Exhibit VGS-CC-2



Memorandum

Surface/Earth Load Evaluation
Vermont Gas Systems, Inc.
Mott MacDonald, LLC
507105094
West Springfield, MA
June 15, 2021

1 Introduction

Vermont Gas Systems, Inc. (VGS) has requested that Mott MacDonald provide additional information regarding Mott MacDonald's prior analysis of whether the construction of the Addison Natural Gas Pipeline (ANGP) meets a HS-20+15% loading standard. Our prior analysis of the ANGP loading included two different assessments of the ANGP under the HS-20+15% loading standard. The first analysis in 2016 involved calculation of the loading on the ANGP using a generic loading calculation tool, the API RP 1102 tool, which is frequently used for general assessments of loading for highway and railway crossings. We used this tool to assess the loading on the ANGP assuming "no compaction¹" at a variety of depths and soil types that could be present along the ANGP. The second analysis utilized a more case-specific loading calculation, ANSI GPTC Z380.1, 2018 edition (GPTC), which is based on the same underlying loading research as the API 1102 tool and is also consistent with ASME/ANSI B31.8. In this 2017 loading analysis, we assessed representative input parameters that included depths of cover greater than or equal to two feet with soil types that exhibited low strength soil properties and the results demonstrated that the ANGP meets the HS-20+15% loading standard under such conditions.

VGS has asked Mott MacDonald to provide additional information about the assumptions used in those analyses in light of questions raised by the Vermont Public Utility Commission (Commission). We have reviewed our prior loading calculations as well as the Commission's January and April 2021 orders in Case No. 17-3550 questioning whether Mott MacDonald's calculations were based on "flawed assumptions about: (1) the diameter of the pipeline (12 inches versus 15 inches); (2) the method of burial (sink-in-the-swamp versus horizontal directional drilling); and (3) the density of the soil surrounding the pipeline." As explained in more detail below, the prior loading calculations utilized appropriate inputs regarding (1) pipe diameter, (2) burial method, and (3) soil density. In our professional opinion, the 2016 loading calculations accurately assessed a HS-20+15% loading standard and the 2017 loading calculations demonstrate the ANGP meets the HS-20+15% loading standard with depths of cover of 2 feet or greater.

In addition, we have performed a variety of sensitivity analyses using different methods (provided in Attachment B) for calculating the loading on the ANGP. These analyses, as well as our prior calculations, demonstrate that the ANGP meets the HS-20+15% loading standard with as little as 2 feet of cover even when assuming low soil strength properties that represent weak soils and/or an absence of soil compaction. In our professional judgment, after analyzing the loading calculations based on a variety of sensitivity assessments, the ANGP meets the HS-20+15% loading standard in areas where it is buried at least two feet.

¹ Our reference to "no compaction" adopts an assumption that mechanical means were not used to compact backfill soil materials. However, as discussed in section 2.3 varying modulus of soil reaction values were used to assess this condition.

2 Additional Information Regarding the 2016 and 2017 Calculations

The following responds to the Commission's specific questions regarding the (1) pipe diameter, (2) burial method, and (3) soil density and explains why the values used in our 2016 and 2017 calculations were appropriate for assessing whether the ANGP meets the HS-20+15% loading standard.

2.1 Diameter of pipeline

Our assessment of the loading on the ANGP assumed a pipe diameter of 12.75" (See Attachment A). The diameter that was utilized in these loading calculations was based on the outside diameter of the steel pipeline. Utilizing the steel pipeline outside diameter (12.75") is industry practice and is required for performing the loading evaluation using any of the standard loading calculation tools used in the industry, including API RP1102, ANSI GPTC Z380.1, 2018 edition (GPTC) and the Canadian Energy Pipeline Association Surface Loading Calculator (CEPA).

The Commission has questioned whether the diameter input should include the extra width of concrete coating on the pipe. The concrete coating is not taken into account in the diameter input because the concrete coating does not provide significant structural value to the steel pipeline itself. The concrete coating applied to the exterior of the ANGP pipeline is not a material factor when assessing the ability of the 12.75" diameter steel pipeline to withstand surface loads. Instead, concrete coating is used to provide negative buoyancy and protect the pipeline against external damage during installation. The industry standard surface and earth loading calculation tools for natural gas pipelines do not recommend changing the pipe diameter input based on a concrete coating layer. The 12.75" input for pipe diameter was therefore appropriate for the surface loading calculations even for those locations where the pipeline was coated with concrete.

2.2 Method of burial

Our assessment of the loading on the ANGP assumed installation of the ANGP was performed using an open trench installation rather than a bore or horizontal directional drill (HDD) installation. The Commission has questioned whether our loading calculations mistakenly assumed the ANGP was installed using HDD. The Commission's January 29, 2021 Order states that the assessment should have assumed an "open-cut trench with a pipeline diameter of 15.75" rather than a "data assessment tool applicable to an HDD installation that assumes a bore width of 12.75 inches." The Order appears to be referring to an input for "bored diameter" on the API RP 1102 calculation sheet, implying that because there was a value used for that input, we had treated the pipeline as though it was installed by bore.

Our use of the API RP 1102 tool for assessing the loading on a pipeline that is installed by open-cut trench was appropriate based on the guidance provided in API RP 1102. In particular, the guidance for that calculation method states in Section 4.7.2.1 that bored diameter ($B_d = D$) should be assumed when analyzing a trenched construction. In other words, the guidance instructs us to input the pipe diameter value for the bored diameter parameter when applying the calculation to an open trench construction. Our loading calculations followed this instruction by inputting the pipeline diameter (D = 12.75") for the bored diameter value (B_d). We were fully aware that the pipeline was being installed by open-cut trench and therefore our calculations were consistent with this understanding and the API RP 1102 guidance.

2.3 Density of soil surrounding the pipeline

The Commission has also questioned whether our prior loading calculations included appropriate assumptions about the density of soil. The purpose of our 2016 loading assessment was to evaluate the "pipeline's integrity under loading without compaction of backfill." The density of the soil surrounding the pipeline is a factor when calculating the loading on the pipeline because different soil types and varying levels of compaction exert and transfer the pressure differently. The relevant parameter in the loading calculation that captures for these

variables is the modulus of soil reaction. Section 6.2 of the API RP 1102 provides general recommendations for trench installation including recommendations for compaction of backfill. The API RP 1102 loading calculation tool does not include an input parameter based on Section 6.2 compaction levels. Instead, the API RP1102 loading tool accounts for soil strength and compaction properties by allowing the user to input relevant modulus of soil reaction values that are consistent with various soil types and levels of compaction.

Accordingly, our 2016 loading evaluation using the API 1102 tool employed sensitivity analysis to evaluate various soil parameters that represented a wide range of modulus of soil reaction values, which is inputted using values ranging from 200 psi (representing very weak soils) to 2,000 psi (representing stronger soils). This modulus of soil reaction range represented soil types exhibiting "soft to medium clays and silts with high plasticities" (200 psi) to "dense to very dense sands and gravels" (2000 psi). The range in modulus of soil reaction values can also be understood as a range of soil compaction, with lower modulus of soil reaction representing backfill with low strength soil properties and no compaction. Accordingly, our 2016 calculations provided an assessment of the "pipeline's integrity under loading without compaction of backfill" under a variety of circumstances including low soil strengths.

Likewise, our 2017 calculation modeled a low strength soil density (fully saturated clay), which is the equivalent of assessing loading with low or no compaction. Under all the soil densities we assessed, including the 2017 GPTC calculation, we concluded that the ANGP achieved the HS-20+15% loading criteria in locations where it is buried a minimum of two feet. We have also confirmed this conclusion by performing a variety of additional calculations as discussed below.

3 Additional Loading Calculation Validation

As part of our review of Mott MacDonald's prior loading calculations for ANGP, we performed several additional calculations utilizing the same GPTC method used in 2017, as well as a CEPA loading calculation tool, which also adheres to the ASME/ANSI B31.8² standard regarding combined equivalent stresses on a steel pipeline. These calculation tools are similar to the API RP 1102 tool used in 2016, are based on the same underlying principles, and are consistent with the combined stress formula found in ASME/ANSI B31.8 paragraph 833.4. Our verification calculations are provided as Attachment B and demonstrate that – like our prior loading calculations – the ANGP meets the HS-20+15% loading standard for a variety of scenarios. For example, one such scenario modeled the loading on the ANGP based on a low strength soil simply "dumped" (100 psi) into the trench with no subsequent compaction. The results show that the total effective stress from a HS-20+15% load is 47,563 psi, which is well below the total effective stress that can be safely handled by the ANGP.

Based on our review of the prior calculations, as well as our calculations verifying similar results under a variety of scenarios, Mott MacDonald is of the opinion that the loading analysis that has been performed utilized appropriate assumptions and input data for the ANGP construction, and the ANGP meets the HS-20+15% loading standard even where it is assumed there is only 2 feet of cover backfill with low strength soils.

² ASME has been defining piping safety since 1922. ASME B31.8 covers gas transmission and distribution piping systems, including gas pipelines, gas compressor stations, gas metering and regulation stations, gas mains, and service lines up to the outlet of the customer's meter set assembly.

Attachment A – 2016 & 2017 Calculations

Project Name: Vermont Gas Systems

Location: Burlington, VT

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 (ps						
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).

5/25/2016

Rev. 1



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 verifica	ation
	B - Analysis and detailed design	D - Other (specify)	

Computer Applications Used:		
Title:	Version Date:	
PIPELINE TOOLBOX	2013	
(a)		

Scopes for Checking Manual and Computer Generated Calculations:

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Sheets	Calculations by			Checked By:		
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b) Identify doo	cuments/technica	I records where o	output will be u	sed:		
> calcula	tions su	mmary P	rovided	to die	nt	
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Approved by P	roject Manager:	Signature: Print name:	Juseph	WOJNAS	5000000000	Date: 5/2.5/16

Distribution: Original

Original to project file



Location Burlington, VT		Date 5/24/20	16	~
API 1102 - Gas Pipeline	e Crossing High	way		
PIPE AND OPERATIONAL DATA	:	SITE A	ND INSTALLATION DATA:	
Operating Pressure [psi]	1440	Soil Ty		d silts with hig
Location Class:	3	E' - Mo	plasticities odulus of Soil Reaction [ksi]	0.2
Operating Temperature [°F]	60.0	Er - Re	esilient Modulus [ksi]	5.0
Pipe Outside Diameter [in]	12.75	Avera	ge Unit Weight of Soil [lb/ft³]	120.00
Pipe Wall Thickness [in]	0.312	-	epth [ft]	3
Pipe Grade: X65		Bored	Diameter [in]	12.75
Specified Minimum Yield Stress	65,000	Installa	ationTemperature [°F]	60.0
Design Factor	0.50	Desigr	Wheel Load from Single Axle	[kips] 18.4
Longitudinal Joint Factor	1.0	Desigr	Wheel Load from Tandem Ax	es [kips] 18.4
Temperature Derating Factor	1.000	Paver	nent Type: None	
Pipe Class: API 5L Electric Re	esistance Welded		t Factor Method: ASCE - Highw	/ay
Young's Modulus for Steel [ksi]	30,000		-	
Poisson's Ratio for Steel	0.30			
Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Applied: API 1102 Pro	ocedure
RESULTS				
Hoop Stress [psi]		29,423	Maximum Circumferential Str	ess [psi] 34,3
Allowable Hoop Stress [psi]		32,500	Maximum Longitudinal Stress	s [psi] 12,2
Stiffness Factor for Earth Load Ci	rcumferential Stress	2,196	Maximum Radial Stress [psi]	-1,4
Burial Factor for Earth Load Circu	mferential Stress	0.83	Total Effective Stress [psi]	31,2
Excavation Factor for Earth Load	Circumferential Stress	0.83	Allowable Effective Stress [ps	si] 32,5
Circumferential Stress from Earth	Load [psi]	1,331		
Impact Factor		1.50	Stress [psi] Calculated Allo	
Highway Stiffness Factor for Cycli	c Circumferential	16.60	Hoop 29,423 32,5 Effective 31,239 32,5	
Highway Geometry Factor for Cyc	lic Circumferential	1.22	Girth Welds 3,229 6,00	
Cyclic Circumferential Stress [psi]		4,271	Long. Welds 4,271 11,5	500 PASS
Highway Stiffness Factor for Cycli	c Longitudinal Stress	13.20		
Highway Geometry Factor for Cyc	lic Longitudinal Stress	1.16		
Cyclic Longitudinal Stress [psi]		3,229		
	culations run using HS-	20 loadir	$na \pm 15\%$	

