

Memorandum

Subject	Surface/Earth Load Evaluation
То	Vermont Gas Systems, Inc.
From	Mott MacDonald, LLC
Our reference	507105094
Office	West Springfield, MA
Date	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 RE	SULTS	GULTS Calculated Effective Stress (r 3' Cover 4' Cover 5' Cov 31,239 31,437 31,2 31,180 31,370 31,1		
	Calculated	d Effective S	Stress (psi)	
Soil type	3' Cover	4' Cover	5' Cover	
Soft to medium clays and silts with high plasticities	31,239	31,437	31,234	
Soft to medium clays and silts with low/medium plasticities	31,180	31,370	31,159	
Loose sands and gravels	30,360	30,550	30,427	
Stiff to very stiff clays and silts	30,216	30,366	30,193	
Medium dense sands and gravels	30,278	30,453	30,318	
Dense to very dense sands and gravels	29,422	29,554	29,437	
ALLOWABLE EFFECTIVE STRESS (psi)		32,500		
Note:				

1. Calculated girth weld and longitudinal weld stress values were less than the allowable (Girth: 6,000 psi & Long. Welds: 11,500 psi).

5/25/2016

Rev. 1



Calculation cover sheet

Project Title:	VERMONT GAS SYSTEMS	Project No:	351481KKØ1
File No:		No. of Sheets:	18
Section:		Subject:	
Calc No:			
Project Manager:		Designer:	
Design Phase:	A - Concept or preliminary	C - Design verifica	tion
	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:

>Back check >Back check	project information individual calculations	to	verify	results

Sheets	Calculations by			Checked By:		
Checked: *	Name:	Signature:	Date:	Name:	Signature:	Date:
18/18	K.KIBBE	Kelsus Kim	52516	J. WUJUAS	1 7 1 (5/25/16
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*If an Excel spread PiMS location of th	sheet or other comp	uter file has been che ed (PiMS nickname	ecked and has not or short link from	- been attached, ente Properties – Genera	r the name, date an I could also be usefi	d full file path or
a) Basic Desig	on Information or	Source and Refe	rence:			
> Design > API IIC	. Into. pe	r Mike ki sign facto	rs and p	procedure	oris with	Giant
b) Identify doo	cuments/technica	I records where o	output will be u	sed:		
> calcula	tions su	mmary P	rovi ded	to die	nt	
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Approved by P	roject Manager:	Signature: Print name:	Juseph	WOJNAS)ate: 5/2.5/16

Distribution: Original

Original to project file



Vermont Gas Systems						
		Date	16			
Bunington, v i		5/24/20				
API 1102 - Gas Pipeline	Crossing High	way				
PIPE AND OPERATIONAL DATA:		SITE A	ND INSTALLA		ν:	
Operating Pressure [psi]	1440	Soil Ty	pe: Soft to m	edium clay	s and silts	with high
Location Class:	3	E' - Mo	plasticitie dulus of Soil Re	es eaction [ksi]		0.2
Operating Temperature [°F]	60.0	Er - Re	silient Modulus	[ksi]		5.0
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] 1			ps] 18.4	
Temperature Derating Factor	1.000	Pavement Type: None				
Pipe Class: API 5L Electric Resi	stance Welded	Impact	Factor Method	ASCE - H	lighway	
Young's Modulus for Steel [ksi]	30,000					
Poisson's Ratio for Steel	0.30					
Coefficient of Thermal Expansion [p	er°F] 0.0000065	Safety	Factor Applied:	API 1102	2 Procedui	re
RESULTS						
Hoop Stress [psi]		29,423	Maximum Circ	cumferentia	ll Stress [p	si] 34,305
Allowable Hoop Stress [psi]		32,500	Maximum Lon	gitudinal S	tress [psi]	12,239
Stiffness Factor for Earth Load Circu	umferential Stress	2,196	Maximum Rad	dial Stress	psi]	-1,440
Burial Factor for Earth Load Circum	erential Stress	0.83	Total Effective	e Stress [ps	i]	31,239
Excavation Factor for Earth Load Ci	rcumferential Stress	0.83	Allowable Effe	ctive Stres	s [psi]	32,500
Circumferential Stress from Earth Lo	oad [psi]	1,331				
Impact Factor		1.50	Stress [psi]	Calculated	Allowable	PASS/FAIL
Highway Stiffness Factor for Cyclic of	Circumferential	16.60	Hoop	29,423	32,500	PASS
Highway Geometry Factor for Cyclic	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 Cyclic	ongitudinal Stress	13.20				
Highway Geometry Factor for Cyclic	Longitudinal Stress	1.16				
Cyclic Longitudinal Stress [psi]		3,229				
Notes: Open cut construction, calcu	lations run using HS-	-20 Ioadin	g + 15%			

Prepared By Kelsey Kibbe Approved By

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	pe: Soft to medium cl	ays and silts with high
Location Class:	3	E' - Mo	plasticities odulus of Soil Reaction [k	(si] 0.2
Operating Temperature [°F]	60.0	Er - Re	esilient Modulus [ksi]	5.0
Pipe Outside Diameter [in]	12.75	Avera	ae Unit Weight of Soil [b/	/ft³] 120.00
Pipe Wall Thickness [in]	0.312	Pipe D	4	
Pipe Grade: X65		Bored	12.75	
Specified Minimum Yield Stress	65,000	Installa	60.0	
Design Factor	0.50	Desiar	e Axle [kips] 18.4	
Longitudinal Joint Factor	1.0	Desiar	em Axles [kips] 18.4	
Temperature Derating Factor	1.000	Paven		
Pipe Class: API 5L Electric Re	esistance Welded	Impac	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
Burial Eactor for Earth Load Circumferential Stress		0.07	Total Effective Stress [nsil 31.4
Burial Factor for Earth Load Circu	mierential Stress	0.97		pol] 01,4
Burial Factor for Earth Load Circu Excavation Factor for Earth Load	Circumferential Stress	0.97	Allowable Effective Str	ess [psi] 32,5
Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth	Circumferential Stress Load [psi]	0.97 0.83 1,555	Allowable Effective Str	ess [psi] 32,5
Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor	Circumferential Stress Load [psi]	0.97 0.83 1,555 1.50	Allowable Effective Str	ess [psi] 32,5
Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycli	Circumferential Stress Load [psi] ic Circumferential	0.97 0.83 1,555 1.50 16.60	Allowable Effective Str Stress [psi] Calculat Hoop 29,423 Effective 31,437	ess [psi] 32,5 ed Allowable PASS/F/ 32,500 PASS 32,500 PASS
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 Cyc	Circumferential Stress Load [psi] ic Circumferential	0.83 1,555 1.50 16.60 1.22	Allowable Effective Str Stress [psi] Calculat Hoop 29,423 Effective 31,437 Girth Welds 3,229	ed Allowable PASS/F/ 32,500 PASS 32,500 PASS 6,000 PASS
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 Cyc Cyclic Circumferential Stress [psi]	Circumferential Stress Load [psi] ic Circumferential clic Circumferential	0.83 1,555 1.50 16.60 1.22 4,271	Allowable Effective StrStress [psi]CalculatHoop29,423Effective31,437Girth Welds3,229Long. Welds4,271	ed Allowable PASS/F/ 32,500 PASS 32,500 PASS 6,000 PASS 11,500 PASS
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] Highway Stiffness Factor for Cycli	Circumferential Stress Load [psi] ic Circumferential clic Circumferential clic Circumferential	0.83 1,555 1.50 16.60 1.22 4,271 13.20	Allowable Effective StrStress [psi]CalculatHoop29,423Effective31,437Girth Welds3,229Long. Welds4,271	ed Allowable PASS/F/ 32,500 PASS 32,500 PASS 32,500 PASS 6,000 PASS 11,500 PASS
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 Highway Geometry Factor for Cycli	Circumferential Stress Load [psi] ic Circumferential clic Circumferential clic Circumferential clic Longitudinal Stress	0.83 1,555 1.50 16.60 1.22 4,271 13.20 1.16	Allowable Effective StrStress [psi]CalculatHoop29,423Effective31,437Girth Welds3,229Long. Welds4,271	ess [psi] 32,5 ed Allowable PASS/F/ 32,500 PASS 32,500 PASS 6,000 PASS 11,500 PASS
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 Highway Geometry Factor for Cycli Cyclic Longitudinal Stress [psi]	Circumferential Stress Load [psi] ic Circumferential clic Circumferential clic Circumferential clic Longitudinal Stress clic Longitudinal Stress	0.83 1,555 1.50 16.60 1.22 4,271 13.20 1.16 3,229	Allowable Effective Str Stress [psi] Calculat Hoop 29,423 Effective 31,437 Girth Welds 3,229 Long. Welds 4,271	ess [psi] 32,5 ed Allowable PASS/F/ 32,500 PASS 32,500 PASS 6,000 PASS 11,500 PASS

