)	meters (m)	0.3048
inches (in.)	millimeters (mm)	25.4
pounds (lb)	kilograms (kg)	0.4536
kips (k)	pounds (lb)	1000
	kilonewtons (kN)	4.448
pounds per square inch (psi)	kilopascals (kPa)	6.895
	kilonewtons per square meter (kN/m^2)	6.895
kips per square inch (ksi)	pounds per square inch (psi)	1000
	megapascals (MPa)	6.895
	meganewtons per square meter (MN/m^2)	6.895
degrees Fahrenheit, °F	degrees Celsius, °C = (°F – 32)/1.8	
pounds per cubic foot (pcf)	pounds per cubic inch (pci)	0.000579
(actually pounds-force)	kilonewtons per cubic meter (kN/m^3)	0.157

References

[1] M. G. Spangler, “Structural Design of Pipeline Casing Pipes,” *Journal of the Pipeline Division*, Volume 94, Number PLI, American Society of Civil Engineers, New York, October 1968, pp. 137 – 154.

[2] T. D. O’Rourke. A. R. Ingraffea, H. E. Stewart, G. L. Panozzo, J. R. Blewitt, and M. S. Tawfik, *State-of-the-Art Review: Practices for Pipeline Crossings at Railroads*, Report GRI-86/02 10, Gas Research Institute. Chicago, August 1986.

[3] T. D. O’Rourke. A. R. Ingraffea, H. E. Stewart, C. W. Crosslev, G. L. Panozzo, J. R. Blewitt, M. S. Tawfik, and A. Barry, *State-of-the-Art Review: Practices for Pipeline Crossings at Highways*, Report GRI-88/ 0287, Gas Research Institute. Chicago, September 1988.

[4] A. R. Ingraffea, T. D. O’Rourke, H. E. Stewart, M. T. Behn, A. Barry, C. W. Crossley, and S. L. El-Gharbawy, *Technical Seminar and Database for Guidelines for Pipelines Crossing Railroads and Highways*, Report GRI91/0185, Gas Research Institute, Chicago, December 1991.

[5] 49 *Code of Federal Regulations* Part 192, Department of Transportation, U.S. Government Printing Office, Washington, D.C.

[6] 49 *Code of Federal Regulations* Part 195, Department of Transportation, U.S. Government Printing Office, Washington, D.C.

[7] API Standard 1104, *Welding of Pipelines and Related Facilities,* American Petroleum Institute, Washington, D.C.

[8] ASME B31.4, *Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia, and Alcohols*, American Society of Mechanical Engineers, New York, NY.

[9] ASME B31.8, Gas *Transmission and Distribution Piping Systems*, American Society of Mechanical Engineers. New York, NY.

[10] A. Marston, “The Theory of External Loads on Closed Conduits in Light of Latest Experiments,” *Proceedings*, Volume 9, Highway Research Board, Washington, D.C., 1930, pp. 138 – 170.

[11] “Roadway and Ballast,” *Manual for Railway Engineering*, Chapter 1, American Railway Engineering Association, Washington, D.C., 1992, pp. 1-5-1 through 1-5-11.

[12] Gas Piping Technology Committee, *Guide for Gas Transmission and Distribution Piping Systems*, American Gas Association, Arlington, VA, 1990/91.

[13] Committee on Pipeline Crossings of Railroads and Highways, *Interim Specifications for the Design of Pipeline Crossings ofí Railroads and Highways*, American Society of Civil Engineers, New York, NY, January 1964.

[14] M. Clant, G. Cigada, D. Sinialio, and S. Venzi, “Fatigue Characteristics for Probabilistic Design of Submarine Vessels,” *Corrosion Science*, Volume 23, Number 6, 1983, pp. 621 – 636.

[15] DIN 2413, *Berechnung der Wanddicke von Stahlrohren gegen Innendruck* (*Calculation of wall Thickness for Steel Pipes Against Internal Pressure*), Deutsches Institute für Normurg, Berlin, April 1989.

[16] API Specification 5L, *Specification for Line Pipe*, American Petroleum Institute, Washington, D.C.

[17] API Recommended Practice 1109, *Marking Liquid Petroleum Pipeline Facilities*, American Petroleum Institute, Washington, D.C.

[18] API Recommended Practice 1117, *Movement of In-Service Pipelines*, American Petroleum Institute, Washington. D.C.

API

Effective January 1, 2007.
API Members receive a 30% discount where applicable.
The member discount does not apply to purchases made for the purpose of resale or for incorporation into commercial products, training courses, workshops, or other commercial enterprises.

2007 Publications Order Form

Available through IHS:
Phone Orders: 1-800-854-7179 (Toll-free in the U.S. and Canada)
303-397-7956 (Local and International)
Fax Orders: 303-397-2740
Online Orders: global.ihs.com

Date: ______________________

❑ **API Member** (Check if Yes)

Invoice To (❑ Check here if same as "Ship To")
Name:
Title:
Company:
Department:
Address:

City: State/Province:
Zip/Postal Code: Country:
Telephone:
Fax:
E-Mail:

Ship To (UPS will not deliver to a P.O. Box)
Name:
Title:
Company:
Department:
Address:

City: State/Province:
Zip/Postal Code: Country:
Telephone:
Fax:
E-Mail:

Quantity	Product Number	Title	SO★	Unit Price	Total
	D110420	API Std 1104, Welding of Pipelines and Related Facilities		$263.00	
	G05L43	API Spec 5L, Specification for Line Pipe		$209.00	
	D11093	API RP 1109, Marking Liquid Petroleum Pipeline Facilities		$79.00	
	D11172	API RP 1117, Movement of In-Service Pipelines		$90.00	

❑ **Payment Enclosed** ❑ **P.O. No.** (Enclose Copy) ______________

❑ **Charge My IHS Account No.** ______________

❑ **VISA** ❑ **MasterCard** ❑ **American Express** ❑ **Diners Club** ❑ **Discover**

Credit Card No.:

Print Name (As It Appears on Card):

Expiration Date:

Signature:

Subtotal	
Applicable Sales Tax *(see below)*	
Rush Shipping Fee *(see below)*	
Shipping and Handling *(see below)*	
Total *(in U.S. Dollars)*	

★ ***To be placed on Standing Order for future editions of this publication, place a check mark in the SO column and sign here:***

Pricing and availability subject to change without notice.

Mail Orders – Payment by check or money order in U.S. dollars is required except for established accounts. State and local taxes, $10 processing fee, and 5% shipping must be added. Send mail orders to: **API Publications, IHS, 15 Inverness Way East, c/o Retail Sales, Englewood, CO 80112-5776, USA.**
Purchase Orders – Purchase orders are accepted from established accounts. Invoice will include actual freight cost, a $10 processing fee, plus state and local taxes.
Telephone Orders – If ordering by telephone, a $10 processing fee and actual freight costs will be added to the order.
Sales Tax – All U.S. purchases must include applicable state and local sales tax. Customers claiming tax-exempt status must provide IHS with a copy of their exemption certificate.
Shipping (U.S. Orders) – Orders shipped within the U.S. are sent via traceable means. Most orders are shipped the same day. Subscription updates are sent by First-Class Mail. Other options, including next-day service, air service, and fax transmission are available at additional cost. Call 1-800-854-7179 for more information.
Shipping (International Orders) – Standard international shipping is by air express courier service. Subscription updates are sent by World Mail. Normal delivery is 3-4 days from shipping date.
Rush Shipping Fee – Next Day Delivery orders charge is $20 in addition to the carrier charges. Next Day Delivery orders must be placed by 2:00 p.m. MST to ensure overnight

e. There may be a 15% restock-

November 7, 2014

Vermont Gas Systems
Attn: Charlie Pughe, Project Manager
85 Swift Street
South Burlington, VT 05403

RE: Addison Natural Gas Project (ANGP) – Review of Pipe Loading within VELCO Corridor
Vermont Gas Systems, Inc.
CHA Project No. 28757.1006.30000

Dear Charlie,

As requested, CHA reviewed the live loading conditions on the transmission pipeline within the Vermont Electric Company (VELCO) right of way (ROW) for the Addison Natural Gas Project (ANGP). The review was performed to verify that the anticipated live loading conditions are within the acceptable factor of safety for the pipe. The review included calculations in general accordance with the American Petroleum Institute method, titled "Steel Pipelines Crossing Railroads and Highways" (API Recommended Practice 1102) and a review of the anticipated strain on the pipe using the method from the American Lifelines Alliance report titled "Guideline for Design of Buried Steel Pipe (July 2001)." The review was performed based on the specified materials, installation methods and calculation assumptions. Actual construction materials and methods are to be verified by Vermont Gas Systems, Inc. (VGS) to ensure the specified construction materials and methods are utilized and performed by the construction contractor. Our review is contingent on the Contractor adhering to the backfilling requirements detailed in the Contract Documents, specifically in the following sections:

1. Vermont Gas Systems (VGS) – Operation & Maintenance Manual, Part 192.319 Installation of Pipe in a Ditch, Section (b). This section states that pipe must be backfilled in a manner that "provides firm support under the pipe and prevents damage to the pipe and pipe coating from equipment or from the backfill material."
2. VGS Operating Procedures, "Excavation, Trenching and Backfilling" section, specifically the "Compaction – General" description.
3. VGS Operating Procedures, "Steel Pipe General", specifically Part E. which states "All backfill shall be compacted to avoid settling."
4. Technical Specification 312333

The pipeline within the VELCO ROW was designed as a Class 3 Location with a design factor of 0.5, in general accordance with Code of Federal Regulations (CFR) Title 49 part 192.111. The pipe to be used within the ROW is carbon steel with 12.75 inch outer diameter, 0.312 inch wall thickness, API-5L, Gr. X-65, PSL-2 with a Maximum Allowable Operational Pressure (MAOP) of 1440 pounds per square inch (psi) and all longitudinal welds on the pipe will be Electronic Resistance Welds (ERW). The pipe will be buried with a minimum of 4 feet of soft silt cover soils using open cut construction methods.

As specified by VELCO, the live loading condition on the pipe were based on the American Association of State Highway and Transportation Officials (AASHTO) HS-20 + 15% truck loading with a single axle load of 36,800 pounds (lbs.) (18,400 lbs. wheel load) on an unpaved surface.

The live load capacity of the pipe was calculated in general accordance with API Recommended Practice 1102 using the computer program GasCalc 5.0 version 007 developed by Bradley B. Bean, PE. Figure 1, attached, is a summary of the calculation performed. The calculation verified that the assumed external loading conditions are within the accepted limit of the pipe for the hoop stress, total effective stress, girth weld fatigue and longitudinal weld fatigue.

Using the method included in "Guideline for Design of Buried Steel Pipe" it was also verified that the anticipated live loads on the pipe are within acceptable factors of safety for wall crushing, wall buckling and ring deflection.

Based on the API Recommended Practice 1102 calculation method and Guideline for Design of Buried Steel Pipe, the anticipated live loading conditions within the VELCO ROW are acceptable. VGS is to verify that the materials, trench conditions and installation methods are in accordance with the project contact documents and specifications.

If you have any questions regarding the information provided, please contact me at (802) 735-0374.

Sincerely,

Brendan Kearns

Digitally signed by Brendan Kearns
DN: cn=Brendan Kearns, o, ou, email=bkearns@chacompanies.com, c=US
Date: 2014.11.07 15:43:03 -05'00'

Brendan Kearns
Engineer II

Attachment (1)
cc: Peter Lind, VELCO Senior Project Manager
V:\Projects\ANY\K3\28757\Corres\Verification of Live Loads_VELCO 11-7-14 Rev1

CHA

FIGURE 1: GASCalc Calculation Sheet

Crossing / External Loading Calculation: ANGP Live Load Verification

Project Identification: 24381
Prepared By: Brendan Kearns
Reviewed By: Tyler Billingsley

Calculation Data/Results...

Filename: c:\vt gas\velco gas calc.ext

Calculation Method: API Recommended Practice 1102

Pipe Data...
Outside Diameter: 12.750 Inches
Pipe Wall Thickness: .312 Inches
Pipe Specification: API 5L - Electric Resistance Welded
Pipe Grade: X65 - ERW
Maximum Pressure: 1440 Psi
Specified Minimum Yield Strength: 65000 Psi

Trench/Bore Data...
Excavation Type: Trenched
Trench/Bore Width: 3 Feet
Depth Below Grade: 4 Feet
Class Location: Class 3
Backfill Type: Silt - Soft

Crossing Data...
Crossing Type: Roadway
Impact Factor: No Pavement - Single
Maximum Load Per Wheel Set: 18400 Lb - Pounds

Calculated Values...
Combined Stress: 29314.050 Psi
Ratio Of Combined Stress To SMYS (Percent SMYS): 45.099%

Other Values...

Value Type	Value, Psi	Limit Value, Psi
Hoop Stress - Due To Internal Pressure	29423	32500 - OK
Effective (Combined) Stress	29314	46800 - OK
Fatigue Stress - Girth Weld	2364	6000 - OK
Fatigue Stress - Longitudinal Weld	2542	11500 - OK

Calculation Notes...

The Combined Stress value was calculated.

Comments:
These calculations are only valid for circular pipe and within the bounds and limits established by the selected calculation method.

These calculations are only valid for carbon steel pipe material.

References:
Calculation Method - American Petroleum Institute, Steel Pipelines Crossing Railroads and Highways, API Recommended Practice 1102, Sixth Ed, 1993.