Prepared By Kelsey Kibbe Approved By

Location Burlington, VT		Date 5/24/20	16	
API 1102 - Gas Pipeline	e Crossing High	way		ж.
PIPE AND OPERATIONAL DATA	:	SITE A	ND INSTALLATION DA	TA:
Operating Pressure [psi]	1440	Soil Ty	•	ays and silts with high
Location Class:	3	E' - Mo	plasticities odulus of Soil Reaction [k	(si] 0.2
Operating Temperature [°F]	60.0		esilient Modulus [ksi]	5.0
Pipe Outside Diameter [in]	12.75		ge Unit Weight of Soil [lb/	
Pipe Wall Thickness [in]	0.312	-	epth [ft]	4
Pipe Grade: X65		•	Diameter [in]	12.75
Specified Minimum Yield Stress	65,000		ationTemperature [°F]	60.0
Design Factor	0.50		Wheel Load from Single	
Longitudinal Joint Factor	1.0	•	Wheel Load from Tand	-
Temperature Derating Factor	1.000	-	nent Type: None	
Pipe Class: API 5L Electric Re	esistance Welded		Factor Method: ASCE -	- Highway
Young's Modulus for Steel [ksi]	30,000	·		0
Poisson's Ratio for Steel	0.30			
Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Applied: API 11	102 Procedure
RESULTS				
Hoop Stress [psi]		29,423	Maximum Circumferen	itial Stress [psi] 34,5
Allowable Hoop Stress [psi]		32,500	Maximum Longitudinal	Stress [psi] 12,3
Stiffness Factor for Earth Load Ci	rcumferential Stress	2,196	Maximum Radial Stres	is [psi] -1,4
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API 1102 - Gas Pipeline Crossing Highway PIPE AND OPERATIONAL DATA: Operating Pressure [psi] 1440 Soil Type: Soft to medium clays and silts with Location Class: 3 Certaing Temperature [°F] 60.0 Er - Resilient Modulus [ksi] 5.0 Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil Tgecino [ksi] 12.75 Average Unit Weight of Soil Tgecino [ksi] 12.75 Specified Minimum Yield Stress 65,000 Installation Temperature [°F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Congitudinal Joint Factor 1.0 Design Wheel Load from Single Axle [kips] 18.4 Congitudinal Joint Factor 1.0 Design Wheel Load from Tandem Axles [kips] 18.4 Congitudinal Joint Factor 1.0 Design Wheel Load from Tandem Axles [kips] 18.4 Congitudinal Stress [psi] 30,000 Poisson's Ratio for Steel 0.30 Coefficient of Thermal Expansion [per"F] 32,500 Maximum Circumferential Stress 2,088 Maximum Radial Stress [psi] 32,500 Circumferential Stress 2,088 Maximum Radial Stress [psi] 32,500 Circumferential Stress 2,088 Maximum Radial Stress [psi] 31,18 Excavation Factor for Cyclic Circumferential 16.60 Effective Stress [psi] 32,20 National Stress [psi] 32,20 Nat	Location Burlington, VT		Date 5/24/20	16			
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Highway Geometry Factor for Cyclic Circumferential1.22Girth Welds3,2296,000PASSCyclic Circumferential Stress [psi]4,27111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress1.16Cyclic Longitudinal Stress [psi]3,229	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth	mferential Stress Circumferential Stress	32,500 2,088 0.83 0.83 1,265	Maximum Lor Maximum Rad Total Effective Allowable Effe	ngitudinal Si dial Stress [e Stress [ps ective Stress	tress [psi] [psi] i] s [psi] Allowable	12,21 -1,44 31,18 32,50 PASS/FA
Cyclic Circumferential Stress [psi]4,271Long. Welds4,27111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress13.20Highway Geometry Factor for Cyclic Longitudinal Stress1.16Cyclic Longitudinal Stress [psi]3,229	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor	mferential Stress Circumferential Stress Load [psi]	32,500 2,088 0.83 0.83 1,265 1.50	Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop	ngitudinal Si dial Stress [ps ective Stress Calculated 29,423	tress [psi] [psi] i] s [psi] Allowable 32,500	12,21 -1,44 31,18 32,50 PASS/FA PASS
Highway Geometry Factor for Cyclic Longitudinal Stress 1.16 Cyclic Longitudinal Stress [psi] 3,229	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycli	mferential Stress Circumferential Stress Load [psi] c Circumferential	32,500 2,088 0.83 0.83 1,265 1.50 16.60	Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective	ngitudinal Si dial Stress [ps ective Stress Calculated 29,423 31,180	tress [psi] [psi] i] s [psi] Allowable 32,500 32,500	12,21 -1,44 31,18 32,50 PASS/FA PASS PASS
Cyclic Longitudinal Stress [psi] 3,229	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Cir Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycli Highway Geometry Factor for Cycli	mferential Stress Circumferential Stress Load [psi] c Circumferential clic Circumferential	32,500 2,088 0.83 0.83 1,265 1.50 16.60 1.22	Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	ngitudinal Si dial Stress [ps ective Stress Calculated 29,423 31,180 3,229	tress [psi] [psi] i] s [psi] Allowable 32,500 32,500 6,000	12,21 -1,440 31,18 32,50 PASS/FA PASS PASS PASS
	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycli Highway Geometry Factor for Cycli Cyclic Circumferential Stress [psi]	mferential Stress Circumferential Stress Load [psi] c Circumferential clic Circumferential	32,500 2,088 0.83 1,265 1.50 16.60 1.22 4,271	Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	ngitudinal Si dial Stress [ps ective Stress Calculated 29,423 31,180 3,229	tress [psi] [psi] i] s [psi] Allowable 32,500 32,500 6,000	12,21 -1,44 31,18 32,50 PASS/FA PASS PASS PASS
Notes: Open cut construction, calculations run using HS-20 loading + 15%	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycli Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycli	mferential Stress Circumferential Stress Load [psi] c Circumferential clic Circumferential	32,500 2,088 0.83 1,265 1.50 16.60 1.22 4,271 13.20	Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	ngitudinal Si dial Stress [ps ective Stress Calculated 29,423 31,180 3,229	tress [psi] [psi] i] s [psi] Allowable 32,500 32,500 6,000	12,21 -1,440 31,18 32,50 PASS/FA PASS PASS PASS
	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Cir Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycli Highway Geometry Factor for Cycli Highway Stiffness Factor for Cycli Highway Stiffness Factor for Cycli	mferential Stress Circumferential Stress Load [psi] c Circumferential clic Circumferential	32,500 2,088 0.83 1,265 1.50 16.60 1.22 4,271 13.20 1.16	Maximum Lor Maximum Rad Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	ngitudinal Si dial Stress [ps ective Stress Calculated 29,423 31,180 3,229	tress [psi] [psi] i] s [psi] Allowable 32,500 32,500 6,000	12,21 -1,44 31,18 32,50 PASS/FA PASS PASS PASS

Location Burlington, VT		Date 5/24/20	16		
API 1102 - Gas Pipelin	e Crossing High	way			
PIPE AND OPERATIONAL DATA	A:	SITE A	ND INSTALLATION DAT	A:	
Operating Pressure [psi]	1440	Soil Ty			with
Location Class:	3	F' - Mc	low/medium plastic odulus of Soil Reaction [ks		0.5
Operating Temperature [°F]	60.0		esilient Modulus [ksi]	.1	5.0
Pipe Outside Diameter [in]	12.75		ge Unit Weight of Soil [lb/ft	3]	120.00
Pipe Wall Thickness [in]	0.312		epth [ft]		4
Pipe Grade: X65		-	Diameter [in]		12.75
Specified Minimum Yield Stress	65,000		ationTemperature [°F]		60.0
Design Factor	0.50		Wheel Load from Single	Axle [kips]	18.4
Longitudinal Joint Factor	1.0	•	Wheel Load from Tander		osl 18.4
Temperature Derating Factor	1.000	•	nent Type: None		
Pipe Class: API 5L Electric R	esistance Welded		t Factor Method: ASCE - I	Highway	
Young's Modulus for Steel [ksi]	30,000			0)	
Poisson's Ratio for Steel	0.30				
Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Applied: API 110	2 Procedur	e
RESULTS					
Hoop Stress [psi]		29,423	Maximum Circumferenti	al Stress [p	si] 34,48
Allowable Hoop Stress [psi]		32,500	Maximum Longitudinal S	Stress [psi]	12,28
Stiffness Factor for Earth Load C	ircumferential Stress	2,088	Maximum Radial Stress	[psi]	-1,44
Burial Factor for Earth Load Circu	umferential Stress	0.97	Total Effective Stress [p	si]	31,37
Excavation Factor for Earth Load	Circumferential Stress	0.83	Allowable Effective Stres	ss [psi]	32,50
Circumferential Stress from Earth	n Load [psi]	1,479			
Impact Factor		1.50		Allowable	
Highway Stiffness Factor for Cyc	lic Circumferential	16.60	Hoop 29,423 Effective 31,370	32,500 32,500	PASS PASS
Highway Geometry Factor for Cy	clic Circumferential	1.22	Girth Welds 3,229	6,000	PASS
Cyclic Circumferential Stress [psi]	4,271	Long. Welds 4,271	11,500	PASS
Highway Stiffness Factor for Cyc	lic Longitudinal Stress	13.20			
Highway Geometry Factor for Cy	clic Longitudinal Stress	1.16			
Cyclic Longitudinal Stress [psi]		3,229			
Notes: Open cut construction, ca	lculations run using HS	-20 loadir	ng + 15%		
Reference: API RP 1102 "Steel F	-		-		
			proved By	Revi	

Location Rurlington VT		Date 5/24/20	16			
Burlington, VT	- Crossing High					
API 1102 - Gas Pipeline	e crossing riigh	vvay				
PIPE AND OPERATIONAL DATA	.:	SITE A	ND INSTALLA	TION DATA	.:	
Operating Pressure [psi]	1440	Soil Ty		edium clay		with
Location Class:	3	E' - Mo	odulus of Soil Re	um plasticit eaction [ksi]		0.5
Operating Temperature [°F]	60.0	Er - Re	esilient Modulus	[ksi]		5.0
Pipe Outside Diameter [in]	12.75	Avera	e Unit Weight o	of Soil [lb/ft³	1	120.00
Pipe Wall Thickness [in]	0.312	Pipe D	epth [ft]	-	-	5
Pipe Grade: X65		·	Diameter [in]			12.75
Specified Minimum Yield Stress	65,000		ationTemperatu	re [°F]		60.0
Design Factor	0.50		Wheel Load fr		xle [kips]	18.4
Longitudinal Joint Factor	1.0		Wheel Load fr	-		osl 18.4
Temperature Derating Factor	1.000	•	nent Type: Non			-
Pipe Class: API 5L Electric Re	esistance Welded		t Factor Method		iahwav	
Young's Modulus for Steel [ksi]	30,000				<u> </u>	
Poisson's Ratio for Steel	0.30					
Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Applied:	API 1102	2 Procedur	e
RESULTS						
Hoop Stress [psi]		29,423	Maximum Cire	cumferentia	l Stress [p	si] 34,20
Allowable Hoop Stress [psi]		32,500	Maximum Lor	ngitudinal St	tress [psi]	12,1
Stiffness Factor for Earth Load Ci	rcumferential Stress	2,088	Maximum Ra	dial Stress [psi]	-1,44
Burial Factor for Earth Load Circu	Imferential Stress	1.08	Total Effective	e Stress [ps	i]	31,1
Excavation Factor for Earth Load	Circumferential Stress	0.83	Allowable Effe	ective Stres	s [psi]	32,50
Circumferential Stress from Earth	Load [psi]	1,647				
Impact Factor		1.50	Stress [psi]	Calculated		PASS/FA
Highway Stiffness Factor for Cycl	ic Circumferential	16.60	Hoop	29,423	32,500	PASS
Highway Geometry Factor for Cyc	clic Circumferential	1.10	Effective Girth Welds	31,159 3,006	32,500 6,000	PASS PASS
Cyclic Circumferential Stress [psi]	3,850	Long. Welds	3,850	11,500	PASS
	ic Longitudinal Stress	13.20				
Highway Stiffness Factor for Cycl		1 00				
	clic Longitudinal Stress	1.08				
Highway Stiffness Factor for Cycl	clic Longitudinal Stress	3,006				

Prepared By Kelsey Kibbe	Approved By
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Revision: 13.0.1