Burlington, VT		Date 5/24/20	16			
API 1102 - Gas Pipelin	e Crossing High	way				
PIPE AND OPERATIONAL DAT	A:	SITE A	ND INSTALLAT	ION DATA		
Operating Pressure [psi]	1440	Soil Ty	pe: Soft to m	edium clays	s and silts	with high
Location Class:	3	E' - Mo	plasticitie dulus of Soil Re	s action [ksi]		0.2
Operating Temperature [°F]	60.0	Er - Resilient Modulus [ksi]				5.0
Pipe Outside Diameter [in]	12.75	Averad	e Unit Weight o	f Soil [lb/ft³]		120.00
Pipe Wall Thickness [in]	0.312	Pipe D	epth [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 fro	om Single A	xle [kips]	18.4
Longitudinal Joint Factor	1.0	Design Wheel Load from Tandem Axles			ı Axles [kip	os] 18.4
Temperature Derating Factor	1.000	Pavem	ent Type: None	;		•
Pipe Class: API 5L Electric R	lesistance Welded	Impact	Factor Method:	ASCE - Hi	ighway	
Young's Modulus for Steel [ksi]	30,000	·				4
Poisson's Ratio for Steel	0.30					
Coefficient of Thermal Expansior	n [per°F] 0.0000065	Safety	Factor Applied:	API 1102	Procedur	e
RESULTS						
Hoon Stress Incil						
		29,423	Maximum Circ	umferential	l Stress [p	si] 34,28
Allowable Hoop Stress [psi]		29,423 32,500	Maximum Circ Maximum Lon	umferential gitudinal St	l Stress [p: ress [psi]	si] 34,28 12,13
Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C	ircumferential Stress	29,423 32,500 2,196	Maximum Circ Maximum Lon Maximum Rac	umferential gitudinal St lial Stress [i	l Stress [p ress [psi] psi]	si] 34,24 12,13 -1,44
Allowable Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circ	ircumferential Stress	29,423 32,500 2,196 1.08	Maximum Circ Maximum Lon Maximum Rac Total Effective	cumferential gitudinal St lial Stress [j Stress [psi	l Stress [p ress [psi] psi] i]	si] 34,28 12,13 -1,44 31,23
Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circl Excavation Factor for Earth Load	ircumferential Stress umferential Stress I Circumferential Stress	29,423 32,500 2,196 1.08 0.83 -	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe	cumferential gitudinal St lial Stress [] Stress [psi ctive Stress	l Stress [p: ress [psi] psi] i] s [psi]	si] 34,24 12,13 -1,44 31,23 32,50
Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circl Excavation Factor for Earth Load Circumferential Stress from Earth	Circumferential Stress umferential Stress I Circumferential Stress h Load [psi]	29,423 32,500 2,196 1.08 0.83 - 1,732	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe	cumferential gitudinal St lial Stress [Stress [psi ctive Stress	l Stress [p: ress [psi] psi] i] s [psi]	si] 34,24 12,13 -1,44 31,23 32,51
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	Circumferential Stress umferential Stress d Circumferential Stress h Load [psi]	29,423 32,500 2,196 1.08 0.83 1,732 1.50	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe	cumferential gitudinal St lial Stress [psi Stress [psi ctive Stress Calculated	l Stress [p ress [psi] psi] i] s [psi] Allowable	si] 34,28 12,13 -1,44 31,23 32,50 PASS/FA
Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circ Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc	Circumferential Stress umferential Stress I Circumferential Stress h Load [psi]	29,423 32,500 2,196 1.08 0.83 1,732 1.50 16.60	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe	cumferential gitudinal St lial Stress [psi ctive Stress Calculated 29,423	I Stress [p ress [psi] psi] i] s [psi] Allowable 32,500	si] 34,24 12,13 -1,44 31,23 32,50 PASS/FA PASS
Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circ Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Highway Geometry Factor for Cyc	Circumferential Stress umferential Stress d Circumferential Stress h Load [psi] dic Circumferential rclic Circumferential	29,423 32,500 2,196 1.08 0.83 1,732 1.50 16.60 1.10	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	cumferential gitudinal St lial Stress [psi ctive Stress Calculated 29,423 31,234 3,006	I Stress [p: ress [psi] psi] i] s [psi] Allowable 32,500 32,500 6 000	si] 34,24 12,13 -1,44 31,23 32,50 PASS/FA PASS PASS PASS
Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circl Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Highway Geometry Factor for Cy Cyclic Circumferential Stress [ps	Circumferential Stress umferential Stress d Circumferential Stress h Load [psi] dic Circumferential rclic Circumferential	29,423 32,500 2,196 1.08 0.83 1,732 1.50 16.60 1.10 3,850	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds	cumferential gitudinal St lial Stress [psi ctive Stress Calculated 29,423 31,234 3,006 3,850	I Stress [psi] ress [psi] i] s [psi] Allowable 32,500 32,500 6,000 11,500	si] 34,24 12,13 -1,44 31,23 32,50 PASS/FA PASS PASS PASS PASS
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 Highway Geometry Factor for Cyc Cyclic Circumferential Stress [ps Highway Stiffness Factor for Cyc	Circumferential Stress umferential Stress d Circumferential Stress h Load [psi] clic Circumferential clic Circumferential i] clic Longitudinal Stress	29,423 32,500 2,196 1.08 0.83 1,732 1.50 16.60 1.10 3,850 13.20	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds	cumferential gitudinal St lial Stress [psi ctive Stress Calculated 29,423 31,234 3,006 3,850	l Stress [psi] ress [psi] j] s [psi] Allowable 32,500 32,500 6,000 11,500	si] 34,28 12,13 -1,44 31,23 32,50 PASS/FA PASS PASS PASS PASS PASS
Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circ Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Cyclic Circumferential Stress [ps Highway Stiffness Factor for Cyc Highway Geometry Factor for Cyc	Circumferential Stress umferential Stress d Circumferential Stress h Load [psi] clic Circumferential cclic Circumferential i] clic Longitudinal Stress cclic Longitudinal Stress	29,423 32,500 2,196 1.08 0.83 1,732 1.50 16.60 1.10 3,850 13.20 1.08	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds	cumferential gitudinal St lial Stress [psi ctive Stress Calculated 29,423 31,234 3,006 3,850	I Stress [p: ress [psi] psi]] 6 [psi] Allowable 32,500 32,500 6,000 11,500	si] 34,24 12,13 -1,44 31,23 32,50 PASS PASS PASS PASS PASS
Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circl Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Cyclic Circumferential Stress [ps Highway Stiffness Factor for Cyc Highway Stiffness Factor for Cyc Cyclic Circumferential Stress [ps Highway Geometry Factor for Cyc	Circumferential Stress umferential Stress d Circumferential Stress h Load [psi] clic Circumferential cclic Circumferential i] clic Longitudinal Stress clic Longitudinal Stress	29,423 32,500 2,196 1.08 0.83 1,732 1.50 16.60 1.10 3,850 13.20 1.08 3,006	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds	cumferential gitudinal St lial Stress [psi ctive Stress Calculated 29,423 31,234 3,006 3,850	l Stress [p: ress [psi] psi] i] 6 [psi] Allowable 32,500 32,500 6,000 11,500	si] 34,24 12,13 -1,44 31,23 32,50 PASS PASS PASS PASS PASS
Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circl Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Highway Geometry Factor for Cyc Highway Stiffness Factor for Cyc Highway Stiffness Factor for Cyc Uyclic Circumferential Stress [psi] Highway Geometry Factor for Cyc Notes: Open cut construction, ca	Circumferential Stress umferential Stress d Circumferential Stress h Load [psi] dic Circumferential clic Circumferential dic Longitudinal Stress clic Longitudinal Stress	29,423 32,500 2,196 1.08 0.83 1,732 1.50 16.60 1.10 3,850 13.20 1.08 3,006	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds	cumferential gitudinal St lial Stress [psi ctive Stress Calculated 29,423 31,234 3,006 3,850	I Stress [p: ress [psi] psi]] s [psi] Allowable 32,500 32,500 6,000 11,500	si] 34,28 12,13 -1,44 31,23 32,50 PASS PASS PASS PASS PASS
Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circl Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Cyclic Circumferential Stress [ps Highway Stiffness Factor for Cyc Highway Geometry Factor for Cyc Highway Geometry Factor for Cyc Cyclic Longitudinal Stress [psi] Notes: Open cut construction, ca Reference: API RP 1102 "Steel I	Circumferential Stress umferential Stress d Circumferential Stress h Load [psi] clic Circumferential cclic Circumferential i] clic Longitudinal Stress clic Longitudinal Stress alculations run using HS-	29,423 32,500 2,196 1.08 0.83 1,732 1.50 16.60 1.10 3,850 13.20 1.08 3,006 -20 loadin	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds	cumferential gitudinal St lial Stress [psi ctive Stress Calculated 29,423 31,234 3,006 3,850	l Stress [p: ress [psi] psi] i] 6 [psi] Allowable 32,500 6,000 11,500	si] 34,24 12,1: -1,44 31,2: 32,50 PASS PASS PASS PASS PASS