VERMONT GAS SYSTEMS, INC.
P.O. Box 467
BURLINGTON, VERMONT 05402
(802) 863-4511
FAX (802) 863-8873

JOB: PIPE DESIGN CALCULATION FOR ANGP
SHEET NO. 1 OF 1
CALCULATED BY: CHRISTOPHER LEFORCE DATE: 6/2/2016
CHECKED BY: DATE:
SCALE: N/A

- PIPE DESIGN FORMULA FOR STEEL PIPE:

$$P = (2St/D) \times F \times E \times T$$

- NEED TO CALCULATE THE MINIMUM WALL THICKNESS NEEDED:

$$t = PD/(2S \times F \times E \times T).$$

- VGS PURCHASED X65 PIPE, SO YIELD STRENGTH (S) IS 65,000 PSI.
- THE PIPE IS DESIGNED TO BE FOR CLASS 3 LOCATIONS, SO THE DESIGN FACTOR (F) IS 0.5.
- THE PIPE WAS PURCHASED TO API 5L SPECIFICATION AND ELECTRIC RESISTANCE WELDED, SO THE LONGITUDINAL JOINT FACTOR (E) IS 1.00.
- THE GAS TEMPERATURE IN °F IN THE VGS SYSTEM IS LESS THAN 250. THE TYPICAL RANGE IS 30-70°F, SO THE TEMPERATURE DERATING FACTOR (T) IS 1.000.
- THE MAXIMUM DESIGN PRESSURE (P) IS 1,440 PSI AND THE NOMINAL OUTSIDE DIAMETER (D) IS 12.75 INCHES.
- $t = (1{,}440)(12.75) / [2(65{,}000) \times 1 \times 0.5 \times 1]$

t = 0.2824 INCHES (MINIMUM WALL THICKNESS TO MEET DESIGN)

- THE PIPE THAT WAS ORDERED IS: 12.75" O.D. × 0.312" W.T., STEEL, GRADE X65, API-5L, PSL-2.

Project Name: Vermont Gas Systems 5/25/2016

Location: Burlington, VT Rev. 1

Prepared for: Vermont Gas Systems

Prepared by: Mott MacDonald

Purpose:

Mott MacDonald has prepared the stress calculations included herein for Vermont Gas Systems, to ensure the pipeline's integrity under loading without compaction of backfill. The stress calculations were performed per API 1102, using various combinations of soil type and depth of cover to confirm that 90% compaction will not be necessary.

Knowns:

- Class 3 Location, Design Factor of 0.5
- 12.75 inch OD
- 0.312 inch WT
- API-5L Electric Resistance Welded
- Grade X-65
- MAOP of 1440 psi
- Design Wheel Load HS-20 + 15%

Results:

A summary table has been provided below. The stress calculations show that under all soil types, paired with 3', 4', and 5' of cover, the pipeline passes all stress checks (Hoop, Effective, Girth Weld, and Longitudinal Weld). In conclusion, Mott MacDonald recommends a minimum depth of cover of 4 feet. Although 3 feet of cover is sufficient under the given loading, a one foot buffer would help ensure that even if settlement were to occur, the pipeline would remain safe and operational.

API 1102 STRESS CALCULATION RESULTS			
	Calculated Effective Stress (psi)		
Soil type	3' Cover	4' Cover	5' Cover
Soft to medium clays and silts with high plasticities	31,239	31,437	31,234
Soft to medium clays and silts with low/medium plasticities	31,180	31,370	31,159
Loose sands and gravels	30,360	30,550	30,427
Stiff to very stiff clays and silts	30,216	30,366	30,193
Medium dense sands and gravels	30,278	30,453	30,318
Dense to very dense sands and gravels	29,422	29,554	29,437
ALLOWABLE EFFECTIVE STRESS (psi)	**32,500**		

Note:
1. Calculated girth weld and longitudinal weld stress values were less than the allowable (Girth: 6,000 psi & Long. Welds: 11,500 psi).

Mott MacDonald

Calculation cover sheet

Project Title:	VERMONT GAS SYSTEMS	**Project No:**	351481KK01
File No:		**No. of Sheets:**	18
Section:		**Subject:**	
Calc No:			
Project Manager:		**Designer:**	
Design Phase:	A - Concept or preliminary	C - Design verification	
	B - Analysis and detailed design	D - Other (specify)	

Computer Applications Used:	
Title:	Version Date:
PIPELINE TOOLBOX	2013

Scopes for Checking Manual and Computer Generated Calculations:

> Back check project information
> Back check individual calculations to verify results

Sheets Checked: *	**Calculations by:**			**Checked By:**		
	Name:	Signature:	Date:	Name:	Signature:	Date:
18/18	K. KIBBE	[signature]	5/25/16	J. WOJNAS	[signature]	5/25/16

**If an Excel spreadsheet or other computer file has been checked and has not been attached, enter the name, date and full file path or PIMS location of the file that was checked. (PIMS nickname or short link from Properties – General could also be useful.)*

a) Basic Design Information or Source and Reference:

> Design Info. per Mike Reagan's discussions with client
> API 1102 for design factors and procedure

b) Identify documents/technical records where output will be used:

> calculations summary provided to client

Approved by Project Manager:	**Signature:** [signature] **Print name:** Joseph WOJNAS	**Date:** 5/25/16

Distribution: Original to project file

Step

Project		
Vermont Gas Systems		
Location Burlington, VT	**Date** 5/24/2016	

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Soft to medium clays and silts with high plasticities
E' - Modulus of Soil Reaction [ksi]	0.2
Er - Resilient Modulus [ksi]	5.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	3
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	2,196
Burial Factor for Earth Load Circumferential Stress	0.83
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,331
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	16.60
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	4,271
Highway Stiffness Factor for Cyclic Longitudinal Stress	13.20
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	3,229

Maximum Circumferential Stress [psi]	34,305
Maximum Longitudinal Stress [psi]	12,239
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	31,239
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	31,239	32,500	PASS
Girth Welds	3,229	6,000	PASS
Long. Welds	4,271	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

Project		
Vermont Gas Systems		
Location: Burlington, VT	Date: 5/24/2016	

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Soft to medium clays and silts with high plasticities
E' - Modulus of Soil Reaction [ksi]	0.2
Er - Resilient Modulus [ksi]	5.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	4
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway
Safety Factor Applied:	API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	2,196
Burial Factor for Earth Load Circumferential Stress	0.97
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,555
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	16.60
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	4,271
Highway Stiffness Factor for Cyclic Longitudinal Stress	13.20
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	3,229

Maximum Circumferential Stress [psi]	34,529
Maximum Longitudinal Stress [psi]	12,306
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	31,437
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	31,437	32,500	PASS
Girth Welds	3,229	6,000	PASS
Long. Welds	4,271	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

Project	
Vermont Gas Systems	
Location Burlington, VT	**Date** 5/24/2016

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Soft to medium clays and silts with high plasticities
E' - Modulus of Soil Reaction [ksi]	0.2
Er - Resilient Modulus [ksi]	5.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	5
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	2,196
Burial Factor for Earth Load Circumferential Stress	1.08
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,732
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	16.60
Highway Geometry Factor for Cyclic Circumferential	1.10
Cyclic Circumferential Stress [psi]	3,850
Highway Stiffness Factor for Cyclic Longitudinal Stress	13.20
Highway Geometry Factor for Cyclic Longitudinal Stress	1.08
Cyclic Longitudinal Stress [psi]	3,006

Maximum Circumferential Stress [psi]	34,285
Maximum Longitudinal Stress [psi]	12,136
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	31,234
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	31,234	32,500	PASS
Girth Welds	3,006	6,000	PASS
Long. Welds	3,850	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

Project		
Vermont Gas Systems		
Location: Burlington, VT	Date: 5/24/2016	

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Soft to medium clays and silts with low/medium plasticities
E' - Modulus of Soil Reaction [ksi]	0.5
Er - Resilient Modulus [ksi]	5.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	3
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway
Safety Factor Applied:	API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	2,088
Burial Factor for Earth Load Circumferential Stress	0.83
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,265
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	16.60
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	4,271
Highway Stiffness Factor for Cyclic Longitudinal Stress	13.20
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	3,229

Maximum Circumferential Stress [psi]	34,239
Maximum Longitudinal Stress [psi]	12,219
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	31,180
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	31,180	32,500	PASS
Girth Welds	3,229	6,000	PASS
Long. Welds	4,271	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

Project		
Vermont Gas Systems		
Location: Burlington, VT	Date: 5/24/2016	

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Soft to medium clays and silts with low/medium plasticities
E' - Modulus of Soil Reaction [ksi]	0.5
Er - Resilient Modulus [ksi]	5.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	4
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway
Safety Factor Applied:	API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	2,088
Burial Factor for Earth Load Circumferential Stress	0.97
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,479
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	16.60
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	4,271
Highway Stiffness Factor for Cyclic Longitudinal Stress	13.20
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	3,229

Maximum Circumferential Stress [psi]	34,453
Maximum Longitudinal Stress [psi]	12,284
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	31,370
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	31,370	32,500	PASS
Girth Welds	3,229	6,000	PASS
Long. Welds	4,271	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

Project		
Vermont Gas Systems		
Location: Burlington, VT	Date: 5/24/2016	

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Soft to medium clays and silts with low/medium plasticities
E' - Modulus of Soil Reaction [ksi]	0.5
Er - Resilient Modulus [ksi]	5.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	5
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	2,088
Burial Factor for Earth Load Circumferential Stress	1.08
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,647
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	16.60
Highway Geometry Factor for Cyclic Circumferential	1.10
Cyclic Circumferential Stress [psi]	3,850
Highway Stiffness Factor for Cyclic Longitudinal Stress	13.20
Highway Geometry Factor for Cyclic Longitudinal Stress	1.08
Cyclic Longitudinal Stress [psi]	3,006

Maximum Circumferential Stress [psi]	34,200
Maximum Longitudinal Stress [psi]	12,111
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	31,159
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	31,159	32,500	PASS
Girth Welds	3,006	6,000	PASS
Long. Welds	3,850	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

Project		
Vermont Gas Systems		
Location: Burlington, VT	Date: 5/24/2016	

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Loose sands and gravels
E' - Modulus of Soil Reaction [ksi]	0.5
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	3
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	2,088
Burial Factor for Earth Load Circumferential Stress	0.83
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,265
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	12.60
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	3,241
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	2,275

Maximum Circumferential Stress [psi]	33,209
Maximum Longitudinal Stress [psi]	11,265
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	30,360
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,360	32,500	PASS
Girth Welds	2,275	6,000	PASS
Long. Welds	3,241	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

Project		
Vermont Gas Systems		
Location: Burlington, VT	Date: 5/24/2016	

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Loose sands and gravels
E' - Modulus of Soil Reaction [ksi]	0.5
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	4
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	2,088
Burial Factor for Earth Load Circumferential Stress	0.97
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,479
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	12.60
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	3,241
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	2,275

Maximum Circumferential Stress [psi]	33,423
Maximum Longitudinal Stress [psi]	11,330
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	30,550
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,550	32,500	PASS
Girth Welds	2,275	6,000	PASS
Long. Welds	3,241	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

Project Vermont Gas Systems		
Location Burlington, VT	Date 5/24/2016	

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Loose sands and gravels
E' - Modulus of Soil Reaction [ksi]	0.5
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	5
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	2,088
Burial Factor for Earth Load Circumferential Stress	1.08
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,647
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	12.60
Highway Geometry Factor for Cyclic Circumferential	1.10
Cyclic Circumferential Stress [psi]	2,923
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30
Highway Geometry Factor for Cyclic Longitudinal Stress	1.08
Cyclic Longitudinal Stress [psi]	2,118

Maximum Circumferential Stress [psi]	33,273
Maximum Longitudinal Stress [psi]	11,223
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	30,427
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,427	32,500	PASS
Girth Welds	2,118	6,000	PASS
Long. Welds	2,923	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

Project		
Vermont Gas Systems		
Location: Burlington, VT	Date: 5/24/2016	

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Stiff to very stiff clays and silts
E' - Modulus of Soil Reaction [ksi]	1.0
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	3
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway
Safety Factor Applied:	API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	1,934
Burial Factor for Earth Load Circumferential Stress	0.78
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,102
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	12.60
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	3,241
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	2,275

Maximum Circumferential Stress [psi]	33,046
Maximum Longitudinal Stress [psi]	11,216
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	30,216
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,216	32,500	PASS
Girth Welds	2,275	6,000	PASS
Long. Welds	3,241	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

Project		
Vermont Gas Systems		
Location: Burlington, VT	Date: 5/24/2016	

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Stiff to very stiff clays and silts
E' - Modulus of Soil Reaction [ksi]	1.0
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	4
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway
Safety Factor Applied:	API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	1,934
Burial Factor for Earth Load Circumferential Stress	0.90
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,271
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	12.60
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	3,241
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	2,275

Maximum Circumferential Stress [psi]	33,215
Maximum Longitudinal Stress [psi]	11,267
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	30,366
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,366	32,500	PASS
Girth Welds	2,275	6,000	PASS
Long. Welds	3,241	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

Project		
Vermont Gas Systems		
Location Burlington, VT	Date 5/24/2016	

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Stiff to very stiff clays and silts
E' - Modulus of Soil Reaction [ksi]	1.0
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	5
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	1,934
Burial Factor for Earth Load Circumferential Stress	0.98
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,384
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	12.60
Highway Geometry Factor for Cyclic Circumferential	1.10
Cyclic Circumferential Stress [psi]	2,923
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30
Highway Geometry Factor for Cyclic Longitudinal Stress	1.08
Cyclic Longitudinal Stress [psi]	2,118

Maximum Circumferential Stress [psi]	33,010
Maximum Longitudinal Stress [psi]	11,144
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	30,193
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,193	32,500	PASS
Girth Welds	2,118	6,000	PASS
Long. Welds	2,923	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