Location Burlington, VT		Date 5/24/20	16				
API 1102 - Gas Pipeline	e Crossing High	way					
PIPE AND OPERATIONAL DATA	:	SITE A		ALLA		A:	
Operating Pressure [psi]	1440	Soil Ty	pe: Lo	ose sa	ands and g	ravels	
Location Class:	3	E' - Mc	dulus of \$	Soil Re	eaction [ks	il	0.5
Operating Temperature [°F]	60.0		silient Mo		-		10.0
Pipe Outside Diameter [in]	12.75				of Soil [lb/ft	3]	120.00
Pipe Wall Thickness [in]	0.312	_	epth [ft]	- 3			3
Pipe Grade: X65		•	Diameter	[in]			12.75
Specified Minimum Yield Stress	65,000		ationTemp	• •	re [°F]		60.0
Design Factor	0.50				om Single	Axle [kips]	18.4
Longitudinal Joint Factor	1.0	Ū			om Tandei		
Temperature Derating Factor	1.000		ent Type:			•	
Pipe Class: API 5L Electric Re	esistance Welded				: ASCE - H	Highway	
Young's Modulus for Steel [ksi]	30,000	•					
Poisson's Ratio for Steel	0.30						
Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Ap	oplied:	API 110)2 Procedu	re
RESULTS							
Hoop Stress [psi]		29,423	Maximu	ım Cir	cumferenti	al Stress [psi] 33,2
Allowable Hoop Stress [psi]		32,500	Maximu	ım Lor	ngitudinal S	Stress [psi]	11,2
Stiffness Factor for Earth Load Ci	rcumferential Stress	2,088	Maximu	ım Ra	dial Stress	[psi]	-1,4
Burial Factor for Earth Load Circu	mferential Stress	0.83	Total Ef	fective	e Stress [p	si]	30,3
Excavation Factor for Earth Load	Circumferential Stress	0.83	Allowab	le Effe	ective Stres	ss [psi]	32,
Circumferential Stress from Earth	Load [psi]	1,265					
Impact Factor		1.50	Stress [psi]	-	Allowable	3
Highway Stiffness Factor for Cycli	c Circumferential	12.60	Hoop Effective	ρ	29,423 30,360	32,500 32,500	PASS PASS
Highway Geometry Factor for Cyc	clic Circumferential	1.22	Girth W		2,275	6,000	PASS
Cyclic Circumferential Stress [psi]		3,241	Long. V	Velds	3,241	11,500	PASS
Highway Stiffness Factor for Cycl	c Longitudinal Stress	9.30					
Highway Geometry Factor for Cyc	clic Longitudinal Stress	1.16					
Cyclic Longitudinal Stress [psi]		2,275					
	culations run using HS-		450/				

Reference: API RP 1102 "Steel Pipelines Crossing Railroads and Highways"

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Location Burlington, VT		Date 5/24/20	16				
API 1102 - Gas Pipeline	e Crossing High	way					
PIPE AND OPERATIONAL DATA	:	SITE A		ISTALLA	TION DATA	ν:	
Operating Pressure [psi]	1440	Soil Ty	vpe:	Loose sa	ands and gr	avels	
Location Class:	3	E' - Mo	odulus	of Soil Re	eaction [ksi]		0.5
Operating Temperature [°F]	60.0			Modulus			10.0
Pipe Outside Diameter [in]	12.75				of Soil [lb/ft ³	1	120.00
Pipe Wall Thickness [in]	0.312	Pipe D		_			4
Pipe Grade: X65		Bored		-			12.75
Specified Minimum Yield Stress	65,000			emperatu	re [°F]		60.0
Design Factor	0.50			-	om Single A	xle [kips]	18.4
Longitudinal Joint Factor	1.0	_			om Tanden		
Temperature Derating Factor	1.000	•		pe: Non		i i indo fini	.01 .0
Pipe Class: API 5L Electric Re	esistance Welded				: ASCE - H	iahway	
Young's Modulus for Steel [ksi]	30,000	mpao		, mourou		ignitaj	
Poisson's Ratio for Steel	0.30						
Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Facto	r Applied:	API 1102	2 Procedur	e
RESULTS						7	
Hoop Stress [psi]		29,423	Maxi	mum Ciro	cumferentia	I Stress [p	si] 33,42
Allowable Hoop Stress [psi]		32,500	Maxi	mum Lor	ngitudinal St	ress [psi]	11,33
Stiffness Factor for Earth Load Ci	rcumferential Stress	2,088	Maxi	mum Rad	dial Stress [psi]	-1,44
Burial Factor for Earth Load Circu	mferential Stress	0.97	Tota	I Effective	e Stress [ps	i]	30,58
Excavation Factor for Earth Load	Circumferential Stress	0.83	Allov	vable Effe	ective Stress	s [psi]	32,50
Circumferential Stress from Earth	Load [psi]	1,479					
Impact Factor		1.50	Stres	ss [psi]	Calculated		
Highway Stiffness Factor for Cycli	c Circumferential	12.60	Hoop		29,423	32,500	PASS
Highway Geometry Factor for Cyc	lic Circumferential	1.22	Effec	Welds	30,550 2,275	32,500 6,000	PASS PASS
Cyclic Circumferential Stress [psi]		3,241			3,241	11,500	PASS
Highway Stiffness Factor for Cycli	c Longitudinal Stress	9.30	5V				
Highway Geometry Factor for Cyc	lic Longitudinal Stress	1.16					
Cyclic Longitudinal Stress [psi]		2,275					
				i%			

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Approved By

Revision: 13.0.1

API 1102 - Gas Pipeline Crossing Highway PIPE AND OPERATIONAL DATA: SITE AND INSTALLATION DATA: Operating Pressure [psi] 1440 Soil Type: Loces sands and gravels Location Class: 3 E' - Modulus of Soil Reaction [ksi] 0.5 Operating Temperature [°F] 60.0 Er - Resilient Modulus [ksi] 10.0 Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil [lb/ft³] 120.00 Pipe Grade: X65 Bored Diameter [in] 12.75 Specified Minimum Yield Stress 65,000 InstallationTemperature [°F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Longitudinal Joint Factor 1.00 Pavement Type: None Impact Factor Method: ASCE - Highway Young's Modulus for Steel 0.30 Coefficient of Thermal Expansion [per"F] 0.0000065 Safety Factor Applied: API 1102 Procedure RESULTS 29,423 Maximum Circumferential Stress [psi] 33,27 Allowable Hoop Stress [psi] 29,423 Maximum Longitudinal Stress [psi] 11,22 Stiffness Factor for Earth Load Circumferential Stress 2,08 Maximum Radial Stress [psi] 1,44 Buri	Location Burlington, VT		Date 5/24/20	16			
Operating Pressure [psi] 1440 Soil Type: Locas and gravels Location Class: 3 E' - Modulus of Soil Reaction [ksi] 0.5 Operating Temperature [°F] 60.0 Er - Resilient Modulus [ksi] 10.0 Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil [lb/ft³] 120.00 Pipe Grade: X65 Bored Diameter [in] 12.75 Specified Minimum Yield Stress 65.000 InstallationTemperature [°F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Longitudinal Joint Factor 1.0 Design Wheel Load from Tandem Axles [kips] 18.4 Temperature Derating Factor 1.000 Pavement Type: None Impact Factor Method: ASCE - Highway Young's Modulus for Steel 0.30 Coefficient of Thermal Expansion [per°F] 0.0000065 RESULTS 32,500 Maximum Circumferential Stress [psi] 33,27 Allowable Hoop Stress [psi] 29,423 Maximum Circumferential Stress [psi] 31,22 Stiffness Factor for Earth Load Circumferential Stress 2,088 Maximum Calualitated Allowable PASS/FA Burial Factor for Earth Load Circumferential Stress 0.83		e Crossing High	way				
Location Class: 3 E' - Modulus of Soil Reaction [ksi] 0.5 Operating Temperature [°F] 60.0 Er - Resilient Modulus [ksi] 10.0 Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil [lb/ft ^a] 120.00 Pipe Wall Thickness [in] 0.312 Pipe Depth [ft] 5 Pipe Grade: X65 Bored Diameter [in] 12.75 Specified Minimum Yield Stress 65,000 InstallationTemperature [°F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Longitudinal Joint Factor 1.0 Design Wheel Load from Tandem Axles [kips] 18.4 Temperature Derating Factor 1.000 Pavement Type: None Impact Factor Method: ASCE - Highway Young's Modulus for Steel 0.30 Coefficient of Thermal Expansion [per*F] 0.000065 Safety Factor Applied: API 1102 Procedure RESULTS Hoop Stress [psi] 32,500 Maximum Longitudinal Stress [psi] 33,27 Allowable Hoop Stress [psi] 29,423 Maximum Longitudinal Stress [psi] 34,42 Burial Factor for Earth Load Circumferential Stress 0.83 Allowable Effective Stress [psi] 30,42	PIPE AND OPERATIONAL DATA		SITE A	ND INSTALLA	TION DATA:		
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	Operating Pressure [psi]	1440	Soil Ty	pe: Loose sa	ands and gra	ivels	
Operating Temperature [°F]60.0Er - Resilient Modulus [ksi]10.0Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft ^a]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]31,27Allowable Hoop Stress [psi]29,423Maximum Radial Stress [psi]11,22Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]34,42Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,42Excavation Factor for Earth Load Circumferential1.647Impact Factor1.50Effective 30,42732,500Ingate Factor1.50Stress [psi]2,942332,500PASSEffective 30,42732,500PASSCircumferential Stress [psi]1.647Impact Factor1.50Effective 30,42732,500PASSHighway Geometry Factor for Cyclic Circumferential1.60Stress [psi]2,9423 <td>Location Class:</td> <td>3</td> <td>E' - Mo</td> <td>dulus of Soil Re</td> <td>eaction [ksi]</td> <td></td> <td>0.5</td>	Location Class:	3	E' - Mo	dulus of Soil Re	eaction [ksi]		0.5
Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft ^{an}]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000Installation Temperature ["F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,000Safety Factor Applied:API 1102 ProcedurePoisson's Ratio for Steel0.30Safety Factor Applied:API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]11,22Movable Hoop Stress [psi]29,423Maximum Radial Stress [psi]11,22Stiffness Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,42Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,42Circumferential Stress form Earth Load Circumferential1.647Hoop29,423Azimum Radial Stress [psi]32,500Highway Stiffness Factor for Cyclic Circumferential1.647Impact Factor1.50Stress [psi]22,500PASSCyclic Circumferential1.60Effective30,42732,500PASSStress [psi]2,92311,500PASSCyclic Circumferential1	Operating Temperature [°F]	60.0					
Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade::X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,00030Coefficient of Thermal Expansion [per°F]0.0000065Pipe Stress [psi]29,423Maximum Circumferential Stress [psi]33.27Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11.22Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]30.42Excavation Factor or Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30.42Circumferential Stress from Earth Load Circumferential1.647Hoop29,42332,500PASSHighway Stiffness Factor for Cyclic Circumferential1.647Hoop29,42332,500PASSHighway Geometry Factor for Cyclic Circumferential1.00Effective 30,42732,500PASSKiffness Factor for Cyclic Circumferential1.00Effective 30,42732,500PASSHighway Geometry Factor for Cyclic Corcumferential1.01Girth Welds 2,1186,000PASSCyclic Circumferential Stress [psi]2,9231,500 <td>Pipe Outside Diameter [in]</td> <td>12.75</td> <td></td> <td></td> <td></td> <td></td> <td></td>	Pipe Outside Diameter [in]	12.75					
Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,00030.000Safety Factor Applied:API 1102 ProcedureRESULTS0.30Safety Factor Applied:API 1102 Procedure11.22RESULTS29,423Maximum Circumferential Stress [psi]33,27Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11.42Stiffness Factor for Earth Load Circumferential Stress1.08Total Effective Stress [psi]30,42Linautor Factor1.50Stress [psi]32,500PASSHighway Stiffness Factor for Cyclic Circumferential1.50Stress [psi]32,500Highway Stiffness Factor for Cyclic Circumferential1.50Stress [psi]29,42332,500Highway Stiffness Factor for Cyclic Circumferential1.50Stress [psi]30,427Highway Geometry Factor for Cyclic Circumferential1.10Girth Weids 2,1186,000Cyclic Circumferential Stress [psi]2,92311,500PASSHighway Geometry Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Lo	Pipe Wall Thickness [in]	0.312	-	-			
Specified Minimum Yield Stress65,000InstallationTemperature ["F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,00030,000Safety Factor Applied: API 1102 ProcedurePoisson's Ratio for Steel0.30Coefficient of Thermal Expansion [per"F]0.0000065RESULTS100029,423Maximum Circumferential Stress [psi]11,22Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,22Stiffness Factor for Earth Load Circumferential Stress2,088Maximum Radial Stress [psi]1,44Burial Factor1.6471.6471.647Impact Factor1.50Stress [psi]29,42332,500Highway Stiffness Factor for Cyclic Circumferential1.6471.6029,42332,500Highway Geometry Factor for Cyclic Circumferential1.6471.6029,42332,500PASSHighway Stiffness Factor for Cyclic Circumferential1.10Stress [psi]Calculated Allowable PASS/FAHighway Geometry Factor for Cyclic Longitudinal Stress9.3011,500PASSLinghway Stiffness Factor for Cyclic Longitudinal Stress9.3011,500PASSLinghway Geometry Factor for Cyclic Longitudinal Stress9.3011,500PASSLinghway Geometry Factor for Cyclic Long	Pipe Grade: X65						-
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Project	
Vermont Gas Systems	
Location	Date
Burlington, VT	5/24/2016