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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: So	ft to m	edium cla	ys and silts	with
Location Class:	3	E' - Mo	low dulus of S	//medi Soil Re	ium plastic eaction [ks	ities i1	0.5
Operating Temperature [°F]	60.0	Er - Re	esilient Mo	dulus	[ksi]	.,	5.0
Pipe Outside Diameter [in]	12.75	Averac	ae Unit We	eiaht c	of Soil [lb/ft	3]	120.00
Pipe Wall Thickness [in]	0.312	Pipe D	epth [ft]	9	•		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			Axle [kips]	18.4	
Longitudinal Joint Factor	1.0	Desigr	Wheel L	oad fro	om Tandei	m Axles [kip	os] 18.4
Temperature Derating Factor	1.000	Pavem	ent Type:	None	е		
Pipe Class: API 5L Electric Re	esistance Welded	Impact	Factor M	lethod	: ASCE - I	Highway	
Young's Modulus for Steel [ksi]	30,000						
Poisson's Ratio for Steel	0.30	o ()					
Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Ap	pilea:	API 110	2 Procedur	e
RESULTS							
Hoop Stress [psi]		29,423	Maximu	m Ciro	cumferenti	al Stress [p	si] 34,239
Allowable Hoop Stress [psi]		32,500	Maximu	m Lor	ngitudinal S	Stress [psi]	12,219
Stiffness Factor for Earth Load Ci	rcumferential Stress	2,088	Maximu	m Rad	dial Stress	[psi]	-1,440
Burial Factor for Earth Load Circu	mferential Stress	0.83	Total Effective Stress [psi]			31,180	
Excavation Factor for Earth Load	Circumferential Stress	0.83	Allowab	le Effe	ective Stres	ss [psi]	32,500
Circumferential Stress from Earth	Load [psi]	1,265					
Impact Factor		1.50	Stress [psi]	Calculated	dAllowable	PASS/FAIL
Lindwoy Stiffnoon Easter for Aug	c Circumferential	16.60	Hoop		29,423	32,500	PASS
righway summess ractor for Cycli		1 00	Girth W	elds	31,180	6.000	PASS
Highway Geometry Factor for Cycli	cilo Circumferentiai	1.22			4 271	11 500	DASS
Highway Geometry Factor for Cycli Cyclic Circumferential Stress [psi]	alic Circumferential	1.22 4,271	Long. W	/elds	.,	11,000	FA33
Highway Geometry Factor for Cycli Highway Geometry Factor for Cyc Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycli	c Longitudinal Stress	1.22 4,271 13.20	Long. W	/elds		111,000	FASS
Highway Geometry Factor for Cycli Highway Geometry Factor for Cyc Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycli Highway Geometry Factor for Cyc	c Longitudinal Stress	1.22 4,271 13.20 1.16	Long: W	/elds	<u></u>	11,000	FASS
Highway Geometry Factor for Cycli Highway Geometry Factor for Cyc Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycli Highway Geometry Factor for Cyc Cyclic Longitudinal Stress [psi]	c Longitudinal Stress	4,271 13.20 1.16 3,229	Long: W	/elds			FAGG
Highway Geometry Factor for Cycli Highway Geometry Factor for Cycli Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycli Highway Geometry Factor for Cycli Cyclic Longitudinal Stress [psi] Notes: Open cut construction, cal	c Longitudinal Stress clic Longitudinal Stress clic Longitudinal Stress culations run using HS-	4,271 13.20 1.16 3,229 -20 loadir	Long: W	/elds	<u></u>	11,000	FAGO
Highway Geometry Factor for Cycli Highway Geometry Factor for Cycli Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycli Highway Geometry Factor for Cycli Cyclic Longitudinal Stress [psi] Notes: Open cut construction, call Reference: ABL RP 1102 "Steel P	c Longitudinal Stress clic Longitudinal Stress culations run using HS-	4,271 13.20 1.16 3,229 -20 loadir	Long: M Ig + 15%	/elds	<u></u>	11,000	FA33

Location Burlington, VT		Date 5/24/20	16			
API 1102 - Gas Pipelin	e Crossing High	way	đ			
PIPE AND OPERATIONAL DATA		SITE A	ND INSTALLATIO	N DATA:		
Operating Pressure [psi]	1440	Soil Ty	pe: Soft to medi	um clays	and silts	with
Location Class:	3	F' - Mc	low/medium dulus of Soil Reac	plasticitie tion [ksi]	S.	0.5
Operating Temperature [°F]	60.0	Er - Re	esilient Modulus [ks			5.0
Pipe Outside Diameter [in]	12.75	Avera	ae Unit Weight of S	oil [lb/ft³]		120.00
Pipe Wall Thickness [in]	0.312	Pipe Depth [ft]				4
Pipe Grade: X65		Bored Diameter [in]				12.75
Specified Minimum Yield Stress	65,000	InstallationTemperature [°F]				60.0
Design Factor	0.50	Design Wheel Load from Single Axle			le [kips]	18.4
Longitudinal Joint Factor	1.0	Design Wheel Load from Tandem Ax			Axles (kii	os] 18.4
Temperature Derating Factor	1.000	Paven	nent Type: None			
Pipe Class: API 5L Electric Re	esistance Welded	Impac	t Factor Method: A	SCE - Hig	Ihway	
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	Procedur	e
RESULTS						
Hoop Stress [psi]		29,423	Maximum Circun	nferential	Stress [p	si] 34,48
Allowable Hoop Stress [psi]		32,500	Maximum Longiti	udinal Stre	ess [psi]	12,28
Stiffness Factor for Earth Load Ci	rcumferential Stress	2,088	Maximum Radial	Stress [p	si]	-1,44
Burial Factor for Earth Load Circu	Imferential Stress	0.97	Total Effective St	ress [psi]		31,37
Excavation Factor for Earth Load	Circumferential Stress	0.83	Allowable Effectiv	ve Stress	[psi]	32,50
Circumferential Stress from Earth	Load [psi]	1,479				
Impact Factor		1.50	Stress [psi] Ca	Iculated	llowable	PASS/FA
Highway Stiffness Factor for Cycl	ic Circumferential	16.60	Hoop 29	,423 3	32,500 32,500	PASS
Highway Geometry Factor for Cyd	clic Circumferential	1.22	Girth Welds 3,2	229 6	5,000	PASS
Cyclic Circumferential Stress [psi	1	4,271	Long. Welds 4,2	271 1	1,500	PASS
Highway Stiffness Factor for Cycl	ic Longitudinal Stress	13.20				
Highway Geometry Factor for Cyd	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	Pipelines Crossing Railr	oads and	Highways"			
		Apr	roved By		Revi	sion: 12

Location Burlington, VT		Date 5/24/20	16			
API 1102 - Gas Pipeline	e Crossing High	way				
PIPE AND OPERATIONAL DATA		SITE A	ND INSTALLA		A :	
Operating Pressure [psi]	1440	Soil Ty	pe: Soft to m	edium cla	s and silt	s with
Location Class:	3	E' - Mo	0.5			
Operating Temperature [°F]	60.0	Er - Re	silient Modulus	[ksi]		5.0
Pipe Outside Diameter [in]	12.75	Average Unit Weight of Soil [lb/ft³]				120.00
Pipe Wall Thickness [in]	0.312	Pipe Depth [ft]				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 [kip				ips] 18.4
Temperature Derating Factor	1.000	Pavem	ent Type: None	Э	-	
Pipe Class: API 5L Electric Re	esistance Welded	Impact	Factor Method	: ASCE - I	lighway	
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 110	2 Procedu	ıre
RESULTS						
Hoop Stress [psi]		29,423	Maximum Cire	cumferenti	al Stress [psi] 34,2
Allowable Hoop Stress [psi]		32,500	Maximum Lor	ngitudinal S	Stress [psi]	12,1
Stiffness Factor for Earth Load Ci	cumferential Stress	2,088	Maximum Rad	dial Stress	[psi]	-1,4
Burial Factor for Earth Load Circu	mferential Stress	1.08	Total Effective	e Stress [p	si]	31,1
Excavation Factor for Earth Load	Circumferential Stress	0.83	Allowable Effe	ective Stres	ss [psi]	32,5
Circumferential Stress from Earth	Load [psi]	1,647				
Impact Factor		1.50	Stress [psi]	Calculate	Allowable	e PASS/F
Highway Stiffness Factor for Cycli	c Circumferential	16.60	Hoop	29,423	32,500	PASS
Highway Geometry Factor for Cyc	lic Circumferential	1.10	Girth Welds	3,006	6,000	PASS
Cyclic Circumferential Stress [psi]		3,850	Long. Welds	3,850	11,500	PASS
Highway Stiffness Factor for Cycli	c Longitudinal Stress	13.20				
Highway Geometry Factor for Cyc	lic Longitudinal Stress	1.08				
		2 006				