Project		
Vermont Gas Systems		
Location: Burlington, VT	Date: 5/24/2016	

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Medium dense sands and gravels
E' - Modulus of Soil Reaction [ksi]	1.0
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	3
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway
Safety Factor Applied:	API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	1,934
Burial Factor for Earth Load Circumferential Stress	0.83
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,172
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	12.60
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	3,241
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	2,275

Maximum Circumferential Stress [psi]	33,116
Maximum Longitudinal Stress [psi]	11,238
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	30,278
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,278	32,500	PASS
Girth Welds	2,275	6,000	PASS
Long. Welds	3,241	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By: Kelsey Kibbe	Approved By	Revision: 13.0.1

Project		
Vermont Gas Systems		
Location: Burlington, VT	Date: 5/24/2016	

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Medium dense sands and gravels
E' - Modulus of Soil Reaction [ksi]	1.0
Er - Resilient Modulus [ksi]	10.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	4
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway
Safety Factor Applied:	API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	1,934
Burial Factor for Earth Load Circumferential Stress	0.97
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,370
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	12.60
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	3,241
Highway Stiffness Factor for Cyclic Longitudinal Stress	9.30
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	2,275

Maximum Circumferential Stress [psi]	33,314
Maximum Longitudinal Stress [psi]	11,297
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	30,453
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,453	32,500	PASS
Girth Welds	2,275	6,000	PASS
Long. Welds	3,241	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

Project	Date
Vermont Gas Systems	
Location: Burlington, VT	5/24/2016

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi] 1440
Location Class: 3
Operating Temperature [°F] 60.0
Pipe Outside Diameter [in] 12.75
Pipe Wall Thickness [in] 0.312
Pipe Grade: X65
Specified Minimum Yield Stress 65,000
Design Factor 0.50
Longitudinal Joint Factor 1.0
Temperature Derating Factor 1.000
Pipe Class: API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi] 30,000
Poisson's Ratio for Steel 0.30
Coefficient of Thermal Expansion [per°F] 0.0000065

SITE AND INSTALLATION DATA:

Soil Type: Medium dense sands and gravels
E' - Modulus of Soil Reaction [ksi] 1.0
Er - Resilient Modulus [ksi] 10.0
Average Unit Weight of Soil [lb/ft³] 120.00
Pipe Depth [ft] 5
Bored Diameter [in] 12.75
InstallationTemperature [°F] 60.0
Design Wheel Load from Single Axle [kips] 18.4
Design Wheel Load from Tandem Axles [kips] 18.4
Pavement Type: None
Impact Factor Method: ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi] 29,423
Allowable Hoop Stress [psi] 32,500
Stiffness Factor for Earth Load Circumferential Stress 1,934
Burial Factor for Earth Load Circumferential Stress 1.08
Excavation Factor for Earth Load Circumferential Stress 0.83
Circumferential Stress from Earth Load [psi] 1,525
Impact Factor 1.50
Highway Stiffness Factor for Cyclic Circumferential 12.60
Highway Geometry Factor for Cyclic Circumferential 1.10
Cyclic Circumferential Stress [psi] 2,923
Highway Stiffness Factor for Cyclic Longitudinal Stress 9.30
Highway Geometry Factor for Cyclic Longitudinal Stress 1.08
Cyclic Longitudinal Stress [psi] 2,118

Maximum Circumferential Stress [psi] 33,151
Maximum Longitudinal Stress [psi] 11,186
Maximum Radial Stress [psi] -1,440
Total Effective Stress [psi] 30,318
Allowable Effective Stress [psi] 32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	30,318	32,500	PASS
Girth Welds	2,118	6,000	PASS
Long. Welds	2,923	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By	Approved By	Revision
Kelsey Kibbe		Revision: 13.0.1

Project	Date
Vermont Gas Systems	
Location Burlington, VT	5/24/2016

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Dense to very dense sands and gravels
E' - Modulus of Soil Reaction [ksi]	2.0
Er - Resilient Modulus [ksi]	20.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	3
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	1,693
Burial Factor for Earth Load Circumferential Stress	0.78
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	964
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	9.30
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	2,393
Highway Stiffness Factor for Cyclic Longitudinal Stress	6.20
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	1,517

Maximum Circumferential Stress [psi]	32,060
Maximum Longitudinal Stress [psi]	10,417
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	29,422
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	29,422	32,500	PASS
Girth Welds	1,517	6,000	PASS
Long. Welds	2,393	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By	Approved By	Revision
Kelsey Kibbe		Revision: 13.0.1

Project Vermont Gas Systems		
Location Burlington, VT	Date 5/24/2016	

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Dense to very dense sands and gravels
E' - Modulus of Soil Reaction [ksi]	2.0
Er - Resilient Modulus [ksi]	20.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	4
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway

Safety Factor Applied: API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	1,693
Burial Factor for Earth Load Circumferential Stress	0.90
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,113
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	9.30
Highway Geometry Factor for Cyclic Circumferential	1.22
Cyclic Circumferential Stress [psi]	2,393
Highway Stiffness Factor for Cyclic Longitudinal Stress	6.20
Highway Geometry Factor for Cyclic Longitudinal Stress	1.16
Cyclic Longitudinal Stress [psi]	1,517

Maximum Circumferential Stress [psi]	32,209
Maximum Longitudinal Stress [psi]	10,462
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	29,554
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	29,554	32,500	PASS
Girth Welds	1,517	6,000	PASS
Long. Welds	2,393	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

Project		
Vermont Gas Systems		
Location: Burlington, VT	Date: 5/24/2016	

API 1102 - Gas Pipeline Crossing Highway

PIPE AND OPERATIONAL DATA:

Operating Pressure [psi]	1440
Location Class:	3
Operating Temperature [°F]	60.0
Pipe Outside Diameter [in]	12.75
Pipe Wall Thickness [in]	0.312
Pipe Grade:	X65
Specified Minimum Yield Stress	65,000
Design Factor	0.50
Longitudinal Joint Factor	1.0
Temperature Derating Factor	1.000
Pipe Class:	API 5L Electric Resistance Welded
Young's Modulus for Steel [ksi]	30,000
Poisson's Ratio for Steel	0.30
Coefficient of Thermal Expansion [per°F]	0.0000065

SITE AND INSTALLATION DATA:

Soil Type:	Dense to very dense sands and gravels
E' - Modulus of Soil Reaction [ksi]	2.0
Er - Resilient Modulus [ksi]	20.0
Average Unit Weight of Soil [lb/ft³]	120.00
Pipe Depth [ft]	5
Bored Diameter [in]	12.75
InstallationTemperature [°F]	60.0
Design Wheel Load from Single Axle [kips]	18.4
Design Wheel Load from Tandem Axles [kips]	18.4
Pavement Type:	None
Impact Factor Method:	ASCE - Highway
Safety Factor Applied:	API 1102 Procedure

RESULTS

Hoop Stress [psi]	29,423
Allowable Hoop Stress [psi]	32,500
Stiffness Factor for Earth Load Circumferential Stress	1,693
Burial Factor for Earth Load Circumferential Stress	0.98
Excavation Factor for Earth Load Circumferential Stress	0.83
Circumferential Stress from Earth Load [psi]	1,211
Impact Factor	1.50
Highway Stiffness Factor for Cyclic Circumferential	9.30
Highway Geometry Factor for Cyclic Circumferential	1.10
Cyclic Circumferential Stress [psi]	2,157
Highway Stiffness Factor for Cyclic Longitudinal Stress	6.20
Highway Geometry Factor for Cyclic Longitudinal Stress	1.08
Cyclic Longitudinal Stress [psi]	1,412

Maximum Circumferential Stress [psi]	32,071
Maximum Longitudinal Stress [psi]	10,386
Maximum Radial Stress [psi]	-1,440
Total Effective Stress [psi]	29,437
Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Hoop	29,423	32,500	PASS
Effective	29,437	32,500	PASS
Girth Welds	1,412	6,000	PASS
Long. Welds	2,157	11,500	PASS

Notes: Open cut construction, calculations run using HS-20 loading + 15%

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

PIPA Recommended Practice ND13

ND13 "Reduce Transmission Pipeline Risk through Design and Location of New Utilities and Related Infrastructure"

Practice Statement Utilities (both above and below ground) and related infrastructure should be preferentially located and designed to reduce the consequences that could result from a transmission pipeline incident and to reduce the potential of interference with transmission pipeline maintenance and inspections.

Audience(s): Local Government, Property Developer and Owner

Practice Description

Utilities that cross and/or parallel transmission pipelines should be developed in close cooperation with the pipeline operator to avoid costly relocation of the pipeline or potential conflict with pipeline operations and maintenance. Items to consider include:

- The transmission pipeline's horizontal and vertical orientation must be considered, including any offset distance required by the transmission pipeline operator.
- Utilities crossing the transmission pipeline should be designed so they do not interfere with the pipeline, including its cathodic protection, and should assure the transmission pipeline operator has access to the pipeline.
- To the extent possible, design and construction of underground utilities and related infrastructure should try to minimize potential "migration paths" that could allow leaks from the pipeline to migrate to buildings.

Coordination with the transmission pipeline operator during planning and construction is critical, especially given the history of transmission pipeline incidents associated with utility installation and maintenance.

References

- Common Ground Alliance Best Practices
- American Petroleum Institute (API) Recommended Practice (RP) 1102, "Steel Pipelines Crossing Railroads And Highways" , 7th edition, 2007, API Product Number: D11021
- 49 CFR 192.467
- American Petroleum Institute (API) Recommended Practice (RP) 1162, Public Awareness Programs for Pipeline Operators

Navigate to Other Practices:

- **Baseline (BL) Recommended Practices**: BL01 BL02 BL03 BL04 BL05 BL06 BL07 BL08 BL09 BL10 BL11 BL12 BL13 BL14 BL15 BL16 BL17 BL18
- **New Development (ND) Recommended Practices**: ND01 ND02 ND03 ND04 ND05 ND06 ND07 ND08 ND09 ND10 ND11 ND12 **ND13** ND14 ND15 ND16 ND17 ND18 ND19 ND20 ND21 ND22 ND23 ND24 ND25 ND26 ND27 ND28
- **Table of Recommended Practices**

Interpretation Response #PI-75-0116

Below is the interpretation response detail and a list of regulations sections applicable to this response.

Interpretation Response Details

Response Publish Date: 12-02-1975

Location state: OK **Country:** US

View the Intepretation Document

Request text:

Williams Brothers Engineering Company
6600 South Yale Avenue
Tulsa, Oklahoma 74136

July 31, 1975
U. S. Department of Transportation Office of Pipeline Safety
Washington, D. C. 20590

Attention: Mr. Ceasar De Leon
Subject: Interpretation of Sub-Sections 192.103, 192.105, and 192.111(b)(2)
Gentlemen:

Attached is a print of our Figure 1-12.
Sub-sections 192.103, 192.105(a) and 192. 111(b)(2) deal with external loads, design formula for steel pipe, and design factor (F) for steel pipe.

INTERPRETATIONS BROWSER

View All

Hazmat

Pipelines

The attached Figure 1-12 is an example that illustrates our interpretation of these sub-sections of the code. Basically our interpretation is that for any given pipe size and wall thickness; and for a given design factor (F) the design pressure (internal pressure allowed) will be a lesser pressure when installed uncased under a hard surface road than when installation results in parallel encroachment on roads right-of-way.

Our interpretation is based upon:

A. 192. 103
Pipe must be designed with sufficient wall thickness, or must be installed with adequate protection to withstand anticipated external pressures and loads that will be imposed on the pipe after installation.

B. 192.105 (a)
t = Nominal wall thickness of the pipe in inches. ... additional wall thickness required for concurrent external loads in accordance with 192.103 may not be included in computing design pressure.

C. API RP 1102 Fourth Edition, September 1968 - Recommended Practice for Liquid Petroleum Pipelines Crossing Railroads and Highways

Paragraphs 3.1 a, b, and c.

Using this information Figure 1-12 has been constructed and indicates that for 12.75" 0.D. x .255" W. T., X-60 pipe the design pressure would be limited to 1350 psig for an uncased road crossing of a hard surfaced road in a Class 1.location, while the design pressure for the same pipe would be 1440 psig for parallel encroachment on highways or public streets in a Class I location.

Please advise if you concur with our interpretation of the regulations. Your prompt consideration of this matter will be appreciated.

Yours very truly,

WILLIAMS BROTHERS ENGINEERING COMPANY
J. L. Williams Attachment

Response text:

December 2, 1975

Mr. J.L. Williams
Williams Brothers Engineering Company
6600 South Yale Avenue
Tulsa, OK 74136

Dear Mr. Williams:
This is with regard to the telephonic conversation between you and Mr. George L. Mocharko of this Office concerning installing gas pipelines uncased under a hard surface road.

Your interpretation of 49 CPR §192.103, §192.105, and §192.111(b)(2) is correct per your letter and attachments dated August 4, 1975.

We trust this adequately responds to your inquiry.