API 1102 - Gas Pipeline Crossing Highway

- 1				
	PIPE AND OPERATIONAL DATA:		SITE AND INSTALLATION DATA:	
	Operating Pressure [psi]	1440	Soil Type: Stiff to very stiff clays and silts	
	Location Class:	3	E' - Modulus of Soil Reaction [ksi]	1.0
	Operating Temperature [°F]	60.0	Er - Resilient Modulus [ksi]	10.0
	Pipe Outside Diameter [in]	12.75	Average Unit Weight of Soil [lb/ft³]	120.00
	Pipe Wall Thickness [in]	0.312	Pipe Depth [ft]	3
	Pipe Grade: X65		Bored Diameter [in]	12.75
	Specified Minimum Yield Stress	65,000	InstallationTemperature [°F]	60.0
	Design Factor	0.50	Design Wheel Load from Single Axle [kips]	18.4
	Longitudinal Joint Factor	1.0	Design Wheel Load from Tandem Axles [kips	s] 18.4
	Temperature Derating Factor	1.000	Pavement Type: None	
	Pipe Class: API 5L Electric Resistance Welded		Impact Factor Method: ASCE - Highway	
	Young's Modulus for Steel [ksi]	30,000		
	Poisson's Ratio for Steel	0.30	Out of Easter Anglistic ADI 4400 December	
	Coefficient of Thermal Expansion [per°F] 0.0000065	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

9,423	Maximum Circumferential Stress [psi]	33,046
2,500	Maximum Longitudinal Stress [psi]	11,216
934	Maximum Radial Stress [psi]	-1,440
78	Total Effective Stress [psi]	30,216
.83	Allowable Effective Stress [psi]	32,500

Stress [psi]	Calculated	Allowable	PASS/FAIL
Ноор	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	
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Location Burlington, VT		Date 5/24/20	16			
API 1102 - Gas Pipeline	e Crossing High	way				
PIPE AND OPERATIONAL DATA	:	SITE A	ND INSTALLA	TION DATA		
Operating Pressure [psi]	1440	Soil Ty	pe: Stiff to ve	ery stiff clay	s and silts	
Location Class:	3	E' - Mo	dulus of Soil Re	eaction [ksi]		1.0
Operating Temperature [°F]	60.0		silient Modulus			10.0
Pipe Outside Diameter [in]	12.75		e Unit Weight o		1	120.00
Pipe Wall Thickness [in]	0.312	-	epth [ft]	•	<u>.</u>	4
Pipe Grade: X65		-	Diameter [in]			12.75
Specified Minimum Yield Stress	65,000		ationTemperatu	re [°F]		60.0
Design Factor	0.50		Wheel Load fr		xle [kips]	18.4
Longitudinal Joint Factor	1.0	•	Wheel Load fr	-		
Temperature Derating Factor	1.000	•	ent Type: Non		.	
Pipe Class: API 5L Electric Re	esistance Welded		Factor Method		iahwav	
Young's Modulus for Steel [ksi]	30,000				.g,	
Poisson's Ratio for Steel	0.30					
Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Applied	API 1102	Procedur	е
RESULTS						
Hoop Stress [psi]		29,423	Maximum Cir	cumferentia	l Stress [p	si] 33,21
Allowable Hoop Stress [psi]	24	32,500	Maximum Lor	ngitudinal St	ress [psi]	11,26
Stiffness Factor for Earth Load Ci	rcumferential Stress	1,934	Maximum Ra	dial Stress [psi]	-1,44
Burial Factor for Earth Load Circu	mferential Stress	0.90	Total Effective	e Stress [ps	i]	30,36
Excavation Factor for Earth Load	Circumferential Stress	0.83	Allowable Effe	ective Stress	s [psi]	32,50
Circumferential Stress from Earth	Load [psi]	1,271				
Impact Factor		1.50	Stress [psi]	Calculated		
Highway Stiffness Factor for Cycli	c Circumferential	12.60	Hoop Effective	29,423 30,366	32,500 32,500	PASS PASS
Highway Geometry Factor for Cyc	lic Circumferential	1.22	Girth Welds	2,275	6,000	PASS
Cyclic Circumferential Stress [psi]		3,241		3,241	11,500	PASS
Highway Stiffness Factor for Cycli	c Longitudinal Stress	9.30				
Highway Geometry Factor for Cyc	lic Longitudinal Stress	1.16				
Cyclic Longitudinal Stress [psi]		2,275				
	culations run using HS-					

Prepared By Kelsey Kibbe

i.

Approved By

Revision: 13.0.1

Location Burlington, VT		Date 5/24/20	16	
API 1102 - Gas Pipeline	e Crossing High	way		
PIPE AND OPERATIONAL DATA	i.	SITE A	ND INSTALLATION DATA:	
Operating Pressure [psi]	1440	Soil Ty	pe: Stiff to very stiff clays and	silts
Location Class:	3	E' - Mo	dulus of Soil Reaction [ksi]	1.0
Operating Temperature [°F]	60.0	Er - Re	esilient Modulus [ksi]	10.0
Pipe Outside Diameter [in]	12.75		e Unit Weight of Soil [lb/ft³]	120.00
Pipe Wall Thickness [in]	0.312		epth [ft]	5
Pipe Grade: X65		·	Diameter [in]	12.75
Specified Minimum Yield Stress	65,000		ationTemperature [°F]	60.0
Design Factor	0.50		Wheel Load from Single Axle [ki	ps] 18.4
Longitudinal Joint Factor	1.0	-	Wheel Load from Tandem Axles	
Temperature Derating Factor	1.000	•	ent Type: None	
Pipe Class: API 5L Electric Re	esistance Welded		: Factor Method: ASCE - Highway	v
Young's Modulus for Steel [ksi]	30,000			•
Poisson's Ratio for Steel	0.30			
Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Applied: API 1102 Proce	edure
RESULTS				
Hoop Stress [psi]		29,423	Maximum Circumferential Stres	s [psi] 33,01
Allowable Hoop Stress [psi]		32,500	Maximum Longitudinal Stress [osi] 11,14
Stiffness Factor for Earth Load Ci	rcumferential Stress	1,934	Maximum Radial Stress [psi]	-1,44
Burial Factor for Earth Load Circu	mferential Stress	0.98	Total Effective Stress [psi]	30,19
Excavation Factor for Earth Load	Circumferential Stress	0.83	Allowable Effective Stress [psi]	32,50
Circumferential Stress from Earth	Load [psi]	1,384		
Impact Factor		1.50	Stress [psi] Calculated Allowa	12 m
Highway Stiffness Factor for Cycli	c Circumferential	12.60	Hoop 29,423 32,50 Effective 30,193 32,50	
Highway Geometry Factor for Cyc	lic Circumferential	1.10	Girth Welds 2,118 6,000	
Cyclic Circumferential Stress [psi]		2,923	Long. Welds 2,923 11,50	· · · · · · · · · · · · · · · · · · ·
Highway Stiffness Factor for Cycli	c Longitudinal Stress	9.30		
Highway Geometry Factor for Cyc	clic Longitudinal Stress	1.08		
Cyclic Longitudinal Stress [psi]		2,118		

Approved By

Prepared By Kelsey Kibbe

Revision: 13.0.1

Burlington, VT		Date 5/24/20	16	
API 1102 - Gas Pipelir	ne Crossing High			
PIPE AND OPERATIONAL DAT	A :	SITE A	ND INSTALLATION DATA:	
Operating Pressure [psi]	1440	Soil Ty	pe: Medium dense sands	and gravels
Location Class:	3	F' - Mc	odulus of Soil Reaction [ksi]	1.0
Operating Temperature [°F]	60.0		esilient Modulus [ksi]	10.0
Pipe Outside Diameter [in]	12.75		ge Unit Weight of Soil [lb/ft³]	120.00
Pipe Wall Thickness [in]	0.312		epth [ft]	3
Pipe Grade: X65			Diameter [in]	12.75
Specified Minimum Yield Stress	65,000		ationTemperature [°F]	60.0
Design Factor	0.50		Wheel Load from Single Axl	
Longitudinal Joint Factor	1.0	-	Wheel Load from Tandem A	
Temperature Derating Factor	1.000	-	ent Type: None	
Pipe Class: API 5L Electric F	Resistance Welded		t Factor Method: ASCE - Higl	hway
Young's Modulus for Steel [ksi]	30,000	inipae		, inc.y
Poisson's Ratio for Steel	0.30			
Coefficient of Thermal Expansion	n [per°F] 0.0000065	Safety	Factor Applied: API 1102 F	Procedure
RESULTS				
Hoop Stress [psi]		29,423	Maximum Circumferential S	Stress [psi] 33,1
		32,500	Maximum Longitudinal Stre	
Allowable Hoop Stress (psi)				ss [psi] 11,2
Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C	Circumferential Stress		Ū	
Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circ	¥.	1,934 0.83	Maximum Radial Stress [ps Total Effective Stress [psi]	si] -1,44
Stiffness Factor for Earth Load C	umferential Stress	1,934 0.83	Maximum Radial Stress [ps	si] -1,44 30,2
Stiffness Factor for Earth Load C Burial Factor for Earth Load Circ Excavation Factor for Earth Load	umferential Stress I Circumferential Stress	1,934 0.83	Maximum Radial Stress [ps Total Effective Stress [psi]	si] -1,44 30,2
Stiffness Factor for Earth Load C Burial Factor for Earth Load Circ Excavation Factor for Earth Load Circumferential Stress from Eart	umferential Stress I Circumferential Stress	1,934 0.83 0.83	Maximum Radial Stress [ps Total Effective Stress [psi] Allowable Effective Stress [ii] -1,44 30,2 psi] 32,5
Stiffness Factor for Earth Load C Burial Factor for Earth Load Circ	umferential Stress I Circumferential Stress h Load [psi]	1,934 0.83 0.83 1,172	Maximum Radial Stress [psi] Total Effective Stress [psi] Allowable Effective Stress [Stress [psi] Calculated Ai Hoop 29,423 32	ii] -1,44 30,2 psi] 32,5 llowable PASS/FA 2,500 PASS
Stiffness Factor for Earth Load C Burial Factor for Earth Load Circ Excavation Factor for Earth Load Circumferential Stress from Eart Impact Factor Highway Stiffness Factor for Cyc	umferential Stress I Circumferential Stress h Load [psi] lic Circumferential	1,934 0.83 0.83 1,172 1.50	Maximum Radial Stress [psi] Total Effective Stress [psi] Allowable Effective Stress [Stress [psi] Calculated All Hoop 29,423 32 Effective 30,278 32	ii] -1,44 30,2 psi] 32,5 Ilowable PASS/FA 2,500 PASS 2,500 PASS
Stiffness Factor for Earth Load C Burial Factor for Earth Load Circ Excavation Factor for Earth Load Circumferential Stress from Eart Impact Factor	umferential Stress d Circumferential Stress h Load [psi] dic Circumferential volic Circumferential	1,934 0.83 0.83 1,172 1.50 12.60	Maximum Radial Stress [psi]Total Effective Stress [psi]Allowable Effective Stress [Stress [psi]Calculated AlHoop29,423Stfective30,27832Girth Welds2,2756,	ii] -1,44 30,2 psi] 32,5 llowable PASS/FA 2,500 PASS
Stiffness Factor for Earth Load C Burial Factor for Earth Load Circ Excavation Factor for Earth Load Circumferential Stress from Eart Impact Factor Highway Stiffness Factor for Cyc Highway Geometry Factor for Cyc	umferential Stress d Circumferential Stress h Load [psi] dic Circumferential volic Circumferential	1,934 0.83 0.83 1,172 1.50 12.60 1.22	Maximum Radial Stress [psi]Total Effective Stress [psi]Allowable Effective Stress [Stress [psi]Calculated AlHoop29,423Stfective30,27832Girth Welds2,2756,	ii] -1,44 30,2 psi] 32,5 llowable PASS/FA 2,500 PASS 2,500 PASS ,000 PASS
Stiffness Factor for Earth Load C Burial Factor for Earth Load Circ Excavation Factor for Earth Load Circumferential Stress from Eart Impact Factor Highway Stiffness Factor for Cyc Highway Geometry Factor for Cy Cyclic Circumferential Stress [ps	umferential Stress d Circumferential Stress h Load [psi] dic Circumferential volic Circumferential i] dic Longitudinal Stress	1,934 0.83 0.83 1,172 1.50 12.60 1.22 3,241 9.30	Maximum Radial Stress [psi]Total Effective Stress [psi]Allowable Effective Stress [Stress [psi]Calculated AlHoop29,423Stfective30,27832Girth Welds2,2756,	ii] -1,44 30,2 psi] 32,5 llowable PASS/FA 2,500 PASS 2,500 PASS ,000 PASS
Stiffness Factor for Earth Load C Burial Factor for Earth Load Circ Excavation Factor for Earth Load Circumferential Stress from Eart Impact Factor Highway Stiffness Factor for Cyc Cyclic Circumferential Stress [ps Highway Stiffness Factor for Cyc	umferential Stress d Circumferential Stress h Load [psi] dic Circumferential volic Circumferential i] dic Longitudinal Stress	1,934 0.83 0.83 1,172 1.50 12.60 1.22 3,241 9.30	Maximum Radial Stress [psi]Total Effective Stress [psi]Allowable Effective Stress [Stress [psi]Calculated AlHoop29,423Stfective30,27832Girth Welds2,2756,	ii] -1,44 30,2 psi] 32,5 llowable PASS/FA 2,500 PASS 2,500 PASS ,000 PASS