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		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	Er - Re	silient Mo	odulus	[ksi]		10.0
Pipe Outside Diameter [in]	12.75	Avera	e Unit W	eiaht a	of Soil [lb/ft	3]	120.00
Pipe Wall Thickness [in]	0.312	Pipe D	epth [ft]	- 3			3
Pipe Grade: X65		Bored	Diameter	[in]			12.75
Specified Minimum Yield Stress	65,000	Installa	ationTemp	beratu	re [°F]		60.0
Design Factor	0.50	Desigr	Wheel L	oad fr	om Single	Axle [kips]	18.4
Longitudinal Joint Factor	1.0	Desigr	Wheel L	oad fr	om Tandei	m Axles [ki	ips] 18.4
Temperature Derating Factor	1.000	Paver	ent Type:	Non	е	•	
Pipe Class: API 5L Electric Re	esistance Welded	Impact	t Factor M	lethod	: 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	im 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]	Calculated	Allowable	PASS/F
Highway Stiffness Factor for Cycli	c Circumferential	12.60	Hoop	ρ	29,423	32,500	PASS
Highway Geometry Factor for Cyc	clic Circumferential	1.22	Girth W	elds	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					
			450/				

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

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		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	Er - Re	esilient	Modulus	[ksi]		10.0
Pipe Outside Diameter [in]	12.75	Averac	ae Unit	Weiaht o	of Soil [lb/ft ³	1	120.00
Pipe Wall Thickness [in]	0.312	Pipe D	epth [f	1 1			4
Pipe Grade: X65		Bored	Diame	ter [in]			12.75
Specified Minimum Yield Stress	65,000	Installa	ationTe	emperatu	re [°F]		60.0
Design Factor	0.50	Desigr	Whee	el Load fr	om Sinale A	xle [kips]	18.4
Longitudinal Joint Factor	1.0	Desigr	Whe	el Load fr	om Tander	Axles [kir	osl 18.4
Temperature Derating Factor	1.000	Paver	ient Ti	ne: Non	8	i i indo fini	.01 .0
Pipe Class: API 5L Electric Re	esistance Welded	Impact	t Facto	r Method	· 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	Allowable	PASS/FA
Highway Stiffness Factor for Cycli	c Circumferential	12.60	Hoop) ativo	29,423	32,500	PASS
Highway Geometry Factor for Cyc	lic Circumferential	1.22	Girth	Welds	2.275	6.000	PASS
Cyclic Circumferential Stress [psi]		3,241	Long	. Welds	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					

Prepared By	Kelsey Kibbe	
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Approved By

Revision: 13.0.1

Location Burlington, VT		Date 5/24/20	16				
API 1102 - Gas Pipelin	e Crossing High	way					
PIPE AND OPERATIONAL DATA	٨:	SITE A	ND INSTA	LLA	TION DATA	٨:	
Operating Pressure [psi]	1440	Soil Ty	vpe: Loos	se sa	ands and gr	avels	
Location Class:	3	E' - Mo	odulus of Se	oil Re	eaction [ksi]	l	0.5
Operating Temperature [°F]	60.0	Er - Re	esilient Mod	lulus	[ksi]		10.0
Pipe Outside Diameter [in]	12.75	Averac	ae Unit Wei	ight c	of Soil [lb/ft³	1	120.00
Pipe Wall Thickness [in]	0.312	Pipe D	epth [ft]	0	L		5
Pipe Grade: X65		Bored	Diameter [i	in]			12.75
Specified Minimum Yield Stress	65,000	Installa	- ationTempe	- eratui	re [°F]		60.0
Design Factor	0.50	Desigr	n Wheel Lo	ad fro	om Single A	Axle [kips]	18.4
Longitudinal Joint Factor	1.0	Desigr	n Wheel Lo	ad fro	om Tanden	n Axles [ki	ps] 18.4
Temperature Derating Factor	1.000	Paver	nent Type:	None	Э	-	
Pipe Class: API 5L Electric R	esistance Welded	Impact	t Factor Me	ethod	: ASCE - H	lighway	
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 App		API 1102	2 Procedu	re
RESULTS							
Hoop Stress [psi]		29,423	Maximun	n Ciro	cumferentia	al Stress [p	si] 33,2
Allowable Hoop Stress [psi]		32,500	Maximun	n Lor	ngitudinal S	tress [psi]	11,2
Stiffness Factor for Earth Load C	ircumferential Stress	2,088	Maximun	n Rad	dial Stress	[psi]	-1,44
Burial Factor for Earth Load Circo	umferential Stress	1.08	Total Effe	ective	e Stress [ps	i]	30,42
Excavation Factor for Earth Load	Circumferential Stress	0.83	Allowable	e Effe	ective Stres	s [psi]	32,5
Circumferential Stress from Earth	ו Load [psi]	1,647					
Impact Factor		1.50	Stress [p	si]	Calculated	Allowable	PASS/FA
Highway Stiffness Factor for Cyc	lic Circumferential	12.60	Hoop		29,423	32,500	PASS
Highway Geometry Factor for Cy	clic Circumferential	1.10	Girth We	lds	2,118	6,000	PASS
Cyclic Circumferential Stress [ps	J	2,923	Long. We	elds	2,923	11,500	PASS
Highway Stiffness Eactor for Cyc	lic Longitudinal Stress	9.30					
righway ounness racior for Oyc	clic Longitudinal Stress	1.08					
Highway Geometry Factor for Cy							
Highway Geometry Factor for Cy Cyclic Longitudinal Stress [psi]		2,118					
Highway Geometry Factor for Cy Cyclic Longitudinal Stress [psi] Notes: Open cut construction, ca	lculations run using HS	2,118 -20 loadir	ng + 15%				
Highway Geometry Factor for Cy Cyclic Longitudinal Stress [psi] Notes: Open cut construction, ca	Iculations run using HS	2,118 -20 loadir oads and	ng + 15% Highways''	1			

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Project	
Vermont Gas Systems	
Location	Date
Burlington, VT	5/24/2016

API 1102 - Gas Pipeline Crossing Highway

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	0.0
Pipe Outside Diameter [in]	12.75	Average Unit Weight of Soil [lb/ft³] 12	20.00
Pipe Wall Thickness [in]	0.312	Pipe Depth [ft] 3	
Pipe Grade: X65		Bored Diameter [in] 12	2.75
Specified Minimum Yield Stress	65,000	InstallationTemperature [°F] 60	0.0
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	
Pipe Class: API 5L Electric Re	esistance Welded	Impact Factor Method: ASCE - 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 Applied: API 1102 Procedure	

RESULTS

Hoop Stress [psi]	29,42
Allowable Hoop Stress [psi]	32,50
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

1.0 10.0 120.00

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

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	Er - Re	silient Modulus	[ksi]		10.0
Pipe Outside Diameter [in]	12.75	Averac	e Unit Weight o	of Soil [lb/ft³	1	120.00
Pipe Wall Thickness [in]	0.312	Pipe D	epth [ft]	•	<u>.</u>	4
Pipe Grade: X65		Bored	Diameter [in]			12.75
Specified Minimum Yield Stress	65,000	Installa	ationTemperatu	re [°F]		60.0
Design Factor	0.50	Desigr	Wheel Load fr	om Sinale A	xle [kips]	18.4
Longitudinal Joint Factor	1.0	Desiar	Wheel Load fr	om Tanderr	n Axles [kir	osl 18.4
Temperature Derating Factor	1.000	Paven	ent Type: Non	8	.	
Pipe Class: API 5L Electric Re	esistance Welded	Impac	Factor Method	- : ASCE - H	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	Allowable	PASS/FA
Highway Stiffness Factor for Cycli	c Circumferential	12.60	Hoop	29,423	32,500	PASS
Highway Geometry Factor for Cyc	lic Circumferential	1.22	Girth Welds	2,275	6,000	PASS
Cyclic Circumferential Stress [psi]		3,241	Long. Welds	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				

Prepared By Kelsey Kibbe

i.