Sincerely,
SIGNED
Cesar DeLeon Acting Director Office of Pipeline Safety Operations

Regulation Sections

Section	Subject

Section	Subject
§ 192.103	General

INTERPRETATIONS BROWSER

Proceedings of the 2016 11th International Pipeline Conference
IPC2016
September 26-30, 2016, Calgary, Alberta, Canada

IPC2016-64050

A NEW APPROACH TO DETERMINE THE STRESSES IN BURIED PIPES UNDER SURFACE LOADING

Fan Zhang, PhD
Kiefner and Associates Inc.
Columbus, OH, USA

Nathan Branam
Kiefner and Associates Inc.
Columbus, OH, USA

Benjamin Zand, PhD
Kiefner and Associates Inc.
Columbus, OH, USA

Mark Van Auker
Kiefner and Associates Inc.
Columbus, OH, USA

ABSTRACT

All buried pipes experience loading from the weight of soil overburden. When pipelines cross railroads, roads, parking lots or construction sites, the pipes also experience live surface loading from vehicles on the ground, including heavy construction equipment in some scenarios. The surface loading results in through-wall bending in pipes, which generates both hoop stress and longitudinal stress. Current standards limit the stresses in buried pipes to maximum values in terms of hoop stress, longitudinal stress and combined biaxial stress. An early approach to estimating stresses and deformations in a pipe subjected to surface loads dates back to Spangler's work in the 1940s. Many models have been developed since then. API RP 1102 provides guidance for the design of pipeline crossings of railroads and highways following the model developed by Cornell University for the Gas Research Institute (GRI). The Cornell model was developed only based on experiments on bored pipes crossing a railroad or a highway at a near-right angle. The live surface loading distribution is also limited to the wheel-layout typical of railroad cars and highway vehicles. Most other existing models only focus on the hoop stress in the pipe. In this paper, a new approach to determine the stresses in buried pipes under surface loading is introduced. The approach is suitable for assessing pipes beneath any type of vehicle or equipment at any relative position and at any angle to the pipe. First, the pressure on the pipe from surface loading is determined through the Boussinesq theory. Second, both hoop stress and longitudinal stress in the pipe are estimated. The hoop stress is estimated through the modified Spangler stress formula proposed by Warman and his co-workers (2006 and 2009). The longitudinal stress, due to local bending and global bending, is estimated by the theory of beam-on-elastic-foundation. The modulus of foundation can be determined through the soil-spring model developed by ASCE. The hoop stress, longitudinal stress and the resulting combined biaxial stress can then be compared against their respective limits from a pertinent standard to assess the integrity of the pipe and determine the proper remediation approach, if necessary. The performance of the proposed approach is compared in this study with the experimental results in the literature and the predictions from API RP 1102.

INTRODUCTION

The pipeline industry has had a vested interest in stresses in buried pipes due to surface loading since Spangler, at Iowa State University, conducted the pioneer work on the topic in the 1940s [1,2,3,4]. Spangler computed hoop stresses in buried pipe with the consideration of the stiffness effect from internal pressure. The formula was known as the "Spangler stress formula", and was later used in an early version of API RP 1102 [5]. He also developed an equation to compute ovality in buried culverts, known as the "Iowa formula", which accounts for bearing support from soil surrounding the pipes.

A multi-year project, sponsored by GRI and conducted by researchers at Cornell University [6,7,8], developed formulae based on finite element analysis (FEA) of bored installed pipes under surface loads. The formulae estimate both hoop stress and longitudinal stress resulting from surface loads, which enable a more accurate estimation of combined biaxial stress. The combined biaxial stress is a more suitable measure of yielding risk than hoop stress alone. Further experiments involving two bored pipes under railroad loads helped to verify the performance of this method. These formulae were later adapted in the current version of API RP 1102 [9]. It is worth noting that the formulae do not consider the changes of stiffness from internal pressure variation, and the application range is limited by the range of pipe dimensions and buried depths investigated by FEA.

Warman et al. [10,11] proposed a modified Spangler stress formula, which is also known as "CEPA equation". The CEPA equation combines the advantages of the original "Spangler stress formula" and the "Iowa formula", which enables it to consider the influence of both internal pressure and the support of the surrounding soil to the predicted hoop stress. Francini and Gertler later found the amplitude of longitudinal stress can be as high as or higher than the hoop stress from their tests [12], which motivated Van Auker and Francini to add the prediction of longitudinal stress in their CEPA surface loading calculator [13].

API RP 1102 is one the most widely used approaches to estimate the stress in buried pipe under surface loading. However, practical application of this approach creates frequent engineering challenges due to its limitations. Some of the limitations include the limited range of buried pipe depths for which it can be applied, the limited range of diameter to wall thickness (D/t) ratios for which the approach is applicable, and the need for the crossing angle between the pipe and the road to be near 90°. Since the method was developed based on FEA for bored pipes, the application of this approach on pipes installed using the open trench method becomes questionable.

In this paper, a new approach to estimate the stress in buried pipes resulting from surface loads is presented. This approach is based on Van Auker and Francini's work [13] with revisions in the method of estimating longitudinal stress. In the first section, the detailed approach is introduced. In the second section, the performance of the new approach is verified by comparison with collected experimental data. The prediction is also compared with that from the current API RP 1102 approach. Discussions regarding the new approach are presented in the third section, and conclusions are summarized at the end of the paper.

APPROACH TO DETERMINE THE STRESSES IN BURIED PIPES UNDER SURFACE LOADING

Surface loading on buried pipes originates from two sources: the live load on the ground surface and the soil overburden on top of the pipe.

Stress from Live Load

The pressure at the pipe surface from live surface loads on the ground can be calculated by the Boussinesq equation as

$$p_{\mathrm{live}} = \frac{3P_{\mathrm{surf}}}{2\pi H^2\left[1+\left(\frac{z}{H}\right)^2\right]^{\frac{5}{2}}} F_{\mathrm{impact}} \qquad (1)$$

where p_{live} is the pressure on the pipe due to the live surface load, P_{surf} is the concentrated load on the ground surface, z is the horizontal offset of the measurement point on the pipe from the location that the concentrated load is applied on the ground, H is the depth of cover (DoC), and F_{impact} is the impact factor to account for the dynamic impact of a moving vehicle.

The Boussinesq equation assumes a homogeneous elastic foundation and provides a conservative estimation for a road with a hard layer at the top surface. The Boussinesq equation has been accepted by the pipeline industry, is used in early versions of API RP 1102 [5], and is also used in the later developed Guidelines for the Design of Buried Steel Pipe [14]. The Boussinesq equation can be generalized to any type of surface loading by integrating contact pressure over the contact areas between wheels or tracks and the ground. Assuming the pressure in a contact area is uniform and equals the internal tire pressure in the pneumatic tire, the area can be divided into a grid of small rectangles with a concentrated load on each rectangle that equals the pressure times the area of the rectangle. The total pressure at a given underground point can then be obtained by summing the contribution from each rectangle to the pressure point. Maximum live pressure on a pipeline can be determined by varying the location of the vehicle with respect to the pipe and repeating the calculations. This maximum pressure is then used to calculate the stress in the pipe.

The original Boussinesq equation only estimates the static load. The impact factor, F_{impact}, in equation (1) helps to account for dynamic loading from the moving vehicle. The impact factor generally ranges from 1.0 to 1.5. While there is no explicit guidance on choosing impact factor, the dynamic loading is affected by vehicle speed, tire pressure, ground unevenness and depth of cover.

The pressure from the live load results in both hoop stress and longitudinal stress in the buried pipe. The CEPA equation [10,11] can be used to determine the hoop stress from the live load as

$$\sigma_{\mathrm{H\_live}} = \frac{3K_{\mathrm{b}}p_{\mathrm{live}}\left(\frac{D}{t}\right)^2}{1+3K_{\mathrm{z}}\frac{p_{\mathrm{i}}}{E}\left(\frac{D}{t}\right)^3+0.0915\frac{E'}{E}\left(\frac{D}{t}\right)^3} \qquad (2)$$

where K_{b} is the bending moment parameter, D and t are the pipe outside diameter (OD) and wall thickness (WT) respectively, K_{z} is the deflection parameter, p_{i} is the internal pressure of the pipe, E' is the modulus of soil reaction, and E is the elastic modulus of steel. The parameters K_{b} and K_{z} were provided by Spangler [4] as shown in Table 1. For pipes installed using an auger boring method, a large bedding angle of 120° can be assumed. For pipes installed using an open trench method, it is conservative to use a bedding angle of 30°, as the bottom reaction occurs over an arc of 30° to 60° [15]. Table 2 lists the values for E' recommended by Hartley and Duncan [16].

The longitudinal stress in the pipe resulting from a live load on the ground has two components. The first, $\sigma_{\mathrm{L\_live\_lb}}$, is due to local bending in the pipe wall under the distributed load on the pipe surface. It can be determined using Bijlaard's solutions for local loading on a pipe [17] as

$$\sigma_{\text{L\_live\_lb}} = \frac{0.153}{1.56}\sqrt{12(1-\nu^2)}\sigma_{\text{H\_live}} \tag{3}$$

where $\boldsymbol{\nu}$ is the Poisson's ratio of steel.

Table 1. Values of Parameters K_{b} and K_{z}

Bedding Angle (deg)	Moment Parameter, K_{b}	Deflection Parameter, K_{z}
0	0.294	0.110
30	0.235	0.108
60	0.189	0.103
90	0.157	0.096
120	0.138	0.089
150	0.128	0.085
180	0.125	0.083

Table 2. Typical Values of the Modulus of Soil Reaction, E' (in psi).

Type of Soil	DoC* (ft)	Standard AASHTO# Relative Compaction			
		85%	90%	95%	100%
Fine-grained soils with less than 25% sand content (CL, ML, CL-ML)	0-5	500	700	1,000	1,500
	5-10	600	1,000	1,400	2,000
	10-15	700	1,200	1,600	2,300
	15-20	800	1,300	1,800	2,600
Coarse-grained soils with fines (SM, SC)	0-5	600	1,000	1,200	1,900
	5-10	900	1,400	1,800	2,700
	10-15	1,000	1,500	2,100	3,200
	15-20	1,100	1,600	2,400	3,700
Coarse-grained soils with little or no fines (SP, SW, GP, GW)	0-5	700	1,000	1,600	2,500
	5-10	1,000	1,500	2,200	3,300
	10-15	1,050	1,600	2,400	3,600
	15-20	1,100	1,700	2,500	3,800

* DoC: Depth of cover
\# AASHTO: the American Association of State Highway Transportation Officials

The second component, $\sigma_{\text{L\_live\_gb}}$, is due to the global bending of the pipe segment under the live load as

$$\sigma_{\text{L\_live\_gb}} = \frac{MD}{2I} \tag{4}$$

where M is the bending moment and I is the moment of inertia of the pipe cross section calculated as

$$I = \frac{\pi}{4}\left[\left(\frac{D}{2}\right)^4 - \left(\frac{D}{2}-t\right)^4\right] \tag{5}$$

The bending moment M can be determined by the solution of beam on elastic foundation [18] considering that the pipe experiences a uniform distributed load, W_i, on a segment with a length of l_i as shown in Figure 1. The distance from a measurement point on the pipe to the two ends of the segment with the distributed load is a_i and b_i, respectively. The bending moment, M_i, at the measurement point on the pipe due to load W_i is

$$M_i = \frac{W_i}{4\lambda^2}F(a_i, b_i) \tag{6}$$

If the measurement point is inside the segment with the distributed load as shown in Figure 1 (a), the $F(a_i, b_i)$ is

$$F(a_i, b_i) = e^{-\lambda a_i}\sin(\lambda a_i) + e^{-\lambda b_i}\sin(\lambda b_i) \tag{7}$$

If the measurement point is outside the segment with the distributed load as shown in Figure 1 (b), the $F(a_i, b_i)$ is

$$F(a_i, b_i) = e^{-\lambda b_i}\sin(\lambda b_i) - e^{-\lambda a_i}\sin(\lambda a_i) \tag{8}$$

In equation (8), it is assumed that $a_i > b_i$. The coefficient λ in equations (6) to (8) is

$$\lambda = \sqrt[4]{\frac{k}{4EI}} \tag{9}$$

where k is the spring coefficient of the soil providing the resistance to the deflection of the pipe. It can be determined as $k = k_0 D\sin(\Omega/2)$, where Ω is bedding angle and k_0, in the unit of pressure/length, is the elastic spring constant (also known as modulus of the foundation) which is based on soil type as listed in Table 3 [18].

Table 3. Values of Modulus of the Foundation, k_0

Soil Type	Range in lb/in^3		Range in N/mm^3	
	Min	Max	Min	Max
Loose Sand	18.42	58.94	0.005	0.016
Medium Sand	36.84	294.71	0.010	0.080
Dense Sand	232.08	471.53	0.063	0.128
Clayed Sand(Medium)	114.20	294.71	0.031	0.080
Silty Sand (Medium)	88.41	176.82	0.024	0.048
Clay, q_u*<0.2 N/mm^2	44.21	88.41	0.012	0.024
Clay, 0.2<q_u<0.4 N/mm^2	88.41	176.82	0.024	0.048
Clay, q_u > 0.4 N/mm^2	176.82		0.048	

* q_u: unconfined compressive strength

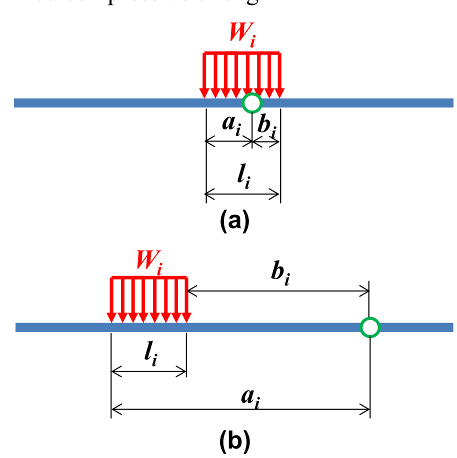


Figure 1. Illustration of Pipe under a Distributed Load W_i over a Segment with Length l_i.