Pipe Wall Thickness [in]0.312Pipe Depth [ft]4Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedureFactor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]-1,4Burial Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,00	Location Burlington, VT	8	Date 5/24/20	16			
Operating Pressure [psi] 1440 Soil Type: Medium dense sands and gravels Location Class: 3 E' - Modulus of Soil Reaction [ksi] 1.0 Operating Temperature [°F] 60.0 Er - Resilient Modulus [ksi] 10.0 Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil [lb/ft*] 12.00 Pipe Grade: X65 Bored Diameter [in] 12.75 Specified Minimum Yield Stress 65,000 InstallationTemperature [°F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Longitudinal Joint Factor 1.0 Design Wheel Load from Tandem Axles [kips] 18.4 Temperature Derating Factor 1.000 Pavement Type: None Impact Factor Method: ASCE - Highway 18.4 Young's Modulus for Steel 0.30 Coefficient of Thermal Expansion [per*F] 0.000065 Safety Factor Applied: API 1102 Procedure 33, RESULTS 29,423 Maximum Longitudinal Stress [psi] 14,4 Burial Factor for Earth Load Circumferential Stress 0.97 Total Effective Stress [psi] 30, Circumferential Stress from Earth Load Circumferential Stress 0.83 Allowable Effective Stress [API 1102 - Gas Pipeline	e Crossing High	way				
Location Class:3E' - Modulus of Soil Reaction [ksi]1.0Operating Temperature ["F]60.0Er - Resilient Modulus [ksi]10.0Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft*]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]4Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000Installation Temperature ["F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied:API 1102 ProcedureCoefficient of Thermal Expansion [per"F]0.0000065Safety Factor Applied:API 1102 ProcedureRESULTS1.934Maximum Circumferential Stress [psi]33,Allowable Hoop Stress [psi]29,423Maximum Radial Stress [psi]14,4Burial Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,00Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,500Impact Factor1.50Stress [psi]32,500PASSCircumferential Stress from Earth Load [psi]1,370Impact Factor Stress [psi]32,500Impact Factor1.50Stress [psi]22,756,000Highway Geometry Fact	PIPE AND OPERATIONAL DATA		SITE A	ND INSTALLA		A:	
Operating Temperature [°F]60.0Er - Resilient Modulus [ksi]1.0Pipe Outside Diameter [in]12.75Average Unit Weight of Soli [lb/ft³]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]4Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30.00030Coefficient of Thermal Expansion [per°F]0.000065Poisson's Ratio for Steel0.30Safety Factor Applied: API 1102 Procedure11,2RESULTS1.934Maximum Circumferential Stress [psi]11,2Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,2Stiffness Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,2Excavation Factor1.50Stress [psi]32,500PASS/Highway Stiffness Factor for Cyclic Circumferential1,275Stress [psi]32,500PASS/Highway Geometry Factor for Cyclic Circumferential1,226Stress [psi]32,500PASS/Highway Stiffness Factor for Cyclic Circumferential1,226Stress [psi]32,41111,500Highway Geometry Factor for Cyclic Longitudinal Stress9,30<	Operating Pressure [psi]	1440	Soil Ty	pe: Medium	dense san	ds and gra	ivels
Operating Temperature [°F] 60.0 Er - Resilient Modulus [ksi] 10.0 Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soil [lb/ft"] 12.00 Pipe Wall Thickness [in] 0.312 Pipe Depth [ft] 4 Pipe Grade: X65 Bored Diameter [in] 12.75 Specified Minimum Yield Stress 65,000 Installation Temperature [°F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Longitudinal Joint Factor 1.00 Pavement Type: None Impact Factor Axles [kips] 18.4 Pipe Class: API 5L Electric Resistance Welded Impact Factor Applied: API 1102 Procedure Young's Modulus for Steel 0.30 Coefficient of Thermal Expansion [per*F] 0.000065 Safety Factor Applied: API 1102 Procedure 11.4 RESULTS 29,423 Maximum Circumferential Stress [psi] 33. 33. Allowable Hoop Stress [psi] 22,642 Maximum Radial Stress [psi] 14.4 Burial Factor for Earth Load Circumferential Stress 0.97 Total Effective Stress [psi] 30. Exca	Location Class:	3	E' - Mo	dulus of Soil Re	eaction [ksi	i]	1.0
Pipe Outside Diameter [in] 12.75 Average Unit Weight of Soli [lb/ft*] 12.00 Pipe Wall Thickness [in] 0.312 Pipe Depth [ft] 4 Pipe Grade: X65 Bored Diameter [in] 12.75 Specified Minimum Yield Stress 65.000 Installation Temperature ["F] 60.0 Design Factor 0.50 Design Wheel Load from Single Axle [kips] 18.4 Longitudinal Joint Factor 1.0 Design Wheel Load from Tandem Axles [kips] 18.4 Temperature Derating Factor 1.00 Pavement Type: None Impact Factor Method: ASCE - Highway 18.4 Young's Modulus for Steel [ksi] 30.000 Poisson's Ratio for Steel 0.30 Safety Factor Applied: API 1102 Procedure 11.3 RESULTS Safety Factor Applied: API 1102 Procedure 11.4 Burial Factor for Earth Load Circumferential Stress 1.934 Maximum Longitudinal Stress [psi] 33. Allowable Hoop Stress [psi] 1.370 1.370 1.370 1.4 Burial Factor for Earth Load Circumferential Stress 0.83 Allowable Effective Stress [psi] 32.500 PASS Fifted two Stiffness Factor for Cyclic Circumferential 1.370 1	Operating Temperature [°F]	60.0			-	-	10.0
Pipe Wall Thickness [in]0.312Pipe Depth [ft]4Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,000Safety Factor Applied:API 1102 ProcedureRESULTS0.30Safety Factor Applied:API 1102 ProcedureReSULTS29,423Maximum Circumferential Stress [psi]33,Allowable Hoop Stress [psi]29,423Maximum Calial Stress [psi]11,Stiffness Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,Sural Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,Circumferential Stress from Earth Load Circumferential Stress0.87Total Effective Stress [psi]32,Impact Factor1.50Stress [psi]32,32,500PASS/FHighway Stiffness Factor for Cyclic Circumferential1.26Hoop29,42332,500PASSCyclic Circumferential Stress [psi]3,24111,500PASSEffective 30,45332,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress9.30Highway	Pipe Outside Diameter [in]	12.75				3]	120.00
Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayPipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Ocoefficient of Thermal Expansion [per °F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,Allowable Hoop Stress [psi]32,500Maximum Radial Stress [psi]11,4Stiffness Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,Stiffness Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,Circumferential Stress from Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,Circumferential Stress from Earth Load Circumferential1,370Impact Factor1,200Impact Factor1.50Stress [psi]22,500PASSHighway Stiffness Factor for Cyclic Circumferential1,22Girth Welds32,2500PASSCyclic Circumferential Stress [psi]3,24111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301,4	Pipe Wall Thickness [in]	0.312		-			4
Specified Minimum Yield Stress65,000Installation Temperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: None18.4Pipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - Highway18.4Young's Modulus for Steel0.30Safety Factor Applied:API 1102 ProcedureCoefficient of Thermal Expansion [per°F]0.0000065Safety Factor Applied:API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,Stiffness Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,Circumferential Stress from Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,Impact Factor1.50Stress [psi]Calculated Allowable PASS/FHighway Stiffness Factor for Cyclic Circumferential1.22Girth Welds2,275Highway Stiffness Factor for Cyclic Longitudinal Stress9.301.16Highway Geometry Factor for Cyclic Longitudinal Stress9.301.16	Pipe Grade: X65						12.75
Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayPipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per°F] 0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,Stiffness Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,Burial Factor1.50Stress [psi]32,500PASSCircumferential Stress from Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,Impact Factor1.50Stress [psi]32,500PASSHighway Stiffness Factor for Cyclic Circumferential1.22Girth Welds 2,2756,000PASSCyclic Circumferential Stress [psi]3,24111,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.301.16	Specified Minimum Yield Stress	65,000			re [°F]		60.0
Longitudinal Joint Factor1.0Design Wheel Load from Tandem Axles [kips]18.4Temperature Derating Factor1.000Pavement Type: NoneImpact Factor Method: ASCE - HighwayPipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per°F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,3Allowable Hoop Stress [psi]32,500Maximum Longitudinal Stress [psi]11,4Stiffness Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,60Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,70Impact Factor1.50Stress [psi]Calculated Allowable PASS/FHighway Stiffness Factor for Cyclic Circumferential1.22Girth Welds2.2756,000Highway Stiffness Factor for Cyclic Longitudinal Stress9.309.304.16	Design Factor	0.50				Axle [kips]	18.4
Temperature Derating Factor1.00Pavement Type: NonePipe Class:API 5L Electric Resistance WeldedImpact Factor Method: ASCE - HighwayYoung's Modulus for Steel [ksi]30,000Safety Factor Method: ASCE - HighwayPoisson's Ratio for Steel0.30Safety Factor Applied: API 1102 ProcedureCoefficient of Thermal Expansion [per°F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,3Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,4Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]14,4Burial Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,0Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,00Impact Factor1.50Stress [psi]23,2500PASSHighway Stiffness Factor for Cyclic Circumferential1.22Girth Welds2,2756,000Highway Stiffness Factor for Cyclic Longitudinal Stress9.309.30Highway Geometry Factor for Cyclic Longitudinal Stress1.16	Longitudinal Joint Factor	1.0	-		-		
Pipe Class:API 5L Electric Resistance Welded Mug's Modulus for Steel [ksi]30,000Poisson's Ratio for Steel0.30Safety Factor Method: ASCE - HighwayCoefficient of Thermal Expansion [per°F]0.0000065Safety Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]11,Stiffness Factor for Earth Load Circumferential Stress1,934Maximum Radial Stress [psi]1,4Burial Factor for Earth Load Circumferential Stress0.97Total Effective Stress [psi]30,0Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,20Impact Factor1.50Stress [psi]Calculated Allowable PASS/FHighway Stiffness Factor for Cyclic Circumferential1.22Girth Welds2,2756,000Highway Stiffness Factor for Cyclic Longitudinal Stress9.301.161.16	Temperature Derating Factor	1.000	Ũ			•	
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Operating Pressure [psi]1440Soil Type:Medium dense sands and gravesLocation Class:3E' - Modulus of Soil Reaction [ksi]1.0Operating Temperature [°F]60.0Er - Resilient Modulus [ksi]10.0Pipe Outside Diameter [in]12.75Average Unit Weight of Soil [lb/ft³]120.00Pipe Wall Thickness [in]0.312Pipe Depth [ft]5Pipe Grade:X65Bored Diameter [in]12.75Specified Minimum Yield Stress65,000InstallationTemperature [°F]60.0Design Factor0.50Design Wheel Load from Single Axle [kips]18.4Longitudinal Joint Factor1.00Pavement Type: None18.4Temperature Derating Factor1.000Pavement Type: None19.2Pipe Class:API 5L Electric Restance WeldedImpact Factor Method: ASCE - Highway18.4Young's Modulus for Steel [ksi]30,0003036etty Factor Applied: API 1102 ProcedureRESULTS29,423Maximum Circumferential Stress [psi]33,14Allowable Hoop Stress [psi]29,423Maximum Longitudinal Stress [psi]33,14Allowable Hoop Stress [psi]1.934Maximum Radial Stress [psi]11,14Stiffness Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,37Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]30,37Excavation Factor for Earth Load Circumferential Stress0.83Allowable Effective Stress [psi]32,50 <th>Location Burlington, VT</th> <th></th> <th>Date 5/24/20</th> <th>16</th> <th></th> <th></th>	Location Burlington, VT		Date 5/24/20	16		
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Highway Stiffness Factor for Cyclic Circumferential12.80Highway Geometry Factor for Cyclic Circumferential1.10Cyclic Circumferential Stress [psi]2,923Highway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress9.30Cyclic Longitudinal Stress [psi]2,118Cyclic Longitudinal Stress [psi]2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load	umferential Stress Circumferential Stress	32,500 1,934 1.08 0.83	Maximum Lon Maximum Rac Total Effective	gitudinal Stress dial Stress [psi] e Stress [psi]	s [psi] 11,18 -1,44 30,31
Highway Geometry Factor for Cyclic Circumferential1.10Girth Welds2,1186,000PASSCyclic Circumferential Stress [psi]2,923Long. Welds2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth	umferential Stress Circumferential Stress	32,500 1,934 1.08 0.83 1,525	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi]	gitudinal Stress dial Stress [psi] Stress [psi] ective Stress [ps Calculated Allo	s [psi] 11,18 -1,44 30,31 si] 32,50
Cyclic Circumferential Stress [psi]2,923Long. Welds2,92311,500PASSHighway Stiffness Factor for Cyclic Longitudinal Stress9.30Highway Geometry Factor for Cyclic Longitudinal Stress1.08Cyclic Longitudinal Stress [psi]2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor	umferential Stress Circumferential Stress n Load [psi]	32,500 1,934 1.08 0.83 1,525 1.50	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop	gitudinal Stress dial Stress [psi] Stress [psi] ctive Stress [ps Calculated Allo 29,423 32,	s [psi] 11,18 -1,44 30,31 si] 32,50 wable PASS/FA 500 PASS
Highway Geometry Factor for Cyclic Longitudinal Stress 1.08 Cyclic Longitudinal Stress [psi] 2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl	umferential Stress Circumferential Stress n Load [psi] lic Circumferential	32,500 1,934 1.08 0.83 1,525 1.50 12.60	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective	gitudinal Stress dial Stress [psi] e Stress [psi] ective Stress [ps Calculated Allo 29,423 32, 30,318 32,	s [psi] 11,18 -1,44 30,31 si] 32,50 wable PASS/FA 500 PASS 500 PASS
Cyclic Longitudinal Stress [psi] 2,118	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Highway Geometry Factor for Cycl	umferential Stress Circumferential Stress h Load [psi] lic Circumferential clic Circumferential	32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	gitudinal Stress dial Stress [psi] e Stress [psi] ective Stress [psi Calculated Allo 29,423 32, 30,318 32, 2,118 6,0	s [psi] 11,18 -1,44 30,31 si] 32,50 wable PASS/FA 500 PASS 500 PASS 00 PASS
	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Highway Geometry Factor for Cycl	umferential Stress Circumferential Stress Load [psi] lic Circumferential clic Circumferential	32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10 2,923	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	gitudinal Stress dial Stress [psi] e Stress [psi] ective Stress [psi Calculated Allo 29,423 32, 30,318 32, 2,118 6,0	s [psi] 11,18 -1,44 30,31 si] 32,50 wable PASS/FA 500 PASS 500 PASS 00 PASS
Notes: Open cut construction, calculations run using HS-20 loading + 15%	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Cyclic Circumferential Stress [psi Highway Stiffness Factor for Cyc	umferential Stress Circumferential Stress h Load [psi] lic Circumferential clic Circumferential] lic Longitudinal Stress	32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10 2,923 9.30	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	gitudinal Stress dial Stress [psi] e Stress [psi] ective Stress [psi Calculated Allo 29,423 32, 30,318 32, 2,118 6,0	s [psi] 11,18 -1,44 30,31 si] 32,50 wable PASS/FA 500 PASS 500 PASS 00 PASS
	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Cyclic Circumferential Stress [psi Highway Stiffness Factor for Cyc Highway Stiffness Factor for Cyc	umferential Stress Circumferential Stress h Load [psi] lic Circumferential clic Circumferential] lic Longitudinal Stress	32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10 2,923 9.30 1.08	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	gitudinal Stress dial Stress [psi] e Stress [psi] ective Stress [psi Calculated Allo 29,423 32, 30,318 32, 2,118 6,0	s [psi] 11,18 -1,44 30,37 si] 32,50 wable PASS/FA 500 PASS 500 PASS 00 PASS
	Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Cyclic Circumferential Stress [psi] Highway Geometry Factor for Cyc Highway Geometry Factor for Cyc	umferential Stress Circumferential Stress h Load [psi] lic Circumferential clic Circumferential] lic Longitudinal Stress clic Longitudinal Stress	32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10 2,923 9.30 1.08 2,118 -20 loadir	Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds	gitudinal Stress dial Stress [psi] e Stress [psi] ective Stress [psi Calculated Allo 29,423 32, 30,318 32, 2,118 6,0	s [psi] 11,18 -1,44 30,31 si] 32,50 wable PASS/FA 500 PASS 500 PASS 00 PASS