Approved By

Revision: 13.0.1

Location		Date				
Burlington, VT		5/24/20	16			
API 1102 - Gas Pipelin	e Crossing High	way				
PIPE AND OPERATIONAL DATA	A:	SITE A			A:	
Operating Pressure [psi]	1440	Soil Ty	pe: Stiff to ve	ery stiff clay	s and silts	ı
Location Class:	3	E' - Mo	dulus of Soil Re	eaction [ksi]	1.0
Operating Temperature [°F]	60.0	Er - Re	esilient Modulus	[ksi]	-	10.0
Pipe Outside Diameter [in]	12.75	Averac	ae Unit Weight c	 of Soil [lb/ft⁵	1	120.00
Pipe Wall Thickness [in]	0.312	Pipe D	epth [ft]			5
Pipe Grade: X65		Bored	Diameter [in]			12.75
Specified Minimum Yield Stress	65,000	Installa	ationTemperatur	e [°F]		60.0
Design Factor	0.50	Desigr	Wheel Load fro	om Single /	Axle [kips]	18.4
Longitudinal Joint Factor	1.0	Desigr	Wheel Load fro	om Tanden	n Axles [ki	ps] 18.4
Temperature Derating Factor	1.000	Pavement Type: None				
Pipe Class: API 5L Electric R	esistance Welded	Impact	t Factor Method:	: ASCE - H	lighway	
Young's Modulus for Steel [ksi]	30,000				0 /	
Poisson's Ratio for Steel	0.30				¥5.	
Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Applied:	API 110	2 Procedu	re
RESULTS						
Hoop Stress [psi]		29,423	Maximum Circ	cumferentia	al Stress [p	si] 33,010
Allowable Hoop Stress [psi]		32,500	Maximum Lon	igitudinal S	tress [psi]	11,144
Stiffness Factor for Earth Load C	ircumferential Stress	1,934	Maximum Rad	dial Stress	[psi]	-1,440
Burial Factor for Earth Load Circu	umferential Stress	0.98	Total Effective	Stress [ps	i]	30,193
Excavation Factor for Earth Load	Circumferential Stress	0.83	Allowable Effe	ctive Stres	s [psi]	32,500
Circumferential Stress from Earth	a Load [psi]	1,384				
Impact Factor		1.50	Stress [psi]	Calculated	Allowable	PASS/FAI
Highway Stiffness Factor for Cycl	lic Circumferential	12.60	Hoop	29,423	32,500	PASS
Highway Geometry Factor for Cyd	clic Circumferential	1.10	Girth Welds	2,118	6,000	PASS
Cyclic Circumferential Stress [psi]	2,923	Long. Welds	2,923	11,500	PASS
Highway Stiffness Factor for Cycl	ic Longitudinal Stress	9.30				
Highway Geometry Factor for Cy	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 Pipelin	e Crossing High	way		
PIPE AND OPERATIONAL DATA	A :	SITE A	AND INSTALLATION DATA:	
Operating Pressure [psi]	1440	Soil Ty	vpe: Medium dense sands an	d gravels
Location Class:	3	E' - Mc	odulus of Soil Reaction [ksi]	1.0
Operating Temperature [°F]	60.0	Er - Re	esilient Modulus [ksi]	10.0
Pipe Outside Diameter [in]	12.75	Averac	ae Unit Weight of Soil [lb/ft³]	120.00
Pipe Wall Thickness [in]	0.312	Pipe D	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	Design	Wheel Load from Single Axle I	[kips] 18.4
Longitudinal Joint Factor	1.0	Desigr	N Wheel Load from Tandem Axl	es [kips] 18.4
Temperature Derating Factor	1.000	Paver	nent Type: None	
Pipe Class: API 5L Electric R	esistance Welded	Impact	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	n [per°F] 0.0000065	Safety	Factor Applied: API 1102 Pro	cedure
RESULTS				
Hoop Stress [psi]		29,423	Maximum Circumferential Stre	ess [psi] 33,1
Allowable Hoop Stress [psi]		32,500	Maximum Longitudinal Stress	[psi] 11,2
Stiffness Factor for Earth Load C	ircumferential Stress	1,934	Maximum Radial Stress [psi]	-1,44
Sumess Factor for Earth Load Circumferential Stress		0.83	Total Effective Stress [psi]	30.2
Burial Factor for Earth Load Circi				
Burial Factor for Earth Load Circle Excavation Factor for Earth Load	Circumferential Stress	0.83	Allowable Effective Stress [ps	i] 32,5
Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth	l Circumferential Stress n Load [psi]	0.83 1,172	Allowable Effective Stress [ps	i] 32,5
Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor	l Circumferential Stress ר Load [psi]	0.83 1,172 1.50	Allowable Effective Stress [ps Stress [psi] Calculated Allov	i] 32,5 wable PASS/F/
Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc	l Circumferential Stress n Load [psi] lic Circumferential	0.83 1,172 1.50 12.60	Allowable Effective Stress [ps] Stress [psi] Calculated Allow Hoop 29,423 32,5 Effective 30,278 32,5	i] 32,5 wable PASS/FA
Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Highway Geometry Factor for Cyc	l Circumferential Stress n Load [psi] lic Circumferential clic Circumferential	0.83 1,172 1.50 12.60 1.22	Allowable Effective Stress [ps]Stress [psi]Calculated AllowHoop29,42332,5Effective30,27832,5Girth Welds2,2756,000	i] 32,5 wable PASS/FA 500 PASS 500 PASS 500 PASS
Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Highway Geometry Factor for Cy Cyclic Circumferential Stress [psi	I Circumferential Stress In Load [psi] lic Circumferential clic Circumferential	0.83 1,172 1.50 12.60 1.22 3,241	Allowable Effective Stress [ps]Stress [psi]Calculated AllowHoop29,42332,5Effective30,27832,5Girth Welds2,2756,00Long. Welds3,24111,5	i] 32,5 wable PASS/FA 500 PASS 500 PASS 500 PASS 500 PASS
Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Highway Geometry Factor for Cyc Cyclic Circumferential Stress [psi Highway Stiffness Factor for Cyc	Circumferential Stress Load [psi] lic Circumferential clic Circumferential i] lic Longitudinal Stress	0.83 1,172 1.50 12.60 1.22 3,241 9.30	Allowable Effective Stress [ps]Stress [psi]Calculated AllowHoop29,42332,5Effective30,27832,5Girth Welds2,2756,00Long. Welds3,24111,5	i] 32,5 wable PASS/FA 500 PASS 500 PASS 500 PASS 500 PASS
Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Highway Geometry Factor for Cyc Highway Stiffness Factor for Cyc Highway Stiffness Factor for Cyc	Circumferential Stress n Load [psi] lic Circumferential clic Circumferential i] lic Longitudinal Stress clic Longitudinal Stress	0.83 1,172 1.50 12.60 1.22 3,241 9.30 1.16	Allowable Effective Stress [ps]Stress [psi]Calculated AllowHoop29,42332,5Effective30,27832,5Girth Welds2,2756,00Long. Welds3,24111,5	i] 32,5 wable PASS/F/ 500 PASS 500 PASS 500 PASS 500 PASS
Burial Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cyc Highway Geometry Factor for Cyc Highway Stiffness Factor for Cyc Highway Stiffness Factor for Cyc Cyclic Longitudinal Stress [psi]	Circumferential Stress n Load [psi] lic Circumferential clic Circumferential i] lic Longitudinal Stress clic Longitudinal Stress	0.83 1,172 1.50 12.60 1.22 3,241 9.30 1.16 2,275	Allowable Effective Stress [ps]Stress [psi]Calculated AllowHoop29,42332,5Effective30,27832,5Girth Welds2,2756,00Long. Welds3,24111,5	i] 32,5 wable PASS/F/ 500 PASS 500 PASS 500 PASS 500 PASS