Alternatively, the spring coefficient, k, can be determined from the pipe soil interaction model as described in Annex A of the paper. Finally, the bending moment, M, at a specified point on the pipe, can be determined by summing up M_i in equation (6) at every small segment along the pipe as

$$M = \sum_i M_i \tag{10}$$

Stress from Soil Overburden

For pipe buried at shallow to moderate depth, the pressure at the pipe surface from soil loading is estimated by prism load of the column of soil over the pipe as

$$p_{\text{soil}} = \gamma H \tag{11}$$

where γ is the weight of soil per unit volume. The prism load is conservative and recommended by Moser [19] for flexible pipe. The resulting hoop stress, $\sigma_{\text{H\_soil}}$, can then be determined via equation (2) by replacing p_{live} with p_{soil} from equation (11).

For a deep-buried pipe, the arching effect helps to distribute part of the prism load to the soil surrounding the pipe. For this scenario, using the prism load approach is overly conservative and an alternative approach, such as that in API RP 1102 [9], can be used to determine the hoop stress from the soil load.

The longitudinal stress resulting from soil overburden is uniformly distributed along a buried pipe. As the axial deformation of a buried pipe is restrained by the soil, the longitudinal stress is determined by the Poisson effect as

$$\sigma_{\text{L\_soil}} = \nu \sigma_{\text{H\_soil}} \tag{12}$$

PERFORMANCE OF THE APPROACH

The performance of the approach introduced above was checked by comparing the predictions from the approach with experimental results collected from literature and the predictions from the current API RP 1102 approach. Only the stresses generated by live loads were investigated as a) limited tests reported the stresses from soil overburden, b) thorough studies have been conducted by other researchers [19] on stresses in buried pipes from soil overburden, and c) the stresses from live loads generally dominates the integrity discussion of pipes under surface loading.

Collected Experimental Results

The experimental results from the work by three different groups were collected.

Battelle and AARRC

The experiments were conducted by the Association of American Railroads Research Center (AARRC) from 1960 to 1967. The data was later analyzed by Battelle Memorial Institute in a summary report to the Research Council on Pipeline Crossings of Railroads and Highways of American Society of Civil Engineers [20]. The report covers the experimental results on an 8.625-inch diameter, 0.219-inch wall thickness pipe and a 24-inch diameter, 0.25-inch wall thickness pipe. The pipes were installed by open trench method in silty sand soil within confining timber bulkheads. The soil was compacted to approximately 95% of its standard Proctor density after the pipe was installed, and before any experiments were conducted. The buried depth of the 8.625-inch pipe was 27.375 inches. Two buried depths of 25 inches and 50 inches were investigated on the 24-inch pipe.

Two loading configurations were used to apply live loads on the 8.625-inch pipe. A three-tie track segment, as shown in Figure 2, was used to simulate a railroad load. Each tie was 7-inches high, 9-inches wide, and 8.5-feet long. The space between the close edges of two adjacent ties was 11 inches as shown in Figure 2. The length of the ties was along the pipe axial direction. The load amplitude applied on the track segment increased from 18 kips up to 95 kips. A total of 2,000,000 cycles of 95 kips force through the three-tie track segment was then applied to simulate the ground compacting at the crossing over a long period of time. The 95 kips load was then applied again to determine the influence of the compaction. After that, the loading configuration of a 15-inch diameter steel plate was used to simulate the point load on unpaved ground. The investigated amplitudes of the load were 10 kips and 15 kips. The internal pressure was zero during the application of all live loads on the 8-inch pipe.

Three loading configurations were used to apply live loads on the 24-inch pipe. An 8-foot long, 6-foot wide and 6-inch thick concrete slab was used to simulate the load on a road with rigid pavement. The length of the slab was along the pipe axial direction. The load amplitude was 25 kips. The same steel plate in the experiments on the 8.625-inch pipe was then used to apply a 25 kips point load. Finally, the same three-tie track segment in the experiments on the 8.625-inch pipe was used to apply a 95 kips railroad load. The live loads were applied before compacting the soil with cyclic loads. All live loads were applied on the pipe with zero internal pressure and also with 550 psig internal pressure.

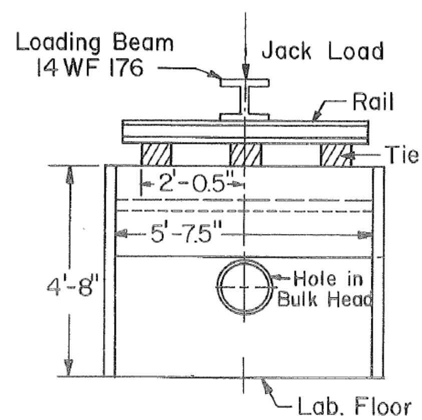


Figure 2. Transverse Section through Simulated Crossing with Three-Tie Track Segment (Battelle and AARRC) (from Figure 2 in Reference [20])

Spangler

The second work was a field casing investigation led by Spangler in the 1960s [21]. The test data consisted of three casing pipes installed at Thorsby, Alabama, one at Gallup, New Mexico, and one at Garden City, Iowa. The tests were conducted over multiple years. Only the maximum hoop stresses due to the passage of trains on the tracks above the pipes were recorded. As these were casing pipes, there was no internal pressure applied during the tests.

Cornell and TTC

The third work was conducted by a research group from Cornell University at the Transportation Test Center (TTC) from 1988 to 1990 [8]. These experiments were part of the effort to develop the approach in the current version of API RP 1102. A 12.75-inch diameter, 0.250-inch wall thickness, X42 pipe and a 36-inch diameter, 0.606-inch wall thickness, X60 pipe were installed using auger boring methods. The soil type at the site was reported as dense sand. The depth of cover for both pipes was 5.75 feet. In reference [8], the maximum hoop stress and longitudinal stress were measured when a train was over the pipe.

The pipe dimensions, buried depth, installation method, soil type, and internal pressure level of above collected experimental data are summarized in Table 4. The loading method and load amplitude are summarized in Table 5.

Analysis with Kiefner Approach

To facilitate the late comparison, the approach introduced previously in the paper is referred to as the Kiefner approach. The input parameters[i] for the analysis with the Kiefner approach are listed in Table 6.

The modulus of soil reaction, E', depends on soil type, buried depth of the pipe, and compaction of backfills as shown in Table 2. In the Battelle-AARRC experiments, the silty sand soil was compacted to 95% of its standard proctor density before the application of live loads. From Table 2, E' is 1,200 psi based on 95% compacted coarse-grained soils with fines (SM, SC) buried deeper than 5 feet. For the 8.625-inch pipe, some of the experiment was conducted after further compacting of the soil with 2,000,000 cycles of load. No significant changes of stresses in the pipe were observed after the first 500,000 cycles of load. The soil should have been fully compacted to 100%. Therefore, a modulus of soil reaction of 1,900 psi was assumed for the experiments after the additional loading cycles were applied. In the Spangler experiments, no detailed information was available for the type of soil at the sites. Since the tests were conducted under the rail road over multiple years, it was reasonable to assume the soil had reached 100% compaction. The types of soil were deduced from the measured stress level[ii] as follows. In the Spangler experiments conducted at Thorsby, Alabama, the three casing pipes were buried at the shallowest depth of 7 feet but produced the lowest stresses among the five investigated casing pipes. As a result, very stiff soil such as "coarse-grained soils with little or no fines" from Table 2 was assumed. For analysis of such soil, a modulus of soil reaction of 3,300 psi with 100% compaction at 5-10 feet depth of cover was utilized.

Table 4. General Information of Collected Experimental Data

	Pipe OD (in)	Pipe WT (in)	DoC (in)	Installation	Soil Type	Internal Pressure (psig)
Battelle-AARRC	8.625 24	0.219 0.25	27.375 25, 50	Open trench	Silty sand	0 0, 550
Spangler	30[#] 36[#] 42[#] 34[!] 30[$]	0.25 0.312 0.375 0.406 0.344	84 101 161	Auger boring	N/A	0
Cornell-TTC	12.75 36	0.25 0.606	69 69	Auger boring	Dense sand	0[*]

\# At Thorsby, Alabama
! At Gallup, New Mexico
$ At Garden City, Iowa
* The experiments also investigated non-zero internal pressure. However, only the maximum stress under zero internal pressure was reported in reference [8] for both pipes.

Table 5. Live Load Information in Collected Experimental Data

	Pipe OD (in)	Loading Method	Load Amplitude (kips)
Battelle-AARRC	8.625	Steel plate Three-tie track segment	10, 15 18, 36, 54, 72, 95
	24	Concrete slab Steel plate Three-tie track segment	25 25 95
Spangler	30 to 42	Single train passing the tracks on top of pipe	N/A
Cornell-TTC	12.75, 36	Single train parking on tracks on top of pipe	N/A

Table 6. Input Parameters for Kiefner Approach

	Pipe OD (in)	E' (psi)	Bedding Angle (deg)	F_{impact}
Battelle-AARRC	8.625 24	1200, 1900 1200	30	1.0
Spangler	30 36 42 34 30	3300 2700 2000	120	1.5
Cornell-TTC	12.75 36	1800*	120	1.0*

* Following the value provided in reference [8]

[i] The pipe dimensions and buried depths have been listed in Table 4 and Table 5 and are not repeated in Table 6.

[ii] There is a very coarse estimation as the stresses level in the pipe also depends on the dimensions of pipes, applied loads and other factors.

At Garden City, Iowa, the 30-inch pipe was buried at the greatest depth of nearly 13 feet, but the highest stress was measured. Therefore, very soft soil such as "fine-grained soils with less than 25% sand content" was assumed. For analysis of such soil, a modulus of soil reaction of 2,300 psi with 100% compaction at 10-15 feet depth of cover was utilized. Finally at Gallup, New Mexico, the 34-inch pipe was buried at a moderate depth of around 8 feet with moderate measured stress. The soil type assumed was "coarse-grained soils with fines". For analysis of such soil, a modulus of soil reaction of 2,700 psi with 100% compaction at 5-10 feet depth of cover was utilized. For Cornell-TTC experiments, a soil modulus of reaction of 1800 psi was reported in reference [8].

The bedding angle was used to determine the parameters K_b and K_z in equation (2). The bedding angle depends on the installation method of the pipe. In the Battelle-AARRC experiments, the pipes were installed through the open trench method. As a result, the bedding angle was conservatively selected as 30°. In the Spangler experiments and the Cornell-TTC experiments, the casing pipes and line pipes were installed through the auger boring method beneath the railroads. The bedding angle was therefore selected as 120°.

The impact factor, F_{impact}, was determined from loading condition in the tests. In the Battelle-AARRC experiments, all the live loads were applied as static loads. As a result, the impact factor was 1.0. In the Spangler experiments, the stress was measured when moving trains passed along the tracks over the pipes. Therefore, the maximum impact factor of 1.5 was used. In Cornell-TTC experiments, an impact factor of 1.0 for the tests was reported in reference [8].

One parameter not covered in Table 6 is the spring coefficient, k, used in equation (9) to predict the longitudinal stresses. This parameter was determined using the soil spring model following the procedure in Annex A. The soil spring model requires the soil properties including the weight of soil per unit volume, γ, friction angle, ϕ, and cohesion, c. No detailed soil properties other than soil type were recorded during the experiments. For Battelle-AARRC experiments, γ = 120 lb/ft^3, ϕ = 30° and c = 0 were used. These are typical parameters for loose sand which was close to the silty sand soil used in the experiments. For Cornell-TCC experiments, γ = 120 lb/ft^3, ϕ = 40° and c = 0 were used, which are typical parameters for dense sand at the experimental site. As no longitudinal stresses were measured in Spangler experiments, no estimation for k was needed.

The live loads on the ground surface were simulated as follows. In the Battelle-AARRC experiments, three loading configurations were used. The steel plate was simulated as a single point load. The concrete slab was simulated by a grid of small rectangles covering a 6-foot by 8-foot area. The total load of 25 kips was then uniformly distributed among the grid. The three-tie track segment was simulated by a series of concentrated loads distributed along three lines. Each line was along the centerline of a tie. The total live load applied on the track was then distributed uniformly along the three lines. For the Spangler and the Cornell-TCC experiments, the live load from the real train was simulated by a grid of small rectangles with the concentrated load at the center of each rectangle. The amplitude of the concentrated load was determined by the area of the rectangle and the pressure derived from uniformly distributing the 320-kips weight of the loaded train car over an area of 20-feet by 8-feet[iii].

Analysis with Current API RP 1102 Approach

The formulae estimating the stresses in API RP 1102 involve multiple factors. API RP 1102 provides multiple figures with curves that can used to determine the values of these factors, with input parameters such as pipe dimensions, soil properties, and pipe burial depth. The curves in these figures are only provided for pipe diameter/wall thickness ratios less than 100, and buried pipe depths greater than 6 feet for railroad crossings or greater than 3 feet for highway crossings. These specified ranges are due to the investigated range of FEA from which these curves were developed [8].

The input parameters[iv] for the analysis with the API RP 1102 approach are listed in Table 7.

API RP 1102 requires soil resilient modulus, E_r, to predict the stresses resulting from a live load. API RP 1102 provides suggested values for E_r for various soil types[v]. Following the soil types discussed in the previous section of "Analysis with Kiefner Approach", the estimated E_r values are listed in Table 7.

API RP 1102 also has its own recommendation for impact factor, F_i, based on road type and buried depth[vi]. In the Battelle-AARRC experiments, all the live loads were applied as static loads. As a result, the impact factor is 1.0. In the Spangler experiments, the stress was measured when trains passed over the tracks on top of the pipes. Due to this dynamic loading, impact factors greater than 1.0 were determined following the approach in API RP 1102. In the Cornell-TTC experiments, an impact factor of 1.0 for the tests was reported in reference [8].