Location Burlington, VT		Date 5/24/20	16			
API 1102 - Gas Pipelin	e Crossing High					
PIPE AND OPERATIONAL DATA	•••			TION DATA	A:	
Operating Pressure [psi]	1440	Soil Ty	pe: Dense to	o very dense	e sands ar	nd gravels
Location Class:	3	E' - Mc	dulus of Soil R	- action [ksi]	1	2.0
Operating Temperature [°F]	60.0		silient Modulus		1	20.0
Pipe Outside Diameter [in]	12.75		je Unit Weight		31	120.00
Pipe Wall Thickness [in]	0.312	-	epth [ft]		1	3
Pipe Grade: X65			Diameter [in]			3 12.75
Specified Minimum Yield Stress	65,000		ationTemperatu	ro [°E]		60.0
Design Factor	0.50		Wheel Load fr		Avle [kins]	18.4
Longitudinal Joint Factor	1.0	•	Wheel Load fr	•		
Temperature Derating Factor	1.000	•	ent Type: Non			p31 10.4
Pipe Class: API 5L Electric R	esistance Welded		Factor Method		liahway	
Young's Modulus for Steel [ksi]	30,000	mpao			iigiinay	
Poisson's Ratio for Steel	0.30					
	0.00					
Coefficient of Thermal Expansion		Safety	Factor Applied	API 1102	2 Procedu	re
		Safety	Factor Applied	: API 1102	2 Procedu	re
Coefficient of Thermal Expansion		Safety 29,423	Factor Applied Maximum Cir			
Coefficient of Thermal Expansion RESULTS				cumferentia	al Stress [p	osi] 32,0
Coefficient of Thermal Expansion RESULTS Hoop Stress [psi]	[per°F] 0.0000065	29,423	Maximum Cir	cumferentia ngitudinal S	al Stress [p tress [psi]	osi] 32,0 10,4
Coefficient of Thermal Expansion RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi]	[per°F] 0.0000065	29,423 32,500	Maximum Cir Maximum Loi	cumferentia ngitudinal S dial Stress	al Stress [p tress [psi] [psi]	osi] 32,0 10,4 -1,44
Coefficient of Thermal Expansion RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci	[per°F] 0.0000065 ircumferential Stress imferential Stress	29,423 32,500 1,693 0.78	Maximum Cir Maximum Loi Maximum Ra	cumferentia ngitudinal S dial Stress e Stress [ps	al Stress [p tress [psi] [psi] si]	osi] 32,0 10,4 -1,44 29,4
Coefficient of Thermal Expansion RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Circu Burial Factor for Earth Load Circu	[per°F] 0.0000065 ircumferential Stress imferential Stress Circumferential Stress	29,423 32,500 1,693 0.78	Maximum Cir Maximum Lor Maximum Ra Total Effective	cumferentia ngitudinal S dial Stress e Stress [ps	al Stress [p tress [psi] [psi] si]	osi] 32,00 10,4 -1,44 29,43
Coefficient of Thermal Expansion RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Circu Burial Factor for Earth Load Circu Excavation Factor for Earth Load	[per°F] 0.0000065 ircumferential Stress imferential Stress Circumferential Stress	29,423 32,500 1,693 0.78 0.83	Maximum Cir Maximum Lor Maximum Ra Total Effective Allowable Effe	cumferentia ngitudinal S dial Stress [ps ective Stres [Calculated	al Stress [p tress [psi] [psi] si] ss [psi]	osi] 32,00 10,4 -1,44 29,4 32,50
Coefficient of Thermal Expansion RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Circu Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth	[per°F] 0.0000065 frcumferential Stress imferential Stress Circumferential Stress Load [psi]	29,423 32,500 1,693 0.78 0.83 964	Maximum Cir Maximum Lor Maximum Ra Total Effective Allowable Effe Stress [psi] Hoop	cumferentia ngitudinal S dial Stress e Stress [ps ective Stres Calculated 29,423	al Stress [p tress [psi] [psi] si] ss [psi] [Allowable [32,500	osi] 32,00 10,4 -1,44 29,4 32,5 PASS/FA PASS
Coefficient of Thermal Expansion RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Circu Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor	[per°F] 0.0000065 ircumferential Stress imferential Stress Circumferential Stress Load [psi] ic Circumferential	29,423 32,500 1,693 0.78 0.83 964 1.50	Maximum Cir Maximum Lor Maximum Ra Total Effective Allowable Effe	cumferentia ngitudinal S dial Stress [ps ective Stres [Calculated	al Stress [p tress [psi] [psi] si] ss [psi]	osi] 32,0 10,4 -1,4 29,4 32,5
Coefficient of Thermal Expansion RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Circu Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl	[per°F] 0.0000065 ircumferential Stress imferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential	29,423 32,500 1,693 0.78 0.83 964 1.50 9.30	Maximum Cir Maximum Lor Maximum Ra Total Effective Allowable Effe Stress [psi] Hoop Effective	cumferentia ngitudinal S dial Stress [ps ective Stres Calculated 29,423 29,422 1,517	al Stress [p tress [psi] [psi] si] ss [psi] [Allowable [32,500 [32,500	osi] 32,0 10,4 -1,4 29,4 32,5 PASS/FA PASS PASS
Coefficient of Thermal Expansion RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Circu Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Highway Geometry Factor for Cycl	[per°F] 0.0000065 ircumferential Stress imferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential	29,423 32,500 1,693 0.78 0.83 964 1.50 9.30 1.22	Maximum Cir Maximum Lor Maximum Ra Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	cumferentia ngitudinal S dial Stress [ps ective Stres Calculated 29,423 29,422 1,517	al Stress [p tress [psi] [psi] si] ss [psi] Allowable 32,500 32,500 6,000	95i] 32,00 10,4 -1,42 29,4 32,5 PASS/FA PASS PASS PASS
Coefficient of Thermal Expansion RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Circu Excavation Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Highway Geometry Factor for Cycl	[per°F] 0.0000065 ircumferential Stress imferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential clic Circumferential	29,423 32,500 1,693 0.78 0.83 964 1.50 9.30 1.22 2,393 6.20	Maximum Cir Maximum Lor Maximum Ra Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	cumferentia ngitudinal S dial Stress [ps ective Stres Calculated 29,423 29,422 1,517	al Stress [p tress [psi] [psi] si] ss [psi] Allowable 32,500 32,500 6,000	95i] 32,00 10,4 -1,42 29,4 32,5 PASS/FA PASS PASS PASS
Coefficient of Thermal Expansion RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Circu Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Highway Geometry Factor for Cycl Cyclic Circumferential Stress [psi]	[per°F] 0.0000065 ircumferential Stress imferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential clic Circumferential	29,423 32,500 1,693 0.78 0.83 964 1.50 9.30 1.22 2,393 6.20	Maximum Cir Maximum Lor Maximum Ra Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	cumferentia ngitudinal S dial Stress [ps ective Stres Calculated 29,423 29,422 1,517	al Stress [p tress [psi] [psi] si] ss [psi] Allowable 32,500 32,500 6,000	95i] 32,00 10,4 -1,42 29,4 32,5 PASS/FA PASS PASS PASS