Location Burlington, VT			16				
API 1102 - Gas Pipelin	e Crossing High	way					
PIPE AND OPERATIONAL DATA	A:	SITE A	ND INSTALLAT		.:		
Operating Pressure [psi] 1440			pe: Medium (dense sand	s and grav	vels	
Location Class: 3			dulus of Soil Re	action [ksi]		10	
Operating Temperature [°F]	60.0	Er - Re	silient Modulus	[ksi]		10.0	
Pipe Outside Diameter [in]	12.75	Averac	e I Init Weight o	f Soil [lb/ft³]	1	120.00	
Pipe Wall Thickness [in]	0.312	Pine D	enth [ft]		1	4	
Pipe Grade: X65		Bored	Diameter [in]			12 75	
Specified Minimum Yield Stress	65,000	Installa	ntionTemperatur	e l°Fl		60.0	
Design Factor	0.50	Design	Wheel I oad fro	om Sinale A	vle [kips]	18.4	
Longitudinal Joint Factor	1.0	Design	Wheel Load fro	om Tanderr	n Axles [kir	osl 18.4	
Temperature Derating Factor	1.000	Pavement Type: None					
Pipe Class: API 5L Electric R	esistance Welded	Impact	Factor Method:	ASCE - H	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	Procedur	e	
RESULTS					`		
Hoop Stress [psi]		29,423	Maximum Circ	cumferentia	l Stress [p	si] 33,314	
Hoop Stress [psi] Allowable Hoop Stress [psi]		29,423 32,500	Maximum Circ Maximum Lon	cumferentia gitudinal St	l Stress [p: :ress [psi]	si] 33,314 11,297	
Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C	ircumferential Stress	29,423 32,500 1,934	Maximum Circ Maximum Lon Maximum Rac	cumferentia gitudinal St tial Stress [l Stress [p: ress [psi] psi]	si] 33,314 11,297 -1,440	
Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu	ircumferential Stress umferential Stress	29,423 32,500 1,934 0.97	Maximum Circ Maximum Lon Maximum Rac Total Effective	cumferentia gitudinal St dial Stress [Stress [ps	l Stress [p: ress [psi] psi] i]	si] 33,314 11,297 -1,440 30,453	
Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load C Burial Factor for Earth Load Circu Excavation Factor for Earth Load	ircumferential Stress umferential Stress Circumferential Stress	29,423 32,500 1,934 0.97 0.83	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe	cumferentia gitudinal St dial Stress [Stress [ps ctive Stress	l Stress [p: ress [psi] psi] i] s [psi]	si] 33,314 11,297 -1,440 30,453 32,500	
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	ircumferential Stress umferential Stress Circumferential Stress n Load [psi]	29,423 32,500 1,934 0.97 0.83 1,370	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe	cumferentia gitudinal St dial Stress [Stress [ps octive Stress	l Stress [p: ress [psi] psi] i] s [psi]	si] 33,314 11,297 -1,440 30,453 32,500	
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	ircumferential Stress umferential Stress Circumferential Stress n Load [psi]	29,423 32,500 1,934 0.97 0.83 1,370 1.50	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe	cumferentia gitudinal St dial Stress [Stress [ps ctive Stress Calculated	l Stress [p: ress [psi] psi] i] s [psi] Allowable	si] 33,314 11,297 -1,440 30,453 32,500 PASS/FAIL	
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	ircumferential Stress umferential Stress Circumferential Stress Load [psi] lic Circumferential	29,423 32,500 1,934 0.97 0.83 1,370 1.50 12.60	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop	cumferentia gitudinal St dial Stress [ps octive Stress Calculated 29,423	I Stress [p: ress [psi] i] s [psi] Allowable 32,500	si] 33,314 11,297 -1,440 30,453 32,500 PASS/FAIL 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	ircumferential Stress umferential Stress Circumferential Stress Load [psi] lic Circumferential clic Circumferential	29,423 32,500 1,934 0.97 0.83 1,370 1.50 12.60 1.22	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds	cumferentia gitudinal St dial Stress [ps octive Stress Calculated 29,423 30,453 2,275	I Stress [p: ress [psi] i] s [psi] Allowable 32,500 32,500 6,000	si] 33,314 11,297 -1,440 30,453 32,500 PASS/FAIL PASS PASS 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 Highway Geometry Factor for Cyc	ircumferential Stress umferential Stress Circumferential Stress h Load [psi] lic Circumferential clic Circumferential	29,423 32,500 1,934 0.97 0.83 1,370 1.50 12.60 1.22 3,241	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds	cumferentia gitudinal St dial Stress [ps octive Stress Calculated 29,423 30,453 2,275 3,241	I Stress [p: ress [psi] psi] i] s [psi] Allowable 32,500 32,500 6,000 11,500	si] 33,314 11,297 -1,440 30,453 32,500 PASS/FAIL PASS PASS PASS 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	ircumferential Stress umferential Stress Circumferential Stress h Load [psi] lic Circumferential clic Circumferential i] lic Longitudinal Stress	29,423 32,500 1,934 0.97 0.83 1,370 1.50 12.60 1.22 3,241 9.30	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds	cumferentia gitudinal St dial Stress [ps octive Stress Calculated 29,423 30,453 2,275 3,241	I Stress [p: ress [psi] psi] i] s [psi] Allowable 32,500 32,500 6,000 11,500	si] 33,314 11,297 -1,440 30,453 32,500 PASS/FAIL PASS PASS PASS 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 	ircumferential Stress umferential Stress Circumferential Stress h Load [psi] lic Circumferential clic Circumferential i] lic Longitudinal Stress clic Longitudinal Stress	29,423 32,500 1,934 0.97 0.83 1,370 1.50 12.60 1.22 3,241 9.30 1.16	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds	cumferentia gitudinal St dial Stress [ps octive Stress Calculated 29,423 30,453 2,275 3,241	I Stress [p: ress [psi] psi] i] s [psi] Allowable 32,500 32,500 6,000 11,500	si] 33,314 11,297 -1,440 30,453 32,500 PASS/FAIL PASS PASS PASS 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	ircumferential Stress umferential Stress Circumferential Stress Load [psi] lic Circumferential clic Circumferential] lic Ļongitudinal Stress clic Longitudinal Stress	29,423 32,500 1,934 0.97 0.83 1,370 1.50 1.20 1.22 3,241 9.30 1.16 2,275	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds	cumferentia gitudinal St dial Stress [ps octive Stress Calculated 29,423 30,453 2,275 3,241	I Stress [p: ress [psi] i] s [psi] Allowable 32,500 32,500 6,000 11,500	si] 33,314 11,297 -1,440 30,453 32,500 PASS/FAII PASS PASS PASS 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 Cyclic Longitudinal Stress [psi] Notes: Open cut construction, ca	ircumferential Stress umferential Stress Circumferential Stress n Load [psi] lic Circumferential clic Circumferential i] lic Longitudinal Stress clic Longitudinal Stress	29,423 32,500 1,934 0.97 0.83 1,370 1.50 12.60 1.22 3,241 9.30 1.16 2,275 -20 loadin	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds	cumferentia gitudinal St dial Stress [ps octive Stress Calculated 29,423 30,453 2,275 3,241	I Stress [p: ress [psi] psi] i] s [psi] Allowable 32,500 32,500 6,000 11,500	si] 33,314 11,297 -1,440 30,453 32,500 PASS/FAIL PASS PASS PASS 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 Highway Geometry Factor for Cyc Cyclic Longitudinal Stress [psi] Notes: Open cut construction, ca Reference: API RP 1102 "Steel F	ircumferential Stress umferential Stress Circumferential Stress h Load [psi] lic Circumferential clic Circumferential i] lic Longitudinal Stress clic Longitudinal Stress clic Longitudinal Stress	29,423 32,500 1,934 0.97 0.83 1,370 1.50 12.60 1.22 3,241 9.30 1.16 2,275 -20 loadir	Maximum Circ Maximum Lon Maximum Rac Total Effective Allowable Effe Stress [psi] Hoop Effective Girth Welds Long. Welds Long. Welds	cumferentia gitudinal St dial Stress [ps octive Stress Calculated 29,423 30,453 2,275 3,241	I Stress [p: ress [psi] psi] i] s [psi] Allowable 32,500 32,500 6,000 11,500	si] 33,314 11,29 -1,440 30,455 32,500 PASS/FAI PASS PASS PASS PASS	