Table 7. Input Parameters for API RP 1102 Approach

	Pipe OD (in)	E_r (ksi)	F_i
Battelle-AARRC	8.625 24	10	1.0
Spangler	30 36 42	20	From API RP 1102
	34	10	
	30	5	
Cornell-TTC	12.75 36	20*	1.0*

* Following the value provided in reference [8]

[iii] This is a typical design train load known as Cooper E-80. Please see reference [9] for details.

[iv] The pipe dimensions and buried depths have been listed in Table 4 and Table 5 and are not repeated in Table 7.

[v] Table A-2 in reference [9].

[vi] Figure 7 in reference [9].

The API RP 1102 approach uses the pressure on the ground surface, w, to determine the stresses resulting from a live load. There are also different formulae for stresses due to live loads depending on whether the live load is from a railroad or a highway. The selection of formulae and the values of w are summarized in Table 8.

Table 8. Load Configuration Treatment for Analysis with API RP 1102 Approach

	Loading Method	API RP 1102 Formulae	Pressure on the Ground, w (psi)
Battelle-AARRC	Concrete slab	Highway formulae with rigid pavement and single axle	86.8
	Steel plate	Highway formulae with no pavement and single axle	56.6 – 141.5
	Three-tie track segment	Railroad formulae	2.94 - 15.5
Spangler	Single train passing over the pipe	Railroad formulae	13.9
Cornell-TTC	Single train parking over the pipe	Railroad formulae	13.9

In Battelle-AARRC experiments, three loading configurations were used. The concrete slab simulated the load on a road with rigid pavement. As a result, the highway formulae were used with a pavement type factor, R, of 0.9 and an axle configuration factor, L, of 0.65 [vii]. The ground pressure, w = 25,000/(2×144) = 86.8 psi, was determined by considering that the application of total 25 kips load on slab was equivalent to the application of the load of a single axle via two wheels. This value is very close to the design value of 83.3 psi for a single axle truck recommended in [9]. The steel plate simulated a single point load on an unpaved ground surface, for which the highway formulae were selected with R = 1.20 and L = 0.80 for the 8.625-inch pipe and R = 1.10 and L = 0.65 for the 24-inch pipe [viii]. The ground pressure is calculated as $w = F/\pi(d_0/2)^2$, where F is the applied force and d_0 is the diameter of the plate (in this case 15 inches). Three loads of 10 kips, 15 kips and 25 kips were applied during the experiments, resulting in w values of 56.6 psi, 84.9 psi, and 141.5 psi, respectively. The three-tie track segment simulated the railroad loads, for which the railroad formulae were selected. The ground pressure, w, was determined by distributing the total force uniformly over an area of 102 inches by 60 inches [ix]. For the maximum load of 95 kips applied via the three-tie track segment, the result is w = 15.5 psi, which is very close to the design value of 13.9 psi for the Cooper E-80 loaded train car recommended in [9]. For the Spangler and the Cornell-TCC experiments, the live load from the real train was applied. Therefore, the railroad formulae were selected, and the design value of w = 13.9 psi for the Cooper E-80 load was used.

Results Comparison

The comparison between the measured hoop stresses from all collected experimental data and the prediction from the Kiefner approach and the API RP 1102 approach is presented in Figure 3. The blue dots show the predictions from the Kiefner approach and the red dots show those from the API RP 1102 approach. The red dots with a cross indicate the cases that are out of the range of the curves in API RP 1102 to determine the factors used to predict the stresses. For such cases, we used the stress factors determined by the available points on the curves which were closest to the experimental conditions. However, the accuracy of these dots may be arguable. From the figure, the Kiefner approach provided a consistently conservative estimation for all cases with a mean factor of around 2.5. The API RP 1102 approach predicted lower stresses than the Kiefner approach. There are many cases that were out of the range of the API RP 1102 approach. For a considerable proportion of cases, the predicted stresses from the API RP 1102 approach were also nonconservative. Even if one were to neglect the out-of-range cases, there are still several cases with predicted stresses from the API RP 1102 approach that are lower than measured values from the experiments. The comparison between the measured longitudinal stresses from all collected experimental data, the prediction from the Kiefner approach, and the API RP 1102 approach is presented in Figure 4, with trends similar to those of the hoop stresses. For longitudinal stress, the Kiefner approach provided a conservative estimation for all cases except one. However, the mean factor was around 1.3 which was lower than that for the hoop stress. The API RP 1102 approach predicted lower stresses than the Kiefner approach and the predictions were nonconservative for a considerable proportion of cases, even neglecting those which were out of the range of the API RP 1102 approach.

The API RP 1102 approach was developed based on FEA modeling for bored pipe and later was verified through experiments on bored pipes. However, the API RP 1102 approach may underestimate the stresses in pipes installed by the open trench method where the pipe receives less support from the surrounding soil (in the Kiefner approach this translates to a lower bedding angle for a pipe installed by open trench method as compared to a similar bored pipe). In the three groups of experiments, the pipes in the Battelle-AARRC experiments were installed with the open trench method and the pipes in the other two groups of experiments were installed with the auger boring method. Figure 5 shows the comparison of hoop stress predictions with Spangler and Cornell-TTC experiments only. The API RP 1102 approach only

[vii] Following Table 2 in reference [9] for rigid pavement with a single axle load.
[viii] Following Table 2 in reference [9] for no pavement with a single axle load.
[ix] According to the test setup, the length of each tie was 8.5 feet or 102 inches, the width of the tie was 9 inches, and the space between the closest edges of two adjacent ties was 11 inches. Therefore, each tie distribute its load in an area of 102 inches by 20 inches (=11+9). Finally, the total load was distributed by three ties to an area of 102 inches by 60 inches (=3×20).

underestimated the stress in one case[x]. The predictions were conservative for all other cases including those out of the application range. However, a closer observation showed that the predictions did not follow the same trend as the measured stresses. The four red dots at the right side of the figure showed decreased predicted stresses with increased measured stresses, even though they were within the application range of the API RP 1102 approach. The predictions from the Kiefner approach were conservative for all cases and overall followed the same trend with the measured stresses. Figure 6 shows the comparison of longitudinal stress for the Cornell-TTC experiments (no longitudinal stress was reported for the Spangler experiments). The Kiefner approach predicted a higher longitudinal stress than the API RP 1102 approach for one case and was almost identical with the API RP 1102 approach for the other case. The predictions from both approaches were conservative. The inconsistent trend between the API RP 1102 predictions and the measured hoop stress may be due to the inaccurate assumption of soil types at the sites in the Spangler experiments. However, the Kiefner approach provided the same trend as the experimental results using the same assumed soil types.

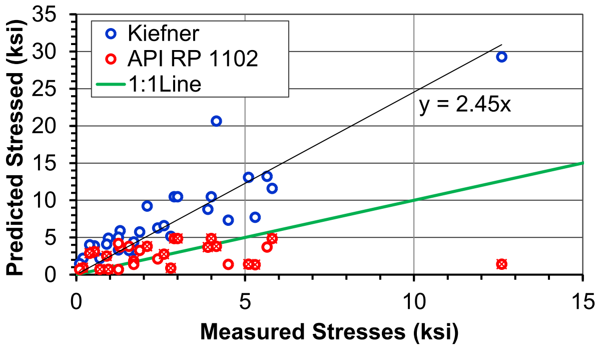


Figure 3. Comparison of Hoop Stress with All Collected Experimental Data

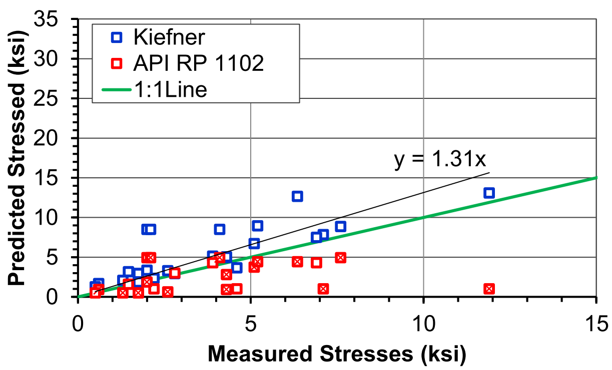


Figure 4. Comparison of Longitudinal Stress with All Collected Experimental Data

[x] This case was Cornell-TTC experiment on 36-inch pipe. In Table 9 of reference [8], the reported measured hoop stress and predicted hoop stress were 2410 psi and 2030 psi, respectively.

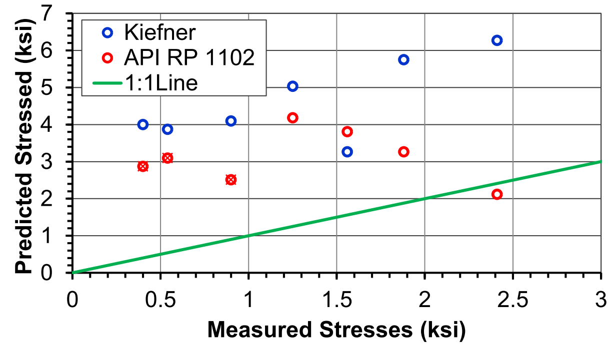


Figure 5. Comparison of Hoop Stress with Experimental Data from Spangler and Cornell-TTC

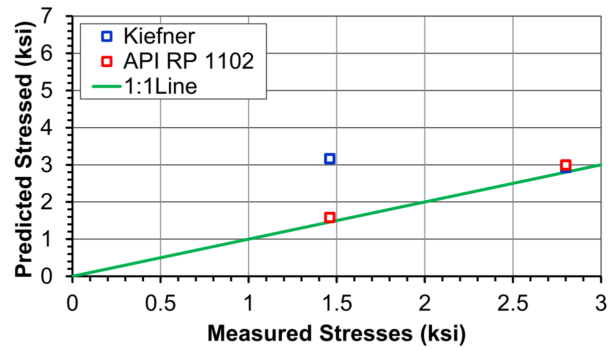


Figure 6. Comparison of Longitudinal Stress with Experimental Data from Cornell-TTC

The comparison with the Battelle experiments was further investigated in Figure 7 and Figure 8 for hoop stress and longitudinal stress, respectively. The steel plate and concrete slab simulated the road crossing and the three-tie track segment simulated the railroad crossing. The Kiefner approach did not distinguish the road crossing and railroad crossing. The only differences between the two types of crossing in the Kiefner approach were the live load distribution and the impact factor. The API RP 1102 approach used different groups of equations for the road crossing and railroad crossing. From Figure 7 and Figure 8, the Kiefner approach only slightly underestimated the longitudinal stress at a single case. The API RP 1102 approach underestimated the stresses for both the road crossing and railroad crossing when the pipe was installed using the open trench method. The 8.625-inch pipe with 27.375-inch DoC and the 24-inch pipe with 25-inch DoC exceeded the application range of API RP 1102. However, both conservative and nonconservative predictions were observed on the two pipes. The 24-inch pipe with 50-inch DoC was within the application range of API RP 1102. The nonconservative stresses were predicted for concrete loads and three-tie track loads on this pipe with zero internal pressure and for steel plate loads on this pipe with both zero internal pressure and 550 psig internal pressure. A brief summary of the observation is that the API RP 1102 approach is not conservative for pipes installed with open trench method.

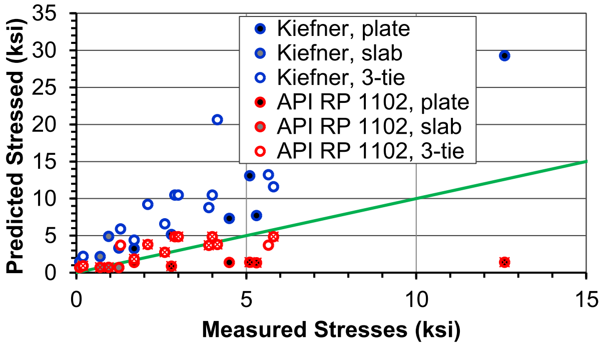


Figure 7. Comparison of Hoop Stress with Experimental Data from Battelle-AARRC

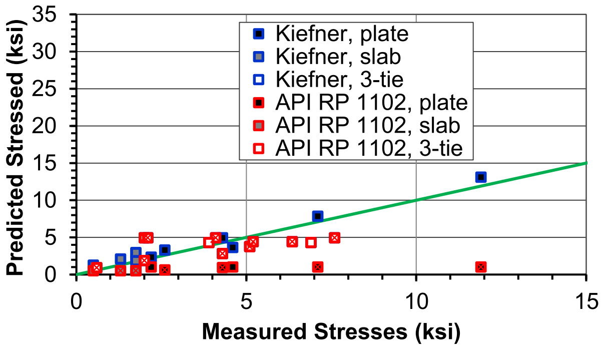


Figure 8. Comparison of Longitudinal Stress with Experimental Data from Battelle-AARRC

DISCUSSION

Based on the comparison with the experimental data in the above section, the Kiefner approach provided conservative estimates in most scenarios, and in more scenarios than the API RP 1102 approach. Furthermore, the overall trends of the predictions were consistent with the observations in the experiments. The API RP 1102 approach underestimated the stresses for multiple cases when compared with the experiments, and the trends were not always consistent with the experimental observation.

The Kiefner approach is a more universal tool to treat a wide range of parameters on buried pipes under surface loading. It is applicable to problems with a wide range of pipe dimensions, buried conditions, loading scenarios, and pipe installation methods. On the contrast, the approach in API RP 1102 was developed based on pipe that was installed through boring with a relatively narrowed range for input parameters.

Under some conditions, the prediction from the Kiefner approach may be too conservative, especially for hoop stress. This stems from the usage of the Boussinesq equation. The Boussinesq equation assumes homogeneous elastic soil. In reality, the ground above buried pipes generally consists of multiple layers with quite different properties. Soil also yields under large live loads and deviates significantly from the behavior of elastic material. However, due to the complexity of the surface loading problem on buried pipes, a relatively large safety margin seems unavoidable to ensure the predictions are always conservative.