Location Burlington, VT		Date 5/24/20	16		2		
API 1102 - Gas Pipeline	e Crossing High	way					
PIPE AND OPERATIONAL DATA	:	SITE A				A:	
Operating Pressure [psi]	1440	Soil Ty	pe: Der	nse to	very dens	se sands an	d gravels
Location Class:	3	E' - Mc	dulus of S	ioil Re	eaction [ks	i]	2.0
Operating Temperature [°F]	60.0		silient Mo		-	-	20.0
Pipe Outside Diameter [in]	12.75		je Unit We			.31	120.00
Pipe Wall Thickness [in]	0.312	-	epth [ft]	-	-	-	4
Pipe Grade: X65		Bored	Diameter [ïn]			12.75
Specified Minimum Yield Stress	65,000		ationTemp	-	e [°F]		60.0
Design Factor	0.50		-			Axle [kips]	18.4
Longitudinal Joint Factor	1.0	-			-	m Axles [kij	os] 18.4
Temperature Derating Factor	1.000	Paverr	ent Type:	None	Э		-
Pipe Class: API 5L Electric Re	esistance Welded	Impact	t Factor Me	ethod	: ASCE - I	Highway	
Young's Modulus for Steel [ksi]	30,000	·					
Poisson's Ratio for Steel	0.30					_	
Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Ap	plied:	API 110)2 Procedui	e
RESULTS							
Hoop Stress [psi]		29,423	Maximur	n Ciro	cumferenti	al Stress [p	si] 32,209
Allowable Hoop Stress [psi]		32,500	Maximur	n Lor	igitudinal S	Stress [psi]	10,462
Stiffness Factor for Earth Load Ci	rcumferential Stress	1,693	Maximur	n Rad	dial Stress	[psi]	-1,440
Duriel Frates for Faith Lood Circu	mferential Stress	0.90	Total Eff	ective	e Stress [p	si]	29,554
Burial Factor for Earth Load Circu				e Effe	ective Stre	ss [psi]	32,500
Excavation Factor for Earth Load	Circumferential Stress	0.83	Allowabl				
		0.83 1,113	Allowabl				
Excavation Factor for Earth Load			Stress [p			- 21 (S	PASS/FAIL
Excavation Factor for Earth Load Circumferential Stress from Earth	Load [psi]	1,113	Stress [p Hoop	osi]	29,423	32,500	PASS
Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor	Load [psi] ic Circumferential	1,113 1.50	Stress [p	osi]		- 21 (S	
Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl	Load [psi] ic Circumferential clic Circumferential	1,113 1.50 9.30	Stress [p Hoop Effective	osi] e elds	29,423 29,554	32,500 32,500	PASS PASS
Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Highway Geometry Factor for Cycl	Load [psi] ic Circumferential clic Circumferential	1,113 1.50 9.30 1.22	Stress [r Hoop Effective Girth We	osi] e elds	29,423 29,554 1,517	32,500 32,500 6,000	PASS PASS PASS
Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Highway Geometry Factor for Cycl Cyclic Circumferential Stress [psi]	Load [psi] ic Circumferential clic Circumferential ic Longitudinal Stress	1,113 1.50 9.30 1.22 2,393 6.20	Stress [r Hoop Effective Girth We	osi] e elds	29,423 29,554 1,517	32,500 32,500 6,000	PASS PASS PASS
Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Highway Geometry Factor for Cycl Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycl	Load [psi] ic Circumferential clic Circumferential ic Longitudinal Stress	1,113 1.50 9.30 1.22 2,393 6.20	Stress [r Hoop Effective Girth We	osi] e elds	29,423 29,554 1,517	32,500 32,500 6,000	PASS PASS PASS

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Prepared By Kelsey Kibbe Approved By Revision: 13.0.1

Location Burlington, VT		Date 5/24/20	16			
API 1102 - Gas Pipeline	e Crossing High	way				
PIPE AND OPERATIONAL DATA	:	SITE A	ND INSTALLAT		:	
Operating Pressure [psi]	1440	Soil Ty	pe: Dense to	very dense	sands an	d gravels
Location Class:	3	E' - Mo	dulus of Soil Re	action [ksi]		2.0
Operating Temperature [°F]	60.0	Er - Re	silient Modulus	[ksi]		20.0
Pipe Outside Diameter [in]	12.75	Averag	je Unit Weight c	f Soil [lb/ft³]		120.00
Pipe Wall Thickness [in]	0.312	-	epth [ft]			5
Pipe Grade: X65			Diameter [in]			12.75
Specified Minimum Yield Stress	65,000		ationTemperatur	e [°F]		60.0
Design Factor	0.50		Wheel Load fro		xle [kips]	18.4
Longitudinal Joint Factor	1.0	-	Wheel Load fro	-		os] 18.4
Temperature Derating Factor	1.000	•	ent Type: None			•
Pipe Class: API 5L Electric Re	esistance Welded		Factor Method		ighway	
Young's Modulus for Steel [ksi]	30,000				0 2	
Poisson's Ratio for Steel	0.30					
Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Applied:	API 1102	Procedur	е
RESULTS						
Hoop Stress [psi]		29,423	Maximum Circ	cumferentia	l Stress [p	si] 32,0
Allowable Hoop Stress [psi]		32,500	Maximum Lor	gitudinal St	ress [psi]	10,3
Stiffness Factor for Earth Load Ci	rcumferential Stress	1,693	Maximum Rad	dial Stress [psi]	-1,44
Burial Factor for Earth Load Circu	mferential Stress	0.98	Total Effective	Stress [psi]	29,4
Excavation Factor for Earth Load	Circumferential Stress	0.83	Allowable Effe	ective Stress	s [psi]	32,5
Circumferential Stress from Earth	Load [psi]	1,211				
Impact Factor		1.50	Stress [psi]	Calculated	the second s	
Highway Stiffness Factor for Cycl	c Circumferential	9.30	Hoop Effective	29,423 29,437	32,500 32,500	PASS PASS
Highway Geometry Factor for Cyc	lic Circumferential	1.10	Girth Welds	1,412	6,000	PASS
Cyclic Circumferential Stress [psi]		2,157	Long. Welds	2,157	11,500	PASS
Highway Stiffness Factor for Cycl	c Longitudinal Stress	6.20				
Highway Geometry Factor for Cyc	clic Longitudinal Stress	1.08				
Cyclic Longitudinal Stress [psi]		1,412				
Notes: Open cut construction, cal		20 loodir	a + 150/			

Prepared By Kelsey Kibbe	Approved By	Revision: 13.0.1

From:	Hartman, Daniel J <daniel.hartman@mottmac.com></daniel.hartman@mottmac.com>
Sent:	Tuesday, June 20, 2017 4:46 PM
To:	John St.Hilaire
Cc:	Wojnas, Joseph E; Wolf, Brian D; Kibbe, Kelsey E; Guthrie, Karen M
Subject:	RE: Vermont Gas Systems - GPTC Calculations

The calculation was run using assuming a fully saturated clay. It would have an effect on the hoop stress from the applied load.

Daniel J. Hartman PE | Project Engineer

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From: John St.Hilaire [mailto:jsthilaire@vermontgas.com]
Sent: Tuesday, June 20, 2017 4:41 PM
To: Hartman, Daniel J <Daniel.Hartman@mottmac.com>
Cc: Wojnas, Joseph E <Joseph.Wojnas@mottmac.com>; Wolf, Brian D <Brian.Wolf@mottmac.com>; Kibbe, Kelsey E <Kelsey.Kibbe@mottmac.com>; Guthrie, Karen M <Karen.Guthrie@mottmac.com>
Subject: Re: Vermont Gas Systems - GPTC Calculations

Sorry one las qu strong. We found some documentation that the soil type is "LK" meaning Livingston clay - flooded. Which category of the original analysis does LK fit into?

Sent from my iPad

On Jun 20, 2017, at 9:11 AM, Hartman, Daniel J <<u>Daniel.Hartman@mottmac.com</u>> wrote:

Hey John,

The previous calculations we ran were using the 2' depth of cover and produced effective stresses less than allowable.

I just ran a scenario where we would have 1' of cover with the 25 kip load (the calculation will not allow a trench depth/width ratio less than .5 so I changed the trench width from 3' to 2' now that the cover is down to 1'). The results produced a hoop stress of 71,752 psi from external loading alone and a total hoop stress of 101,175 psi which exceeds the allowable by a large margin without even adding in the S2 and S3 principal stresses. Long story short the calculations pass for up to a depth of 2' but that is the cutoff. I reduced the load from 25kips down to 10 kips and it still fails at the 1' of cover.

Hopefully this answers your question. Feel free to reach back out should you need any further clarification or evaluation.

Kind Regards,

-Danny

Daniel J. Hartman PE | Project Engineer

From: John St.Hilaire [mailto:jsthilaire@vermontgas.com]
Sent: Monday, June 19, 2017 7:14 AM
To: Hartman, Daniel J <<u>Daniel.Hartman@mottmac.com</u>>; Wojnas, Joseph E
<<u>Joseph.Wojnas@mottmac.com</u>>; Kibbe, Kelsey E <<u>Kelsey.Kibbe@mottmac.com</u>>; Guthrie, Karen M <<u>Karen.Guthrie@mottmac.com</u>>; Kibbe, Kelsey E <<u>Kelsey.Kibbe@mottmac.com</u>>; Guthrie, Karen M <<u>Karen.Guthrie@mottmac.com</u>>; Mojnas

Hi Daniel

Quick follow –up. I am being asked if we are good at 5', 4', 3', and now 2', what is the level where this calculation would show we exceed the total stress? At what depth would the calc exceed 58,500?

Is this something easy to do?

Thanks, John

From: Hartman, Daniel J [mailto:Daniel.Hartman@mottmac.com]
Sent: Wednesday, May 10, 2017 4:54 PM
To: John St.Hilaire; Wojnas, Joseph E
Cc: Wolf, Brian D; Kibbe, Kelsey E; Guthrie, Karen M
Subject: RE: Vermont Gas Systems - GPTC Calculations

Hey John,

Please see below for the calculation of the total effective stress that results from the wheel load applied using the GPTC method. Feel free to reach out with any questions.

From the GPTC calc we get the combined total stress for the principal plane S1 (hoop stress from internal pressure + hoop stress from applied load)

S1 = 29,423 + 20,206 = 49,629 psi

S1 = 49,629 psi

From the below calculation we get the longitudinal stress which represents the principal stress S2

Design Temperature – T _d =	60	°F
Installation Temperature – T_i =	80	°F
Poisson's Ratio – v =	0.30	
Thermal Coefficient of Steel – α =	6.7 x 10 ⁻⁶	1/°F

psi

SL=(*vSH*-*E*α(*Td*-*Ti*)) from ASME B31.8 Clause 833.3 *SL*=(.3*49,629 -29*106*6.7*10-6(60-80)) *SL*= 18,774.7 psi

S2 = 18,774.7 psi

The maximum radial stress results from the negative of the MAOP and represents the principal stress S3

S3 = -1440

The simplified Von Mises equation for principal stresses is used to translate the three principal stresses into the equivalent tensile stress (total effective stress). *Design factor F from ASME B31.8 Clause 833.4b*

Seff=12[S1-S22+S2-S32+S3-S12]

Seff=12[49,629-18,774.7 2+18,774.7 --14402+-1440-49,6292]

Seff=44,545.85

 $Seff \leq SMYS \times F$

44,545.85≤65,000×(.9)

44,545.85≤58,500 OK

Daniel J. Hartman PE | Project Engineer

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From: John St.Hilaire [mailto:jsthilaire@vermontgas.com]
Sent: Wednesday, May 10, 2017 8:12 AM
To: Wojnas, Joseph E <<u>Joseph.Wojnas@mottmac.com</u>>
Cc: Wolf, Brian D <<u>Brian.Wolf@mottmac.com</u>>; Hartman, Daniel J <<u>Daniel.Hartman@mottmac.com</u>>;
Kibbe, Kelsey E <<u>Kelsey.Kibbe@mottmac.com</u>>; Guthrie, Karen M <<u>Karen.Guthrie@mottmac.com</u>>
Subject: RE: Vermont Gas Systems - GPTC Calculations

Hi Joe

Quick question. In the original analysis the result table pulled in "total effective stress". In the additional analysis I do not find this number. How would I correlate the two analysis?

Thanks, John From: Wojnas, Joseph E [mailto:Joseph.Wojnas@mottmac.com]
Sent: Monday, May 01, 2017 11:56 AM
To: John St.Hilaire
Cc: Wolf, Brian D; Hartman, Daniel J; Kibbe, Kelsey E; Guthrie, Karen M
Subject: FW: Vermont Gas Systems - GPTC Calculations

John,

Please see the summary below. Kelsey performed the work under the direction of one of our professional engineers. In summary, the pipe looks good.

In talking with the staff the total effort appears to take less than 4 hours. Timesheets are developed at the end of the week where the exact time is collected. With your permission I was going to honor the rates from the Addison Natural Gas Project contract dated January 9, 2015.

Please do not hesitate to contact us with any other questions and/or comments you may have.