Location Burlington VT		Date 5/24/201	16				
API 1102 - Gas Pipeline	e Crossing High	way					
PIPE AND OPERATIONAL DATA	:	SITE A	ND INSTA	LLAT		۹:	
Operating Pressure [psi]	1440	Soil Ty	pe: Med	dium d	lense sand	ds and gra	avels
Location Class:	3	E' Mo	dulue of S	oil Ro	action [kei	1	1.0
Operating Temperature [°F]	60.0		cilient Mor		action [Kai] [kei]	1	1.0
Pipe Outside Diameter [in]	12.75			iaht o	[KSI] f Sail [Ib/ff:	31	120.00
Pipe Wall Thickness [in]	0.312	Dine D	e Onit we	igni o		1	5
Pipe Grade: X65		Pipe Do	Diameter [inl			12 75
Specified Minimum Yield Stress	65,000	Installa	tionTomp	aratur	o (°E)		60.0
Design Factor	0.50	Docian	Wheello		c [「] m Single /	Avla (kine	1 18 4
Longitudinal Joint Factor	1.0	Design	Wheello	ad fro	m Tander	- Ανίρε [k	inel 18.4
Temperature Derating Factor	1.000	Design		None			
Pipe Class: API 5L Electric Re	esistance Welded	Impact	Eactor Me	athod:		liahway	
Young's Modulus for Steel [ksi]	30,000	impact		stribu.		ngnway	
Poisson's Ratio for Steel	0.30						
Coefficient of Thermal Expansion	[per°F] 0.0000065	Safety	Factor Ap	plied:	API 110	2 Procedu	ure
RESULTS	51		182				
RESULTS Hoop Stress [psi]	51	29,423	Maximur	n Circ	umferentia	al Stress [psi] 33,151
RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi]	51	29,423 32,500	Maximur Maximur	n Circ n Lon	umferentia gitudinal S	al Stress [stress [psi	[psi] 33,151] 11,186
RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Ci	rcumferential Stress	29,423 32,500 1,934	Maximur Maximur Maximur	n Circ n Lon n Rad	umferentia gitudinal S lial Stress	al Stress [stress [psi] [psi]	[psi] 33,151] 11,186 -1,440
RESULTS Hoop Stress [psi] Allowable Hoop Stress [psi] Stiffness Factor for Earth Load Circu Burial Factor for Earth Load Circu	rcumferential Stress mferential Stress	29,423 32,500 1,934 1.08	Maximur Maximur Maximur Total Effe	n Circ n Lon n Rad ective	umferentia gitudinal S lial Stress Stress [ps	al Stress [stress [psi] [psi] si]	[psi] 33,151] 11,186 -1,440 30,318
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	rcumferential Stress mferential Stress Circumferential Stress	29,423 32,500 1,934 1.08 0.83	Maximur Maximur Maximur Total Effe Allowable	n Circ n Lon n Rad ective e Effe	umferentia gitudinal S lial Stress Stress [ps ctive Stres	al Stress [stress [psi] [psi] si] ss [psi]	[psi] 33,151] 11,186 -1,440 30,318 32,500
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	rcumferential Stress mferential Stress Circumferential Stress Load [psi]	29,423 32,500 1,934 1.08 0.83 1,525	Maximur Maximur Maximur Total Effe Allowable	n Circ n Lon n Rad ective e Effe	umferentia gitudinal S lial Stress Stress [ps ctive Stres	al Stress [stress [psi] [psi] si] ss [psi]	[psi] 33,151] 11,186 -1,440 30,318 32,500
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	rcumferential Stress mferential Stress Circumferential Stress Load [psi]	29,423 32,500 1,934 1.08 0.83 1,525 1.50	Maximur Maximur Maximur Total Effe Allowable	n Circ n Lon n Rad ective e Effe osi]	umferentia gitudinal S lial Stress Stress [ps ctive Stres Calculated	al Stress [stress [psi] si] ss [psi]	[psi] 33,151] 11,186 -1,440 30,318 32,500 e PASS/FAII
RESULTS 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	rcumferential Stress mferential Stress Circumferential Stress Load [psi] ic Circumferential	29,423 32,500 1,934 1.08 0.83 1,525 1.50 12.60	Maximur Maximur Maximur Total Effe Allowable Stress [p Hoop	n Circ n Lon n Rad ective e Effe osi]	umferentia gitudinal S lial Stress Stress [ps ctive Stres Calculated 29,423	al Stress [stress [psi] [psi] ss [psi] ss [psi] [Allowabl 32,500	[psi] 33,151] 11,186 -1,440 30,318 32,500 e PASS/FAIL PASS
RESULTS 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	rcumferential Stress mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential	29,423 32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10	Maximur Maximur Maximur Total Effe Allowable Stress [p Hoop Effective Girth We	n Circ n Lon n Rad ective e Effe	umferentia gitudinal S lial Stress Stress [ps ctive Stres Calculated 29,423 30,318 2,118	al Stress [psi] [psi] ss [psi] d Allowabl 32,500 6.000	[psi] 33,151] 11,186 -1,440 30,318 32,500 e PASS/FAIL PASS PASS
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 Cycli Highway Geometry Factor for Cycli	rcumferential Stress mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential	29,423 32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10 2,923	Maximur Maximur Maximur Total Effe Allowable Stress [p Hoop Effective Girth We Long. W	n Circ n Lon n Rad ective e Effe osi] elds elds	umferentia gitudinal S lial Stress Stress [ps ctive Stres Calculated 29,423 30,318 2,118 2,923	al Stress [psi] [psi] si] ss [psi] d Allowabl 32,500 6,000 11,500	[psi] 33,151] 11,186 -1,440 30,318 32,500 e PASS/FAIL PASS PASS PASS PASS
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 Cycli Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycli	rcumferential Stress mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential	29,423 32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10 2,923 9.30	Maximur Maximur Maximur Total Effe Allowable Stress [p Hoop Effective Girth We Long. We	n Circ n Lon n Rad ective e Effe osi]	umferentia gitudinal S lial Stress Stress [ps ctive Stres Calculated 29,423 30,318 2,118 2,923	al Stress [psi [psi] si] ss [psi] d Allowabl 32,500 6,000 11,500	[psi] 33,151] 11,186 -1,440 30,318 32,500 e PASS/FAIL PASS PASS PASS PASS
RESULTS 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 Highway Stiffness Factor for Cycli	rcumferential Stress mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential clic Circumferential	29,423 32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10 2,923 9.30 1.08	Maximur Maximur Maximur Total Effe Allowable Stress [p Hoop Effective Girth We Long. We	n Circ n Lon n Rad ective e Effe osi]	umferentia gitudinal S lial Stress Stress [ps ctive Stres Calculated 29,423 30,318 2,118 2,923	al Stress [psi] [psi] si] ss [psi] 32,500 32,500 6,000 11,500	[psi] 33,151] 11,186 -1,440 30,318 32,500 e PASS/FAIL PASS PASS PASS PASS
RESULTS 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 Highway Stiffness Factor for Cycli Highway Stiffness Factor for Cycli	rcumferential Stress mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential clic Circumferential clic Longitudinal Stress clic Longitudinal Stress	29,423 32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10 2,923 9.30 1.08 2,118	Maximur Maximur Maximur Total Effe Allowable Stress [p Hoop Effective Girth We Long. We	n Circ n Lon n Rad ective e Effe	umferentia gitudinal S lial Stress Stress [ps ctive Stres Calculated 29,423 30,318 2,118 2,923	al Stress [psi] [psi] si] ss [psi] 32,500 32,500 6,000 11,500	[psi] 33,151] 11,186 -1,440 30,318 32,500 e PASS/FAIL PASS PASS PASS PASS
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 Cycli Highway Geometry Factor for Cycli Highway Stiffness Factor for Cycli Highway Stiffness Factor for Cycli Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycli	rcumferential Stress mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential clic Longitudinal Stress clic Longitudinal Stress	29,423 32,500 1,934 1.08 0.83 1,525 1.50 12.60 1.10 2,923 9.30 1.08 2,118	Maximur Maximur Maximur Total Effe Allowable Stress [p Hoop Effective Girth We Long. We	n Circ n Lon n Rad ective e Effe	umferentia gitudinal S lial Stress Stress [ps ctive Stres 29,423 30,318 2,118 2,923	al Stress [psi] [psi] si] ss [psi] d Allowabl 32,500 6,000 11,500	[psi] 33,151] 11,186 -1,440 30,318 32,500 e PASS/FAIL PASS PASS PASS PASS
RESULTS 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 Highway Stiffness Factor for Cycli Highway Stiffness Factor for Cycli Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycli Reference: API RP 1102 "Steel P	rcumferential Stress mferential Stress Circumferential Stress Load [psi] ic Circumferential clic Circumferential ic Longitudinal Stress clic Longitudinal Stress clic Longitudinal Stress	29,423 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 loadin	Maximur Maximur Maximur Total Effe Allowable Stress [p Hoop Effective Girth We Long. W	n Circ n Lon n Rad ective e Effe osi]	umferentia gitudinal S lial Stress Stress [ps ctive Stres 29,423 30,318 2,118 2,923	al Stress [psi] [psi] si] ss [psi] Allowabl 32,500 6,000 11,500	[psi] 33,15] 11,186 -1,440 30,318 32,500 e PASS/FAI PASS PASS PASS PASS

Location		Date 5/24	1/2016	3				
API 1102 - Gas Pipeline	e Crossing High	way	,					
		SIT	F AN			ΓΙΟΝ ΠΑΤΑ		
Operating Pressure [psi]	1440	Soi	I Type	e: De	ense to	verv dense	e sands an	d gravels
Location Class:	3		Mod		Soil De	action [kei]		2.0
Operating Temperature [°F]	60.0			uius oi k				2.0
Pipe Outside Diameter [in]	12.75				eight c	[KSI] of Sail [Ib/ft ^{3]}	1	120.0
Pipe Wall Thickness [in]	0.312	Pin	o Dor	oth [ft]	eignite			3
Pipe Grade: X65		Bor	red Di	iameter	[in]			12 75
Specified Minimum Yield Stress	65,000	Inst	tallatio	onTemr	uni Veratur	e [°F]		60.0
Design Factor	0.50	Des	sian V	Wheel I	oad fro	on Sinale A	vle [kins]	18.4
Longitudinal Joint Factor	1.0	Des	sign V sian V	Wheel I	oad fro	om Tander	n Axles [kir	os] 18.4
Temperature Derating Factor	1.000	Design Wheel Load from Tandem Axles [kips] 18.4						
Pipe Class: API 5L Electric Re	esistance Welded	Imr	oact F	actor N	1ethod	· : ASCE - H	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	Saf	fety Fa	actor A	pplied:	API 1102	2 Procedur	e
RESULTS								
Hoop Stress [psi]		29,42	23 I	Maximu	ım Circ	cumferentia	I Stress [p	si] 32,060
Allowable Hoop Stress [psi]		32,50	00 1	Maximu	ım Lon	igitudinal St	ress [psi]	10,417
Stiffness Factor for Earth Load Ci	rcumferential Stress	1,693	3 1	Maximu	um Rad	dial Stress [psi]	-1,440
Burial Factor for Earth Load Circu	mferential Stress	0.78	-	Total Ef	ffective	e Stress [ps	i] 🔬	29,422
Excavation Factor for Earth Load	Circumferential Stress	0.83		Allowab	ole Effe	ective Stress	s [psi]	32,500
Circumferential Stress from Earth	Load [psi]	964						
Impact Factor		1.50		Stress [[psi]	Calculated	Allowable	PASS/FAIL
Highway Stiffness Factor for Cycli	c Circumferential	9.30		Hoop Effectiv	<u>e</u>	29,423	32,500	PASS
Highway Geometry Factor for Cyc	lic Circumferential	1.22		Girth W	elds	1,517	6,000	PASS
Cyclic Circumferential Stress [psi]		2,393	3 [Long. V	Velds	2,393	11,500	PASS
Highway Stiffness Factor for Cycli	c Longitudinal Stress	6.20						
Highway Geometry Factor for Cyc	lic Longitudinal Stress	1.16						
Cyclic Longitudinal Stress [psi]		1,517	7					
Notes: Open cut construction, cal	culations run using HS	-20 loa	ading	+ 15%				
Reference: API RP 1102 "Steel P	ipelines Crossing Railro	oads a	and H	lighways	s"			