The degree of conservatism in the Kiefner approach is different for hoop stress and longitudinal stress. By comparison with the experiments data used in this study, the Kiefner approach overestimated the hoop stress by an average factor of 2.5 and overestimated the longitudinal stress by an average factor of 1.3. The longitudinal stress resulting from live load has two contributions: one from local bending which is dependent on the hoop stress due to live load, and the other from global bending which is independent of the hoop stress. The level of overestimation for the global bending component may be one of the sources that results in a different estimation level between hoop stress and longitudinal stress. However, the deviation between the predicted levels still seems a little too large. Further work may improve the model.

Finally, the approach in this paper only estimates the stresses resulting from surface loading. These stresses should be added to other existing stresses[xi] in the pipes to determine the total stresses for design or integrity assessment purpose.

CONCLUSION

Kiefner's approach to estimate the stress in buried pipes under surface loading is presented in this paper. This approach considers both hoop stress and longitudinal stress resulting from surface loading. The stiffness effect of internal pressure and the support of soil at the sides of the pipe are also accounted for in this approach. The approach is a universal tool that is able to handle a wide range of loading scenarios.

The comparison with experimental results shows that the Kiefner approach provides a conservative estimate and overall consistent trend with the results observed. The comparison of these results with predictions from the API RP 1102 approach also showed superior performance of the Kiefner approach.

ACKNOWLEDGMENTS

The authors would like to express their appreciation to Mr. Robert Francini for his pioneering work before retiring from Kiefner, which is the foundation of the approach introduced in the paper. The authors would also like to thank Mr. Michael Rosenfeld and Dr. John Kiefner for providing references on experimental data and for reviewing the paper.

[xi] These stress including operational stresses generated by internal pressure and temperature variation in the pipe, as well as stresses generated by external loads other than surface loads.

REFERENCES

1. Spangler, M.G., "The Structural Design of Flexible Pipe Culverts", Bulletin 153, Iowa Engineering Experiment Station, Ames, Iowa, 1941.
2. Spangler, M.G., and Hennessy, R.L., "A Method of Computing Live Loads Transmitted to Underground Conduits", Proceedings Highway Research Board, 26:179, 1946.
3. Spangler, M.G., "Secondary Stresses in Buried High Pressure Pipe Lines", The Petroleum Engineer, November, 1954.
4. Spangler, M.G., "Pipeline Crossing under Railroads and Highways", Journal of the American Waterworks Association, August, 1964.
5. API Recommended Practice 1102, 5th Ed., "Recommended Practice for Liquid Petroleum Pipelines Crossing Railroads and Highways", November 1981.
6 Stewart, H.E., and O'Rourke, T.D., "Live Loads for Pipeline Design at Railroads and Highways", Pipeline Crossings: Proc. of a Specialty Conference Sponsored by the Committee on Pipeline Crossings of the Pipeline Division of the American, Denver, CO, March 1991.
7. Ingraffea, A.R., O'Rourke, T.D., and Stewart, H.E., "Technical Summary and Database for Guidelines for Pipelines Crossing Railroads and Highways", Cornell University School of Civil and Environmental Engineering Final Report to Gas Research Institute, GRI-91/0285, Dec. 1991.
8. Stewart, H.E., Ingraffea, A.R., O'Rourke, T.D., and Behn, M.T., "Design of Uncased Pipelines at Railroad and Highway Crossings", American Petroleum Institute Distribution/Transmission Conference, Houston, TX, April 7-8, 1992.
9. API RP 1102, 6th Ed., "Steel Pipelines Crossing Railroads and Highways", 6th Ed., April 1993 (reaffirmed July 2002).
10. Warman D.J., Chorney, J., Reed, M., and Hart, J.D., "Development of a Pipeline Surface Loading Screening Process", IPC2006-10464, Proc. of 6th International Pipeline Conference, Calgary, Canada, September 25-29, 2006,
11. Warman D.J., Hart, J.D., and Francini, R.B., "Development of a Pipeline Surface Loading Screening Process & Assessment of Surface Load Dispersing Methods", Kiefner Report to Canadian Energy Pipeline Association, 2009.
12. Francini, R.B., and Gertler, R.C., "Field Validation of Surface Loading Stress Calculations for Buried Pipelines", PR-218-104509, Milestone 1 Report for Pipeline Research Council International, July, 2014.
13 Van Auker, M., and Francini, R.B., "Canadian Energy Pipeline Association (CEPA) Surface Loading Calculator User Manual", Kiefner final report 14-017, downloadable from www.kiefner.com.
14. American Lifelines Alliance, "Guidelines for the Design of Buried Steel Pipe", July 2001 (with addenda through February 2005).
15. Pierce, R.N., Lucas, O., Rogers, P., and Rankin, C.L., "Design Procedure for Uncased Natural-Gas Pipeline Crossings of Roads and Highways", Transportation Research Record, 1977, 631: 52-56.
16. Hartley, J.D. and Duncan, J.M., "E' and its Variation with Depth", ASCE Journal of Transportation Engineering, 113(5), 1987.
17. Young, W.C., Roark's Formulas for Stress & Strain, 6th Ed., 1989, McGraw Hill.
18. Boresi, A.P., and Schmidt, R.J., Advanced Mechanics of Materials, 6th Ed., 2003, John Wiley & Sons, Inc. Chapter 10.
19. Moser, A.P., Buried Pipe Design, Second Edition, 2001, McGraw Hill.
20. Rodabaugh, E.C., Atterbury, T.J., and Hinueber, G.L., "Summary Report on Experimental Evaluation of Simulated Uncased Pipeline Crossings of Railroads and Highways", Battelle Summary Report for Research Council on Pipeline Crossings of Railroads and Highways of American Society of Civil Engineers, July 1971.
21. Spangler, M.G., "Experimental Study of the Structural Performance of Pipeline Casing Pipes under Railroads and Highways", Journal of the Pipeline Division, ASCE, Vol 91, No. PL1, Proc. Paper 4419, July, 1965.

ANNEX A

DETERMINE THE COEFFICIENT OF FROM PIPE SOIL INTERACTION MODEL

The spring coefficient of soil resisting pipe deflection, k, used in equation (9) can be determined by soil properties via the pipe soil interaction model. A soil spring model [14] was developed to describe the interaction force between the soil and the pipe. In the soil spring model, the maximum soil force resisting the downward deflection of a buried pipe with a unit length is known as the bearing soil force, Q_d, which is determined as

$$Q_{\mathrm{d}} = N_{\mathrm{c}} c D + N_{\mathrm{q}} \bar{\gamma} \left(H + \frac{D}{2} \right) D + N_{\gamma} \gamma \frac{D^2}{2} \qquad \text{(A-1)}$$

where N_c, N_q, N_γ are bearing capacity factors, c is the soil cohesion, D is the pipe outside diameter, γ is the weight of the soil per unit volume, $\bar{\gamma}$ is the effective weight of soil, which equals γ for pipe buried above the ground water level, and H is the depth of cover.

The bearing capacity factors are determined by the friction angle of the soil, ϕ, in degrees, as

$$N_{\mathrm{c}} = \cot \tilde{\phi} \left[e^{\pi \cdot \tan \tilde{\phi}} \tan^2 \left(45 + \frac{\tilde{\phi}}{2} \right) - 1 \right] \qquad \text{(A-2)}$$

$$N_q = e^{\pi \cdot \tan\phi} \tan^2\left(45 + \frac{\phi}{2}\right) \quad \text{(A-3)}$$

and

$$N_\gamma = e^{(0.18\phi - 2.5)} \quad \text{(A-4)}$$

In equation (A-2), $\tilde{\phi} = \phi + 0.001$. When the amplitude of soil force just reaches Q_d, the critical relative displacement between soil and buried pipe is Δ_{qd}. For granular soils,

$$\Delta_{qd} = 0.1D \quad \text{(A-5)}$$

and for cohesive soils,

$$\Delta_{qd} = 0.2D \quad \text{(A-6)}$$

Finally, the spring coefficient is determined as

$$k = \frac{Q_d}{\Delta_{qd}} \quad \text{(A-7)}$$

Canadian Energy Pipeline Association (CEPA) Final Report No. 05-44R1

Final Report

Development of a Pipeline Surface Loading Screening Process & Assessment of Surface Load Dispersing Methods

David J. Warman, James D. Hart & Robert B. Francini

Revised October 16, 2009

Kiefner & Associates, Inc.
585 Scherers Court ***(614) 888-8220***
Worthington, Ohio 43085 ***www.kiefner.com***

0387-0901

DISCLAIMER

This document presents findings and/or recommendations based on engineering services performed by employees of Kiefner and Associates, Inc. The work addressed herein has been performed according to the authors' knowledge, information, and belief in accordance with commonly accepted procedures consistent with applicable standards of practice, and is not a guaranty or warranty, either expressed or implied.

The analysis and conclusions provided in this report are for the sole use and benefit of the Client. No information or representations contained herein are for the use or benefit of any party other than the party contracting with KAI. The scope of use of the information presented herein is limited to the facts as presented and examined, as outlined within the body of this document. No additional representations are made as to matters not specifically addressed within this report. Any additional facts or circumstances in existence but not described or considered within this report may change the analysis, outcomes and representations made in this report.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Development of a Pipeline Surface Loading Screening Process and Assessment of Surface Load Dispersing Methods

D. J. Warman, J. D. Hart & Robert B. Francini

1.0 INTRODUCTION

The Canadian Energy Pipeline Association (CEPA) represents Canada's oil and gas transmission pipeline operators who are world leaders in providing safe, reliable long-distance energy transportation. CEPA member companies receive numerous requests annually from all over Canada to cross their pipelines. In some cases, these crossing applications are for the establishment of permanent roads over the existing pipelines but in many others they are for temporary crossing by vehicles and equipment in locations without established roads. Regulations compel member companies to determine the potential loading effects of the crossing application and where determined to be excessive, take mitigative measures to reduce the applied stresses to acceptable levels.

A survey by CEPA of member companies indicates that they employ a variety of techniques to evaluate and mitigate surface loading effects on their buried pipelines. One widely used practice, embodied in API 1102 (1993, reaffirmed 2002), is limited to cover depths greater than or equal to 3 feet and has been specifically developed based on AASHTO H20 truck loads with small footprints associated with tire pressures typically in-excess of 550 kPa (80 psig). Several important limitations are inherent to this method. The method cannot be effectively extrapolated to shallow cover situations. It also may not scale correctly to different types of equipment that ride on floatation tires or caterpillar tracks where ground surface pressures are less than 350 kPa (50 psig). Further, it determines pipeline stresses in a non-traditional manner. These conditions create a barrier to uniform adoption of the method.

The National Energy Board (NEB) has requested that CEPA study the issues and determine the feasibility of a standard approach. CEPA wants to examine the above stated limitations as well as to determine the feasibility of a phased approach to crossing assessments that would eliminate the need to perform detailed calculations in most, if not all, cases. At the same time CEPA has identified the need to examine the various temporary load-spreading measures or other mitigation techniques to identify which are the most effective. Kiefner and Associates, Inc. (KAI) jointly with SSD, Inc. conducted this work for CEPA. The following report represents the results of this study.

1.1 Summary

Presented herein is a report detailing the development and implementation of a simplified screening process to assess the effects of surface loads on buried pipelines. The first section provides an overview of the results of a literature survey to identify theoretical models, standards, codes, and recommended practices that are currently used to assess the surface loading effects on buried pipelines.

The second section provides the methodology utilized to develop the screening tool which provides a simple "pass/no pass" determination and is based on attributes which are generally easy to obtain (e.g., wheel or axle load, ground surface contact area and/or surface loading pressure, depth of cover, maximum allowable operating pressure and design factor). Situations that pass this initial screening would require no additional analysis while situations that do not pass the initial screening may need to be evaluated on a more detailed basis. Additional simplified graphs have been included to assist in additional screening prior to performing a more detailed evaluation.

The third section identifies various temporary or permanent surface load-dispersal techniques and other mitigation approaches that are often used as a means to lessen the effects of surface loading. The effectiveness of various methods is also discussed.

In the Appendices are general guidelines and charts that can be adopted by pipeline operators to address infrequent crossings of existing pipelines.

2.0 LITERATURE SEARCH SUMMARY

2.1 Introduction

A limited literature survey has been performed to identify theoretical models, standards, codes, and recommended practices that are currently used to assess the surface loading effects on buried pipelines. Included in this review is the position paper put out by the Canadian Standards Association (CSA) task force at railway crossings on this topic. The goal of this review is to highlight the following items:

- When the techniques were developed and by whom;
- Where they are used;
- The technical nature of the calculations performed;
- A comparative assessment of each method, identifying their strengths and limitations;
- Recommendations as to which method(s) may be suitable for adoption as standard practice;

- Knowledge gaps and areas that might require further study;
- Description of significant pipeline incidents caused by surface vehicle loadings.

2.2 Description of Significant Pipeline Incidents Caused by Surface Vehicle Loadings

Reference GRI-88/0287 provides a section that reviews the performance record of buried pipe crossings based on National Transportation Safety Board (NTSB) pipeline accident reports. At the time of this report publication, a total of four pipeline failures at railway or highway crossings were reported. All of these failures involved cased carrier pipes. The first failure occurred at a substandard girth weld located within the casing that experienced flexure due to soil movements beneath the carrier pipe outside of the casing. The second failure involved a pressure surge which caused failure of a carrier pipe inside of a casing at an area thinned by corrosion. The third failure involved tensile failure due to thermal contraction in a plastic carrier pipe at a coupling located outside the limits of the casing. The fourth failure occurred in a carrier pipe inside of a casing at a location where the wall thickness was reduced to 35% of its initial value due to corrosion. Cased pipeline crossings account for about 20% (a disproportionately high fraction) of corrosion-related reportable incidents, because it is difficult to protect the pipe from corrosion inside the casing and also difficult to monitor corrosion activity therein.