Thank you

Joe

From: Kibbe, Kelsey E
Sent: Monday, May 1, 2017 9:48 AM
To: Wojnas, Joseph E <<u>Joseph.Wojnas@mottmac.com</u>>
Cc: Hartman, Daniel J <<u>Daniel.Hartman@mottmac.com</u>>
Subject: Vermont Gas Systems - GPTC Calculations

Hi Joe –

As requested, I've attached two calculations using 2' depth of cover and the weakest soil type. One calculation was run using 1440 psig internal pressure, the other was run using no internal pressure. **Both** scenarios pass, the total calculated combined stress for each is less than 90% SMYS.

Note: the calculations were performed using the GPTC Guide, as 2' depth of cover is out of scope for the API 1102 (method used for previous calculations). A more conservative design wheel load of 25 kips was used.

Let me know if you need anything further.

Thanks,

Kelsey E. Kibbe Engineer II, EIT

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F +1 (413) 535 0136

<image020.png>

Mott MacDonald 134 Capital Drive Suite D Website | Twitter | LinkedIn | Facebook | YouTube

<VTGas_GPTC Calc_1ftcover.pdf>

Attachment B – Additional CEPA & GPTC Calculations

Results for Surface Loading Calculation

PIPELINE INFORMATION: PIPELINE LOCATION: VEHICLE INFORMATION: VEHICLE TYPE: DATE:

Vermont Gas Burlington, VT HS20+15% Wheel: 3-Axles, 6-Wheels

6/14/2021 17:16 **GENERAL INPUTS** VEHICLE INPUTS LOCATION OF MAXIMUM LOAD D = 12.75 inches (Outside Diameter) Axle or Track Separation 1 : 14 ft The maximum pressure 0.312 inches (Wall Thickness) Axle Separation 2 : 14 ft exerted on the surface of t = P_{internal} = 1440 psig (Maximum Operating Pressure) Axle Width : 6 ft the pipe due to vehicle N/A ft point load occurs: SMYS = 65000 psi (Specified Minimum Yield Strength) Track Length : ΔT = 0°F (Temperature Differential) Axle 1 or Track Vehicle Load : 9200 lbs Under the middle tires. 120 lb/ft3 ρ= (Density) Contact Width 1 : 20 inches 2 ft (Depth of Cover) Tire Pressure 1 : 100 psi H = θ= 30 degrees (Bedding Angle) Axle Load 2 : 36800 lbs E' = 500 psi (Modulus of Soil Reaction) Contact Width 2 : 20 inches IF = 1.50 (Impact Factor) Tire Pressure 2 : 100 psi 36800 lbs Soil Load Equation: Prism Load Equation Axle Load 3 : φ= N/A degrees Contact Width 3 : 20 inches Equivalent Stress Equation: Tresca Equation Tire Pressure 3 : 100 psi Measurement Point X-coord : N/A inches Measurement Point Y-coord : N/A inches

CALCULATED ST	RESS DATA	Variable Description	Pipeline Regulatory Code	Pass / Fail
Hoop Stress (σ _H):				
$\sigma_{H_{internal}MOP} =$	29423 psi	< Internal Pressure @ MOP		
$\sigma_{H_{Live_{Zero}}} =$	21158 psi	< Live Load @ Zero pressure		
$\sigma_{H_{Live_{MOP}}} =$	10788 psi	< Live Load @ MOP		
$\sigma_{H_{Total_{Zero}}} =$	22935 psi	< Total Hoop Stress @ Zero pressure		
$\sigma_{H_Total_MOP} =$	41117 psi	< Total Hoop Stress @ MOP		
$\sigma_{H_{SMYS_{Zero}}} =$	35.3%	< Hoop Stress %SMYS @ Zero pressure	ASME B31.8-2010	PASS
$\sigma_{H_{SMYS_{MOP}}} =$	63.3%	< Hoop Stress %SMYS @ MOP	ASME B31.8-2010	PASS
Longitudinal Stress (o):	-		
$\sigma_{L_{Live_{Zero}}} =$	13741 psi	< Live Load @ Zero pressure		
$\sigma_{L_{Live}MOP} =$	10380 psi	< Live Load @ MOP		
$\sigma_{L_{Total_{Zero}}} =$	14274 psi	< Total Longitudinal Stress @ Zero pressure		
$\sigma_{L_Total_MOP} =$	19479 psi	< Total Longitudinal Stress @ MOP		
$\sigma_{L_{SMYS_{Zero}}} =$	22.0%	< Longitudinal Stress %SMYS @ Zero pressure	ASME B31.8-2010	PASS
$\sigma_{L_{SMYS_{MOP}}} =$	30.0%	< Longitudinal Stress %SMYS @ MOP	ASME B31.8-2010	PASS
Equivalent Stress (σ _ε):		-		
σ _{E_Zero} =	37210 psi	< Equivalent Stress @ Zero pressure		
σ _{E MOP} =	42942 psi	< Equivalent Stress @ MOP		
σ _{E_%SMYS_Zero} =	57.2%	< Equivalent Stress %SMYS @ Zero pressure	ASME B31.8-2010	PASS
$\sigma_{E_{SMYS_{MOP}}} =$	66.1%	< Equivalent Stress %SMYS @ MOP	ASME B31.8-2010	PASS

GENERAL NOTES:

- Refer to "Table 3-Fatigue Endurance Limits, S_{FG} and S_{FU} for Various Steel Grades" on page 18 of API Recommended Practice 1102 when performing fatigue check calculations. This table has also been reproduced courtesy of the American Petroleum Institute on the "API RP 1102 Fatigue Table" tab to provide the user with a quick reference.

Results for Surface Loading Calculation

PIPELINE INFORMATION: PIPELINE LOCATION: VEHICLE INFORMATION: VEHICLE TYPE: Wheel: 3-Axles, 6-Wheels

Vermont Gas Burlington, VT HS20+15%

	VEINCLE III E.	Wheel. 57 Mes, 6 Wheels			
	DATE:	6/14/2021 8:31			
	GENERAL INPUTS		VEHICLE INPUTS		LOCATION OF MAXIMUM LOAD
D =	12.75 inches	(Outside Diameter)	Axle or Track Separation 1 :	14 ft	The maximum pressure
t =	0.312 inches	(Wall Thickness)	Axle Separation 2 :	14 ft	exerted on the surface of
P _{internal} =	1440 psig	(Maximum Operating Pressure)	Axle Width :	6 ft	the pipe due to vehicle
SMYS =	65000 psi	(Specified Minimum Yield Strength)	Track Length :	N/A ft	point load occurs:
ΔT =	0°F	(Temperature Differential)	Axle 1 or Track Vehicle Load :	9200 lbs	
ρ =	120 lb/ft ³	(Density)	Contact Width 1 :	20 inches	Under the middle tires.
H =	2 ft	(Depth of Cover)	Tire Pressure 1 :	100 psi	
θ =	30 degrees	(Bedding Angle)	Axle Load 2 :	36800 lbs	
E' =	100 psi	(Modulus of Soil Reaction)	Contact Width 2 :	20 inches	
IF =	1.50	(Impact Factor)	Tire Pressure 2 :	100 psi	
Soil Load Ec	Soil Load Equation: Prism Load Equation		Axle Load 3 :	36800 lbs	
	φ = N/2	A degrees	Contact Width 3 :	20 inches	
Equivalent	Equivalent Stress Equation: Tresca Equation		Tire Pressure 3 :	100 psi	
			Measurement Point X-coord :	N/A inches	
			Measurement Point Y-coord :	N/A inches	

CALCULATED STRESS DATA		Variable Description	Pipeline Regulatory Code	<u>Pass / Fail</u>
Hoop Stress ($\sigma_{\rm H}$):				
$\sigma_{H_{internal_{MOP}}} =$	29423 psi	< Internal Pressure @ MOP		
$\sigma_{H_{Live_{Zero}}} =$	22884 psi	< Live Load @ Zero pressure		
$\sigma_{H_{Live_{MOP}}} =$	11219 psi	< Live Load @ MOP		
σ _{H_Total_Zero} =	24806 psi	< Total Hoop Stress @ Zero pressure		
$\sigma_{H_Total_MOP} =$	41585 psi	< Total Hoop Stress @ MOP		
$\sigma_{H_{SMYS_{Zero}}} =$	38.2%	< Hoop Stress %SMYS @ Zero pressure	ASME B31.8-2010	PASS
$\sigma_{H_{SMYS_{MOP}}} =$	64.0%	< Hoop Stress %SMYS @ MOP	ASME B31.8-2010	PASS
Longitudinal Stress (σ _L):	_		
$\sigma_{L_Live_Zero} =$	18303 psi	< Live Load @ Zero pressure		
$\sigma_{L_Live_MOP} =$	14522 psi	< Live Load @ MOP		
$\sigma_{L_Total_Zero} =$	18879 psi	< Total Longitudinal Stress @ Zero pressure		
$\sigma_{L_{Total}MOP} =$	23632 psi	< Total Longitudinal Stress @ MOP		
σ _{L_%SMYS_Zero} =	29.0%	< Longitudinal Stress %SMYS @ Zero pressure	ASME B31.8-2010	PASS
σ _{L_%SMYS_MOP} =	36.4%	< Longitudinal Stress %SMYS @ MOP	ASME B31.8-2010	PASS
Equivalent Stress (σ _ε):		-		
σ _{E_Zero} =	43685 psi	< Equivalent Stress @ Zero pressure		
σ _{E MOP} =	47563 psi	< Equivalent Stress @ MOP		
σ _{E_%SMYS_Zero} =	67.2%	< Equivalent Stress %SMYS @ Zero pressure	ASME B31.8-2010	PASS
$\sigma_{E_{SMYS_{MOP}}} =$	73.2%	< Equivalent Stress %SMYS @ MOP	ASME B31.8-2010	PASS

GENERAL NOTES:

- Refer to "Table 3-Fatigue Endurance Limits, S_{FG} and S_{FU} for Various Steel Grades" on page 18 of API Recommended Practice 1102 when performing fatigue check calculations. This table has also been reproduced courtesy of the American Petroleum Institute on the "API RP 1102 Fatigue Table" tab to provide the user with a quick reference.

Project VGS	TECHNICAL	
Location Burlington, VT	Date 6/1/2021	TOOLBOXES

Design of Uncased Pipeline Crossings - GPTC Appendix G-192-15

PIPE AND CROSSING DATA:

Nominal Pipe Size	12 3/4			
Nominal Outside Diameter [in.]	12.75			
Nominal Wall Thickness [in.]	0.312			
Grade	X65			
Specified Minimum Yield Strength [psi]	65,000			
Design Factor	0.50			
Longitudinal Joint Factor	1.0			
Temperature Derating Factor	1.000			
Modulus of Elasticity for Steel [psi] 30	,000,000			
Unit Weight of Soil [lbs/ft³]	120			
Deflection Parameter	0.108			
Bending Parameter	0.235			
Impact Factor	1.5			
Pipeline Internal Pressure [psig]	1440			
Wheel Load [lbs]	18400			
Width of Pipe Trench or Diameter of Bore [ft.] 4				
Height of Soil over Pipe [ft.]	2			

RESULTS OF CALCULATION:

Nominal Pipe Size	12 3/4	Load Coefficient	0.474		
Nominal Outside Diameter [in.]	12.75	Total External Load [lbs/lineal inch of pipe]	367.0		
Nominal Wall Thickness [in.]	0.312	Hoop Stress due to Internal Pressure [psi]	29,423		
Grade	X65	Hoop Stress due to External Loading [psi]	16,442		
Specified Minimum Yield Strength [psi]	65,000	Total Calculated Combined Strees Incil	1E 96E		
Design Factor	0.50	Total Calculated Combined Stress [psi]	45,005		
Longitudinal Joint Factor	1.0	Note: The total calculated combined stress			
Temperature Derating Factor	1.000	should not exceed 100% of SMYS.			
Modulus of Elasticity for Steel [psi] 30	0,000,000				
Unit Weight of Soil [lbs/ft ³]	120				
Deflection Parameter	0.108				
Bending Parameter	0.235				
Impact Factor	1.5				
Pipeline Internal Pressure [psig]	1440				
Wheel Load [lbs]	18400				
Width of Pipe Trench or Diameter of Bore [ft.] 4					
Height of Soil over Pipe [ft.]	2				
Uniform Support Under Pipe [°] and Cro	esina Conditi	ons: 30° Open Trench			
	•	·			
Soil Type: Extreme maximum for clay (completiy sat	uraleu).			
Notes:					
Notes.					

Reference: GPTC - Guide for Gas Transmission and Distribution Systems, Appendix G-192-15, A.G.A.