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	Er - Re	silient Mo	dulus	[ksi]	-	20.0
Pipe Outside Diameter [in]	12.75	Averaç	je Unit We	ight c	of Soil [lb/fl	.31	120.00
Pipe Wall Thickness [in]	0.312	Pipe D	epth [ft]	-	-	-	4
Pipe Grade: X65		Bored	Diameter	ïn]			12.75
Specified Minimum Yield Stress	65,000	Installa	ationTemp	 eratur	e [°F]		60.0
Design Factor	0.50	Desigr	Wheel Lo	oad fro	om Single	Axle [kips]	18.4
Longitudinal Joint Factor	1.0	Desigr	Wheel Lo	oad fro	om Tande	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
Stimness Factor for Earth Load Circumferential 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				
Excavation Factor for Earth Load Circu Circumferential Stress from Earth	Circumferential Stress Load [psi]	0.83 1,113	Allowabl				
Excavation Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor	Circumferential Stress Load [psi]	0.83 1,113 1.50	Allowabl	osi]	Calculate	dAllowable	PASS/FAIL
Excavation Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl	Circumferential Stress Load [psi] c Circumferential	0.83 1,113 1.50 9.30	Allowabl	osi]	Calculate	d Allowable 32,500	PASS/FAIL PASS
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	Circumferential Stress Load [psi] ic Circumferential clic Circumferential	0.83 1,113 1.50 9.30 1.22	Allowabl Stress [p Hoop Effective Girth We	osi] elds	Calculate 29,423 29,554 1,517	d Allowable 32,500 32,500 6,000	PASS/FAIL PASS PASS PASS
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 Cyclic Circumferential Stress [psi]	Circumferential Stress Load [psi] ic Circumferential clic Circumferential	0.83 1,113 1.50 9.30 1.22 2,393	Allowabl Stress [p Hoop Effective Girth We Long. W	osi] e elds felds	Calculate 29,423 29,554 1,517 2,393	d Allowable 32,500 32,500 6,000 11,500	PASS/FAIL PASS PASS PASS PASS
Excavation Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycl	Circumferential Stress Load [psi] ic Circumferential clic Circumferential ic Longitudinal Stress	0.83 1,113 1.50 9.30 1.22 2,393 6.20	Allowabl Stress [p Hoop Effective Girth We Long. W	osi] elds elds	Calculate 29,423 29,554 1,517 2,393	d Allowable 32,500 32,500 6,000 11,500	PASS/FAIL PASS PASS PASS PASS
Excavation Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycl Highway Geometry Factor for Cycl	Circumferential Stress Load [psi] ic Circumferential clic Circumferential ic Longitudinal Stress clic Longitudinal Stress	0.83 1,113 1.50 9.30 1.22 2,393 6.20 1.16	Allowabl Stress [p Hoop Effective Girth We Long. W	osi] elds elds	Calculate 29,423 29,554 1,517 2,393	d Allowable 32,500 32,500 6,000 11,500	PASS/FAIL PASS PASS PASS PASS
Excavation Factor for Earth Load Circu Excavation Factor for Earth Load Circumferential Stress from Earth Impact Factor Highway Stiffness Factor for Cycl Cyclic Circumferential Stress [psi] Highway Stiffness Factor for Cycl Highway Stiffness Factor for Cycl Cyclic Longitudinal Stress [psi]	Circumferential Stress Load [psi] ic Circumferential clic Circumferential ic Longitudinal Stress clic Longitudinal Stress	0.83 1,113 1.50 9.30 1.22 2,393 6.20 1.16 1,517	Allowabl Stress [p Hoop Effective Girth We Long. W	osi] elds elds	Calculate 29,423 29,554 1,517 2,393	d Allowable 32,500 32,500 6,000 11,500	PASS/FAIL PASS PASS PASS PASS

ř.

Prepared By Kelsey Kibbe Approved By Revision: 13.0.1

Location Burlington, VT		Date 5/24/201	16			
API 1102 - Gas Pipeline	e Crossing High	way				
PIPE AND OPERATIONAL DATA	:	SITE A	ND INSTALLAT	ION DATA	:	
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	e Unit Weight o	- f Soil [lb/ft³]		120.00
Pipe Wall Thickness [in]	0.312	Pipe D	epth [ft]			5
Pipe Grade: X65		Bored	Diameter [in]			12.75
Specified Minimum Yield Stress	65,000	Installa	tionTemperatur	e [°F]		60.0
Design Factor	0.50	Design	Wheel Load fro	om Single A	xle [kips]	18.4
Longitudinal Joint Factor	1.0	Design	Wheel Load fro	om Tandem	Axles [kip	os] 18.4
Temperature Derating Factor	1.000	Pavem	ent Type: None	9		•
Pipe Class: API 5L Electric Re	esistance Welded	Impact	Factor Method	ASCE - H	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 Lon	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	ctive Stress	s [psi]	32,5
Circumferential Stress from Earth	Load [psi]	1,211				
Impact Factor		1.50	Stress [psi]	Calculated	Allowable	PASS/F/
Highway Stiffness Factor for Cycl	ic Circumferential	9.30	Hoop	29,423	32,500	PASS
Highway Geometry Factor for Cyc	clic 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	ic Longitudinal Stress	6.20				
Highway Geometry Factor for Cyc	clic Longitudinal Stress	1.08				
Cyclic Longitudinal Stress [psi]		1,412				
		00 loodin	m 1 1 5 0/			

Prepared By Kelsey K	ïbbe	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>>
Cc: Wolf, Brian D <<u>Brian.Wolf@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 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≤*SMYS*×*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,

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<image020.png>

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<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 S	TRESS DAT	<u>A</u>	Variable Description	Pipeline Regulatory Code	Pass / Fail
Hoop Stress (σ_{H}):					
$\sigma_{H_Internal_MOP} =$	29423 p	psi	< Internal Pressure @ MOP		
$\sigma_{H_{Live_{Zero}}} =$	21158 p	psi	< Live Load @ Zero pressure		
$\sigma_{H_{Live}MOP} =$	10788 p	psi	< Live Load @ MOP		
$\sigma_{H_{Total_{Zero}}} =$	22935 p	psi	< Total Hoop Stress @ Zero pressure		
$\sigma_{H_Total_MOP} =$	41117 p	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	י):				
$\sigma_{L_Live_Zero} =$	13741 p	psi	< Live Load @ Zero pressure		
$\sigma_{L_{Live_{MOP}}} =$	10380 p	psi	< Live Load @ MOP		
$\sigma_{L_{Total_{Zero}}} =$	14274 p	psi	< Total Longitudinal Stress @ Zero pressure		
$\sigma_{L_Total_MOP} =$	19479 p	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 _E)	:				
$\sigma_{E_{Zero}} =$	37210 p	psi	< Equivalent Stress @ Zero pressure		
$\sigma_{E_MOP} =$	42942 p	psi	< Equivalent Stress @ MOP		
$\sigma_{E_{SMYS_{Zero}}} =$	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: DATE:

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

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 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' = 100 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 STRESS DATA		Variable Description	Pipeline Regulatory Code	<u>Pass / Fail</u>
Hoop Stress (σ _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		
σ _{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		
$\sigma_{L_{SMYS_{Zero}}} =$	29.0%	< Longitudinal Stress %SMYS @ Zero pressure	ASME B31.8-2010	PASS
$\sigma_{L_{SMYS_{MOP}}} =$	36.4%	< Longitudinal Stress %SMYS @ MOP	ASME B31.8-2010	PASS
Equivalent Stress (σ_E):				
$\sigma_{E_{Zero}} =$	43685 psi	< Equivalent Stress @ Zero pressure		
$\sigma_{E_MOP} =$	47563 psi	< Equivalent Stress @ MOP		
$\sigma_{E_{SMYS_{Zero}}} =$	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.

Location Date	TECHNICAL
Burlington VT 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/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 Bor	e [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 Stress [psi]	45,865				
Design Factor	0.50						
Longitudinal Joint Factor	1.0	Note: The total calculated combined stress should not exceed 100% of SMYS.	ss				
Temperature Derating Factor	1.000						
Modulus of Elasticity for Steel [psi] 30,000,000							
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 B	ore [ft.] 4						
Height of Soil over Pipe [ft.]	2						
Uniform Support Under Pipe [°] and Ci	ossing Conditi	ons: 30° - Open Trench					
Soil Type: Extreme maximum for clay (completly saturated).							
Notoc							
Notes.							

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