It is our observation and experience that the vast majority of pipeline crossing scenarios require little in the way of special measures to protect the pipeline provided the pipeline is in sound condition and has sufficient amounts of competent soil protection. Exceptions exist such as where muskeg soils or exceptionally heavy equipment or very shallow cover might be involved. We are aware of only one pipeline incident associated with a ground surface vehicle. The line was either a cast iron or old steel gas main with very shallow one-foot cover that ruptured under a cement mixer on a car/boat dealer's parking lot. The resulting fire burned up the truck and the dealer's inventory. We are not aware if it was ever established whether the main collapsed under the vehicle load or merely failed due to corrosion coincidentally when a vehicle was parked there. Overall, our familiarity with causes of pipeline failures informs us that the effects of surface vehicle loadings, even in fairly exceptional circumstances, has not historically been implicated as an important or frequent cause of pipeline incidents. This understanding suggests that the practice of carrying out elaborate analyses for every routine situation may be unwarranted. However, we fully recognize the regulatory, social, and business need to assess, and where necessary, mitigate threats.

2.3 Methods Used to Assess Fill and Surface Loading Effects on Buried Pipelines

2.3.1 Review of Spangler's Work

The pipeline industry has a longstanding interest in the problem of evaluating the effects of fill and surface loads on buried pipelines. Virtually all of the pipeline industry research on this topic refers back to the collective works of M. G. Spangler (and his graduate students) at Iowa State University during the 1940s through 1960s time frame, and no review on this subject would be complete without a discussion of Spangler's work. Spangler's most important publications include the following:

- Spangler, 1941. Spangler, M. G., "*The Structural Design of Flexible Pipe Culverts*", Bulletin 153, Iowa Engineering Experiment Station, Ames, Iowa, 1941.
- Spangler, 1946. Spangler, M.G. and Hennessy, R.L., "*A Method of Computing Live Loads Transmitted to Underground Conduits*", Proceedings Highway Research Board, 26:179, 1946.
- Spangler, 1954. Spangler, M.G., "*Secondary Stresses in Buried High Pressure Pipe Lines*", The Petroleum Engineer, November, 1954.
- Spangler, 1964. Spangler, M.G., "*Pipeline Crossings Under Railroads and Highways*", Journal of the AWWA, August, 1964.
- Watkins and Spangler, 1968. Watkins, R.K., and Spangler, M.G., "*Some Characteristics of the Modulus of Passive Resistance of Soil – A Study in Similitude*", Highway Research Board Proceedings, Vol. 37, 1968 pp. 567-583.

The main developments from Spangler's work include the so-called "Spangler stress formula" (used to compute stresses in buried pressurized pipe) and the "Iowa formula" (used to compute ovality in buried culverts). A brief overview of these formulas is provided in the following sections.

2.3.1.1 The Spangler Stress Formula

The Spangler stress formula computes an estimate of the additive circumferential bending stress (σ) at the bottom of the pipe cross section (in psi) due to vertical load as follows:

$$\sigma = \frac{6 \cdot K_b \cdot W_{vertical} \cdot E \cdot t \cdot r}{E \cdot t^3 + 24 \cdot K_z \cdot P \cdot r^3} \qquad (2.1)$$

where $W_{vertical}$ is the vertical load due to fill and surface loads including an impact factor (lb/in), E is the pipe modulus of elasticity (psi), t is the pipe wall thickness (inches), r is the mean pipe radius (inches) and P is the internal pressure (psi). The terms K_b and K_z are bending moment and deflection parameters respectively (based on theory of elasticity solutions for elastic ring bending) which depend on the bedding angle as shown in Table 2-1.

Table 2-1. Spangler Stress Formula Parameters K_b and K_z

Bedding Angle (deg)	Moment Parameter K_b	Deflection Parameter K_z
0	0.294	0.110
30	0.235	0.108
60	0.189	0.103
90	0.157	0.096
120	0.138	0.089
150	0.128	0.085
180	0.125	0.083

Note that the denominator of this expression includes a pipe stiffness term ($E \cdot t^3$) and a pressure term ($24 \cdot K_z \cdot P \cdot r^3$) which is sometimes referred to as a "pressure stiffening" term since the pipe internal pressure will provide resistance to ovalling. Bedding angles of 0, 30 and 90 degrees are taken as corresponding to consolidated rock, open trench and bored trench conditions, respectively. Numerous references in the literature are "hardwired" based on a bedding angle of 30° (i.e., K_b=0.235 and K_z=0.108). The Spangler stress equation is used to compute circumferential stresses due to vertical loads in several pipeline industry guideline documents including:

API RP 1102. American Petroleum Institute, "*Steel Pipelines Crossing Railroads and Highways*", API Recommended Practice 1102, Sixth Edition, April 1993 (reaffirmed July 2002).

GPTC, 1998/2000. GPTC Guide for Gas Transmission and Distribution Systems - 1995-1998 and 1998-2000, Guide Material Appendix G-192-15, "*Design of Uncased Pipeline Crossings of Highways and Railroads*", American Gas Associations, Arlington, VA.

CSA Z662, While not specifically referenced in CSA Z662 the equation was utilized in the development of the section on uncased railway crossings.

According to Spangler, 1964:
"*...this expression (the Spangler stress equation) is limited to pipes laid in open ditches that are backfilled without any particular effort to compact the soil at the sides and to bored in place pipe at an early stage before soil has moved into effective contact with the sides of the pipe. This expression probably gives stresses that are too high in installations where the soil at the sides of the pipe is well compacted in tight contact with the pipe...*" This limitation statement clearly implies that stresses predicted using Spangler stress formula are conservative for buried pipe that is in intimate contact with the soil at the side walls.

2.3.1.2 The Iowa Formula

The Iowa Formula computes an estimate of the pipe ovality due to vertical load as follows:

$$\Delta X = \frac{K_z \cdot [D_L \cdot W_{vertical}] \cdot r^3}{E \cdot I + 0.061 \cdot E' \cdot r^3} \qquad (2.2)$$

where the terms that have not been previously defined in Section 2.3.1.1 are; ΔX the maximum deflection of the pipe (inches), D_L is the "deflection lag factor", I is the moment of inertia of the cross section of the pipe wall per unit length ($I=t^3/12$, in^3) and E' is the modulus of soil reaction (psi). Note that the denominator of this expression includes a pipe stiffness term ($E \cdot I$) and a soil resistance term ($0.061 \cdot E' \cdot r^3$) but does not include a pressure stiffening term since it was developed for un-pressurized, flexible casing pipes. The deflection parameter (K_z) is normally "hardwired" based on a bedding angle of 30° (i.e., K_z=0.108).

Spangler recognized that the soil consolidation at the sides of the pipe under fill loads continued with time after installation of the pipe, and he accounted for this condition using the "deflection lag factor" term D_L. His experience had shown that ovalling deflections could increase by as much as 30% over 40 years. For this reason, he recommended the use of a deflection lag factor of 1.5 as a conservative design procedure for fill loads. Other references (e.g., AWWA Manual M11) refer to D_L values in the range from 1.0 to 1.5. We believe that it would be reasonable and appropriate to consider the use of a different deflection lag factor for fill loads which act on the pipe for long time periods rather than for traffic loads which act on the pipe for short periods of time (i.e., during the vehicle passage).

The modulus of soil reaction, E' which defines the soil's resistance to ovalling is an extremely important parameter in the Iowa formula. Useful background and discussion on the selection of E' values are presented in the following references:

Moser, 1990. Moser, A.P., "*Buried Pipe Design*", McGraw Hill, 1990.
Hartley and Duncan, 1987. Hartley, J.D. and Duncan, J.M., "*E' and its Variation with Depth*", ASCE Journal of Transportation Engineering, Vol. 113, No. 5, September, 1987.
Masada, 2000. Masada, T., "*Modified Iowa Formula for Vertical Deflection of Buried Flexible Pipe*", ASCE Journal of Transportation Engineering, September/October, 2000.

Table 2-2 (after Moser, 1990) provides published average values of the modulus of soil reaction E' for a range of soil types under different levels of bedding compaction.

Table 2.3 (after Hartley and Duncan, 1987) provides a range of values of E' for a range of soil types, compaction levels, and cover depths. Hartley and Duncan, 1987 also provide very clear guidance on the selection of E'. This paper indicates that E' can be taken as equal to the constrained modulus of the soil, M_s which can be established based on relatively simple laboratory tests.

The Iowa formula is used as a basis for estimating ovalling deflections due to vertical loads in several pipeline industry guideline documents including:

- AWWA M11, 1999. American Water Works Association, "*Steel Pipe – A Guide for Design and Installation*", AWWA Manual M11, 3rd Edition, 1999.
- ALA, 2001. American Lifelines Alliance, "*Guidelines for the Design of Buried Steel Pipe*", Published by the ASCE American Lifelines Alliance, www.americanlifelinesalliance.org, July 2001.

Table 2-2. Design Values of E', psi (From Moser, 1990)

TABLE 3.4 Average Values of Modulus of Soil Reaction, *E'* (For Initial Flexible Pipe Deflection)

Soil type-pipe bedding material (Unified Classification System*)	*E'* for degree of compaction of bedding, lb/in^2			
	Dumped	Slight, < 85% proctor, < 40% relative density	Moderate, 85%–95% proctor, 40%–70% relative density	High, >95% proctor, > 70% relative density
Fine-grained soils (LL > 50)† Soils with medium to high plasticity CH, MH, CH-MH	No data available; consult a competent soils engineer; Otherwise use *E'* = 0			
Fine-grained soils (LL < 50) Soils with medium to no plasticity CL, ML, ML-CL, with less than 25% coarse-grained particles	50	200	400	1000
Fine-grained soils (LL < 50) Soils with medium to no plasticity CL, ML, ML-CL, with more than 25% coarse-grained particles Coarse-grained soils with fines GM, GC, SM, SC contains more than 12% fines	100	400	1000	2000
Coarse-grained soils with little or no fines GW, GP, SW, SP‡ contains less than 12% fines	200	1000	2000	3000
Crushed rock	1000	3000	3000	3000
Accuracy in terms of percentage deflection§	± 2	± 2	± 1	± 0.5

*ASTM Designation D2487, USBR Designation E-3
†LL = liquid Limit
‡Or any borderline soil beginning with one of these symbols (i.e., GM-GC, GC-SC)
§For ± 1% accuracy and predicted deflection of 3%, actual deflection would be between 2% and 4%.

NOTE: Values applicable only for fills less than 50 ft (15 m). Table does not include any safety factor. For use in predicting initial deflections only, appropriate deflection lag factor must be applied for long-term deflections. If bedding falls on the borderline between two compaction categories, select lower *E'* value or average the two values. Percentage proctor based on laboratory maximum dry density from test standards using about 12,500 ft-lb/ft^3 (598,000 J/m^3) (ASTM D698, AASHO T-99, USBR Designation E-11). 1 lb/in^2 = 6.9 kN/m^2.

SOURCE: Amster K. Howard, "Soil Reaction for Buried Flexible Pipe," U.S. Bureau of Reclamation, Denver, Colo. Reprinted with Permission from American Society of Civil Engineers *J. Geotech. Eng. Div.*, January 1977, pp. 33–43.

Table 2-3. Design Values of E', psi (from Hartley and Duncan, 1987)

Type of Soil	Depth of Cover (ft)	Standard AASHTO* Relative Compaction			
		85 %	90 %	95 %	100 %
Fine-grained soils with less than 25 percent sand content (CL, ML, CL-ML)	0-5	500	700	1,000	1,500
	5-10	600	1,000	1,400	2,000
	10-15	700	1,200	1,600	2,300
	15-20	800	1,300	1,800	2,600
Coarse-grained soils with fines (SM, SC)	0-5	600	1,000	1,200	1,900
	5-10	900	1,400	1,800	2,700
	10-15	1,000	1,500	2,100	3,200
	15-20	1,100	1,600	2,400	3,700
Coarse-grained soils with little or no fines (SP, SW, GP, GW)	0-5	700	1,000	1,600	2,500
	5-10	1,000	1,500	2,200	3,300
	10-15	1,050	1,600	2,400	3,600
	15-20	1,100	1,700	2,500	3,800

*Note: AASHTO is the American Association of State Highway Transportation Officials.
Table reproduced from Hartley and Duncan, 1987

2.3.1.3 Discussion of Load Terms in Spangler Stress Formula and Iowa Formula

As described above, the Spangler stress formula and the Iowa Formula both operate on a load per unit length of pipe, $W_{vertical}$ resulting from either fill and/or surface loads. Hence, a key aspect of these formulas is the estimation of the effective fill and surface loads at the top of the pipe. These loads are discussed in this section.

Pipe Load Due to Fill

Spangler computed the pressure transmitted to the pipe due to earth (fill) load based on Marston's load theory (Marston, 1913) as follows:

$$W_{fill} = C_d \cdot \gamma \cdot B_d^2 \tag{2.3}$$

where C_d is a fill coefficient, γ is the soil density and B_d is the effective trench width. Values of the fill coefficient C_d for different soils are tabulated as a function of the trench geometry (defined based on the ratio of the depth of soil cover H to the effective trench width B_d) and soil type in several references (e.g., the GPTC Guide, Spangler and Hennessy, 1946, etc.).